DIGITAL ZELLIJ

Human-machine collaboration for traditional Moroccan craft

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Abstract

Zellij is the centuries-old traditional Moroccan craft of cutting and composing mosaic tiles into complex geometric patterns. This master thesis aims to explore whether new use cases for zellij can be generated by the introduction of digital fabrication tools.

This research intends to demonstrate the predisposition of Islamic art for such a digitalisation because of its reliance on mathematical properties, as well as its spiritual and philosophical roots in the materialisation of abstraction. Furthermore, an argument is made for digital fabrication to be understood as a craft rather than an industrial process.

The outcome of this project is a tangible interface prompting a discussion about the future of zellij patterns in a hands-on fashion, and enabling the development of hybrid fabrication processes – a human-machine collaboration for traditional Moroccan craft.

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1. Introduction

The centuries-old tradition of zellij, a Moroccan craft involving the meticulous cutting and assembly of mosaic tiles into intricate geometric patterns, represents an invaluable part of Islamic art. This master thesis explores the potential for integrating digital fabrication tools into the traditional practice of zellij. It aims to explore new use cases and modern applications for this ancient craft.

The basis for this research lies within the conceptual parallels between Islamic art and digital fabrication technologies. Both domains share a foundation in mathematical principles and the materialisation of abstraction, making Islamic geometric patterns particularly predisposed to digitalisation. This fact represents a unique opportunity to reimagine zellij within a contemporary context, leveraging the precision and versatility of digital tools to enhance and innovate traditional crafting techniques.

Central to this work are the research questions addressing how digital tools can be integrated into the workflow of traditional zellij artisans, known as maalemin, without compromising the authenticity and cultural heritage of their craft. This involves a careful consideration of the existing working conditions and the potential benefits and challenges of introducing computer-aided design (CAD) and digital fabrication tools into their practice.

As a Moroccan raised in a rich country, I feel a deep responsibility to contribute to the economic and cultural development of my homeland. By seeking to hybridise traditional and digital workflows, this project seeks to provide new opportunities for craftspeople and to enable a dialogue between traditional artisans, designers, architects, and the wider public about the future of zellij.

In subsequent chapters, this thesis will delve into the technical aspects of combining digital fabrication with zellij, present the outcomes of various prototypes and workshops conducted during the research, and discuss the broader implications of this hybridisation for the preservation and evolution of Islamic art and Moroccan cultural heritage.

2. Research Field

2.1. Clarification of Terms

Islamic Art

Islamic art, which is a part of the wider Islamic culture, is an umbrella term referring to an array of craft-based practices produced since the 7th century CE by craftspeople who lived in places inhabited or ruled by Muslim populations.[1] First coined by Western art historians in the late 19th century CE, this term refers to traditions from a wide range of places, periods and genres.[2] This type of art traditionally avoids any type of representation, except for the use of biomorphic patterns. Other types include Islamic calligraphy and geometric patterns, and these styles can be found in a plethora of mediums ranging from small objects to architectural scale.

Zellij

Zellij refers to a style of mosaic tilework made from tesserae individually cut and chiselled by hand.[3] The pieces are typically made of different colours of tile and assembled into various complex patterns present in the Islamic art tradition, such as radiating star patterns composed of polygons.[4] After the 15th century CE, this traditional style of mosaic fell out of fashion in most countries except Morocco, where it continues to be produced today.[5]

Digital Fabrication

Digital fabrication is a design and production process that combines computing-aided design (CAD) with computer numerical control (CNC) manufacturing. These fabrication processes can be categorised as additive manufacturing, which is also known as 3D printing, or subtractive manufacturing, which can also be referred to as machining, and many other technologies can be applied to materialise the designed objects.[6]

Parametric Design

Parametric design is a design methodology in which design decisions are made based on algorithmic processes rather than direct manipulation. In this technique, parameters and relational rules establish the dialogue between intent and output.[7] The term parametric relates to the input parameters that are plugged into the algorithm.[8]

1 Richard Ettinghausen, Oleg Grabar, and Marilyn Jenkins-Madina, *Islamic Art and Architecture 650 - 1250*, 2. ed, Yale University Press Pelican History of Art (New Haven, Conn.: Yale Univ. Press, 2001).

2 Jonathan Max Bloom and Sheila Blair, *The Grove Encyclopedia of Islamic Art and Architecture* (Oxford: Oxford university press, 2009).

3 'Metiers Du Patrimoine Marocain: Mosaïste' (PNMA, n.d.).

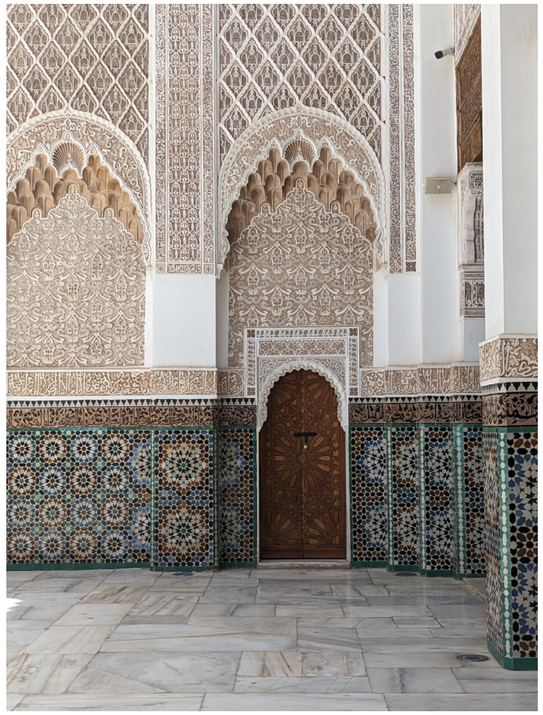
4 *Le Maroc andalou: à la découverte d'un art de vivre*, Deuxième édition (Aix-en-Provence, France: Edisud, 2010).

5 Élie Lambert, 'L'architecture musulmane d'Occident [Georges Marçais, L'Architecture musulmane d'Occident. Tunisie, Algérie, Maroc, Espagne et Sicile]', *Journal des Savants* 1, no. 1 (1956): 19–34.

6 Bernd Bickel et al., 'State of the Art on Stylized Fabrication', *Computer Graphics Forum* 37, no. 6 (September 2018): 325–42, https://doi.org/10.1111/cgf.13327.

7 John Frazer, 'Parametric Computation: History and Future', *Architectural Design* 86, no. 2 (March 2016): 18–23, https://doi.org/10.1002/ad.2019.

8 Wassim Jabi, *Parametric Design for Architecture* (London: Laurence King Publishing, 2013).



2.2. Islamic Art and Zellij

Patterns in Islamic Art

Because Islamic art is intrinsically linked to religious and philosophical considerations held throughout its development, a short summary of the early history of Islam, as well the influences it has undergone is necessary to understand the context in which it was born.[9] This evolution would eventually lead to the creation of the zellij mosaic we are specifically researching here.

Historical Setting

From approximately 610 CE until his death in 632 CE, the Prophet Muhammad received and transcribed the revelations of the Qur'an, which would become the Holy Book of Islam.[10] During his lifetime, the new religion that he spearled would come to supplant the ancient paganism that had been present in the whole Arabian peninsula. Its mission was to reinvigorate the Abrahamic religion in the remnants of the Eastern Roman Empire, and to introduce it to the neighbouring Persian Sassanid Empire and beyond. An impressively rapid expansion would follow, as the modern Islamic world would already be delineated in the following century.

After the Prophet's death, the first dynasty that would take on the mantle would be the Umayyad Caliphate. Started in 661 CE by Mu'awiya who became Caliph, their capital would be set in Damascus (current Syria).[11] This dynasty would be the one carrying out the Islamic expansion until Spain in the West and India and China in the East.

The reign of the Umayyads would later lead to resentment from the Mawali (non-arab muslims). In 750 CE, dissenting factions would organise a revolution against the established rulers, and the second Islamic dynasty would then be born: the Abassid Caliphate. Their capital would be set in Baghdad (current Iraq) in 762 CE. Under the reign of Harun al-Rashid, starting in 786 CE, Baghdad would enter its Golden Age, and in 828 CE, Al-Ma'mum, his grandson and successor would found the Dar-al-Hikhma (House of Wisdom).[12] This place would spearhead the synthesis of classical Greco-roman, as well as Persian and Indian traditions. It is during this time that the foundations of Islamic style in art would be formed.

9 Wendy M. K. Shaw, *What Is 'Islamic' Art? Between Religion and Perception* (Cambridge University Press, 2019), https://doi.org/10.1017/9781108622967.

10 Shaw.

11 Shaw.

12 Shaw.

Religious Dimension

The development of Islamic art can only be understood in the religious context in which it was forged. The characteristics of these art forms are the results of certain religious beliefs present within the muslim faith.[13]

For starters, the Shahada, one of the Five Pillars of Islam, states that "There is no God but God" and that "Muhammad is the Messenger of God". This oath marks Islam's complete rejection of any form of idolatry. No human is to be deified, and God is beyond representation. The connection to God is to be absolutely individual and personal. Therefore no illusion or pretence of reality can be permitted. That is why, in a religious context, Islamic art does not allow any figurative representations of the divine, and by extension, of any human subjects. This does not necessarily apply outside of a religious context.

The Qur'an, Holy Book of Islam, claims that the Divine Nature can only be experienced through the Divine World. It describes the perfection of Creation, as well as the divine quality of light. The text is deeply imbued with other-worldly esotericism. That is why Islamic art strives for the dissolution of matter, and to give hints of the infinity of the cosmos in its expansive repetition of patterns.

Certain Hadiths, which are attributed reports about what the Prophet Muhammad said and did, make more precise distinctions in terms of what should or shouldn't be permitted. Indeed, a distinction is made between vegetal and animal subjects, the representation of the former being deemed allowable but not the latter. Additionally, a similar distinction is made between flat and sculpted surfaces. This further accentuates the aspiration for there to be no illusion or pretence of reality in artistic representation.

Within Islamic belief, there is a very strong emphasis on the underlying principles of existence. This can be found in the concept of Mizan, which can be understood as cosmic symmetry, or the "the overarching divine principle for organising our universe"[14], and is represented by a set of scales. This word also can also be used to describe architectural ground-plans, as well as musical patterns and rhythmic modes. This concept is materialised within the patterns of Islamic art by their symmetrical construction and geometrical ordering.

Finally, another religious concept which is imbued within the characteristics of Islamic art is that of Al-Djanna, the Islamic Paradise. In Islam, Paradise is described as a luxurious tropical garden, and earthly beauty is understood as a pale reflection of the Unseen. The magnificent architecture and exquisite objects produced by muslim craftspeople is created with the intent of transmitting the mindset of the Paradise to come. High quality craftsmanship strives towards a perfection of style and execution. That is why garden imagery such as floral and vegetal motifs can be found among others in mihrabs[15], prayer mats and carpets.

Philosophical and Scientific Contribution

As we saw earlier, the Abbasid Caliphate were the first to realise the value of Ancient Greek sciences such as mathematics, medicine and astronomy. Under their patronage, the translation of these texts would become institutionalised, and by the end of the 9th century, the entire Greek scientific literature would be translated into Arabic and Latin. In doing so, Baghdad became the first great centre of Islamic scientific learning and philosophy.[16]

Pythagoras and his disciples, the Pythagoreans, were the first to believe in Mathematics as the structure of the universe. They saw Arithmetic and Geometry as the key through which to understand the world. Fascinated by ratios and proportions, as well as musical harmony, they would impart them with mystical, esoteric properties.

Plato believed that the world we perceive is only an imperfect copy of a high dimension, something he called the supersensible realm of "Forms". He held the art of representation in low regard, as it would be a mere "copy of a copy". Therefore, he considered geometric and abstract art to be able to reach closer to the perfection of the "Forms".

Both of these Greek philosophers had a considerable influence on Islamic philosophy. From them, the muslim scholars took over the idea of numbers and proportions as the key to understanding nature, and as an essential aspect of beauty. During the Golden Age of Baghdad, these philosophical ideas were reformulated to muslim theological sensibilities. Alas, the Graeco-Islamic intellectual enlightenment would die out with the Fall of Baghdad to the Mongol

13 Brian Wichmann and David Wade, *Islamic Design: A Mathematical Approach*, vol. 2, Mathematics and the Built Environment (Cham: Springer International Publishing, 2017), https://doi.org/10.1007/978-3-319-69977-6.

14 Ziad Hafez, 'Review: The Islamic Worldview, Islamic Jurisprudence: An American Muslim Perspective, Vol. 1, by Azizah Al Hibri', *Contemporary Arab Affairs* 10, no. 3 (1 July 2017): 443–46, https://doi.org/10.1080/17550912.2017.1343929.

15 a niche in the wall of a mosque that indicates the qibla, the direction of the Kaaba in Mecca towards which Muslims should face when praying

16 Wichmann and Wade, *Islamic Design*.

invasion in 1258 CE. However, this translation effort would lead to the western Enlightenment, as classical philosophy was first conveyed to Europe in Latin translations from Arabic sources.

Through this influence, we can understand Islamic art as a legacy of late-Hellenistic cultural values in the Islamic sphere.[17] The muslim reverence towards symmetry, proportions, spacing and a general geometric other-worldly aesthetic are to a certain extent an expression and reinterpretation of Pythagorean and Platonic philosophical concepts. This, combined with the fact that pure geometry is never seen as heretical, made the development of this art style possible.

Evolution of Style

An essential aspect of Islamic art is its recognisable aesthetic signature in all types of mediums. Be they materialised in woodwork, mosaic or plasterwork, connections can be made between the different patterns. This led to this art style being easily assimilated by the different nations and ethnicities within the Islamic realm, each putting their own spin on the common canon. This can be explained by the relative social consistency of muslim societies, as their citizens tend to understand themselves as muslim first and foremost before any nationalistic identity building. Such a mindset thus tends towards social and artistic conservatism, which has left this art style mostly unchanged over centuries.

In opposition to the 20th century western view on the subject[18], Islamic art prides itself as an art of decoration. Decoration is here understood as an act of transformation of objects and surfaces, of a transfiguration reflecting the transitory nature of being. For the reasons we mentioned earlier, these art styles are characterised by orderly, symmetrical arrangements which convey an idealistic otherworldliness. Contrary to popular belief, the specific elements of these patterns are free of symbolic meaning, while the whole conveys the abstraction of the cosmic scale. A certain disregard for scale makes them able to adapt to a variety of applications, from precious artefacts to grandiose edifices. A preference for a-centric arrangements, which avoid obvious focal points, denotes the belief about the Absolute as an even, pervasive force throughout Creation. In this way, repetition is seen as a connection to the spirit world, Plato's realm of "Forms".

The decorative canon of Islamic art can be categorised into distinct variants.[19] The first variant is the art of calligraphy. It is the most noble, as it is the literal visible materialisation of the words of the Qur'an. In the absence of artistic representation, this style takes the place of iconography in muslim culture. The second variant is the art of geometric patterns. For reasons mentioned above, these carry an aura of spirituality, and they are free of spiritual meaning. The third variant is the biomimetic art, sometimes also called arabesque. The most representational of the three, it is characterised by its vegetal and floral motives, and denotes an abstracted connection to Al-Djanna, the Islamic Paradise.

Traditional Islamic culture makes no distinction between art and craft. Furthermore, no division is made between beauty and utility. This tradition has been carried by groups of anonymous craftspeople. The craft has been transmitted in hereditary fashion, usually from father to son, and these craftspeople have congregated in guilds of their specialisations. Until recently, no formal training was available, knowledge being transmitted through an apprentice-master relationship. Because of highly conservative societies in which these traditions developed, little change occurred to them over generations. Change did however come over time, as artisans from various traditions were included into Islamic culture through the early Umayyad conquests.

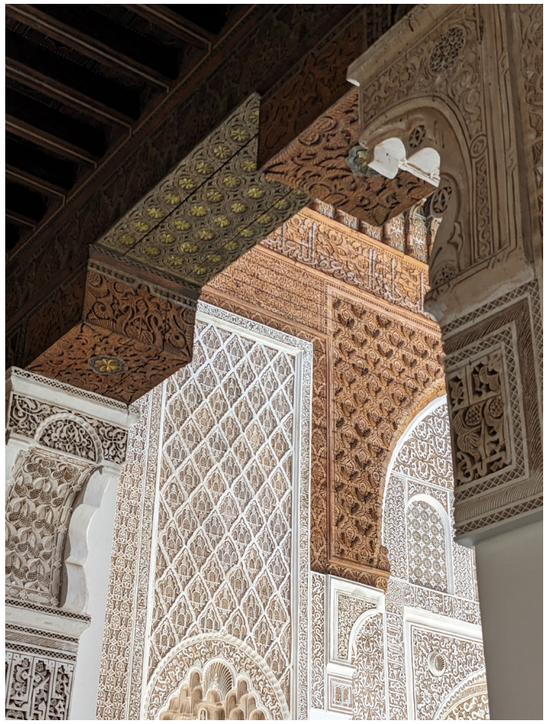
One of these introductions from external traditions which would have a tremendous impact on Islamic art is the fabrication of paper.[20] A Chinese invention, it would permeate into the Islamic realm through its conquests in central Asia and the Greater Khorasan. At first, use-cases for this technology were found in bureaucratic and military applications. Its cheapness and ease of production would soon lead to a rapid spread of paper throughout the 9th and 10th centuries. Over time, it was gradually adopted by artists: at first used in the arts of the book, it later became a standard tool in most crafts. Because it enabled preliminary drafting before working on a piece, the adoption of paper into craft led to a gradual separation of design and manufacturing. This in turn would lead to a stylistic centralisation, as local rulers were then able to create royal studios which would produce the patterns and order production from external craftspeople. Thus, dynastic styles were developed. Paper also enabled designs to travel for the first time, as pattern-books and albums started to be produced and disseminated across the Islamic world. This explains why such similarities in patterns can be found from East to West. Furthermore, this also further enabled the delineation of patterns through the different mediums. All in all, the introduction of paper into the Islamic Realm greatly contributed to the stylistic and cultural homogeneity of Islamic art.

17 Wichmann and Wade.

18 Adolf Loos, '1908: Ornament Und Verbrechen', in *Programme Und Manifeste Zur Architektur Des 20. Jahrhunderts* (DE GRUYTER, 1981), 15–21, https://doi.org/10.1515/9783035602784.15.

19 Wichmann and Wade, *Islamic Design*.

20 Wichmann and Wade.



As mentioned above, Islamic art is very stylistically coherent throughout the different parts of the world where it is practised, while showcasing local variations. Because any surface is considered worthy of decoration, many different expressions of this art can be found in a plethora of mediums, such as the art of the book, woodwork, metalwork, plasterwork or ceramics. In the specific case of zellij, it came to be because of an East-West divide originating in pre-Islamic traditions. In Egypt, Syria and Asia Minor, the focus in architecture was first on stonework, while in the regions under Persian influence, brickwork came to dominate. The latter would start as purely structural and over time progress to include more and more decorative complexity. During the 11th century, in the first stage of this evolution, the decorative aspects would be expressed through a variety of brick bonds. In a later second stage, these decorations would evolve to include carved ornamental inserts which were moulded before firing. At some point, these inserts would start to be glazed and their thickness was reduced until they became what we know today as mosaic tiles.[21]

Zellij Manufacturing Process

The information contained in this chapter comes essentially from conversations with zellij "maalemin" (masters of the craft), as well as documentation provided by members of the PNMA[22].

The manufacturing process of zellij can be broken down into three distinct steps: the fabrication of basic 10x10cm glazed tiles, the cutting and chiselling of the tesserae and the composition and assembly of the zellij pattern.

Tile Making

The manufacturing of zellij tiles starts with the fabrication of basic 10x10cm glazed tiles. This process commonly happens in the open air, in the courtyard of the workshop.

First, clay is extracted in a quarry, usually in close proximity to the workshop's location. This raw material is broken into manageable chunks with a mallet or pickaxe, then ground into a powder, and mixed with water in settling tanks. To obtain a homogenous paste, the resulting slurry is kneaded by hand or trampled by foot, and stones and other impurities are removed by filtration through sieves.

21 Wichmann and Wade.

22 'Metiers Du Patrimoine Marocain: Mosaïste'.

After enough water has evaporated and the consistency of a thick slip is achieved, the clay is spread into a rectangular frame mould which is then removed, and the raw tiles are left to dry in the sun directly on the floor. When these approach a leather hard consistency, they are then flattened smooth to a 1 cm thickness using a wooden spatula and scraping tools, and cut to a 10cm sided square by following a wooden stencil. These are then left to dry until bone dry, first in the shadow and then in the sun, to allow for a slow and progressive drying process, thus avoiding cracking and warping.

The dried tiles then undergo a first bisque firing in either artisanal kilns, which are very polluting because they use old tires or organic waste as fuel, or modern gas-powered kilns. The loading of the kiln can take a whole day, as space has to be optimised as much as possible - the tiles are stacked on their edges in a triangular grid pattern, starting from the outer edges of the kiln until the centre. The firing takes between 6 and 8 hours, and after a cooling down period of 3 to 4 days, the tiles are extracted from the kiln.

Next, the bisque fired tiles are humidified slightly with a sponge, and then have their upper surfaces dipped in glazes of a variety of colours. They then undergo a second glaze firing, using plaster shelves to avoid contact bonding between them, and, finally, a selection of the best tiles is made to ensure quality control.

Cutting and Chiselling

The next step in the zellij tiles manufacturing process is the “taksir”, the cutting and chiselling of the individual tesserae. This operation usually happens in the zellij maalem’s workshop. Because the appropriate clay for the fabrication of zellij tiles comes first and foremost from the northern region of Fes, this step is where the work of most zellij artisans in other Moroccan cities begins by using imported tiles.

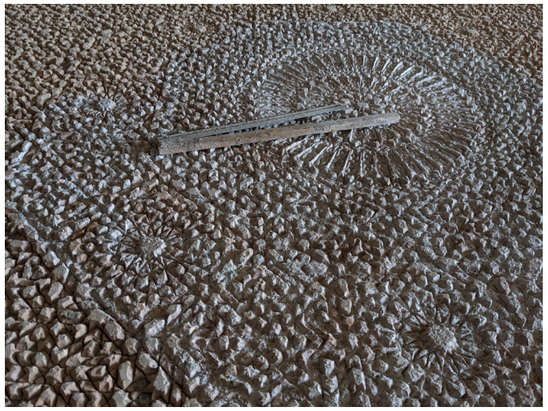
The chiselling maalem starts by tracing the outline, so called “rachm”, of the tesserae on the glazed surface of the tile. To do so, they use a previously cut tessera as well as a stylus dipped in paint. Then, with the aid of a “manqach”, a heavy hammer with a sharp edge, and a sturdy anvil often made of concrete blocks or stones affixed to each other and to the floor with plaster, they cut the tile in successive increasingly precise passes. After a first course pass to separate the individual pieces, a second pass follows the traced outline, and a third creates a bevel at the back of the piece to ensure that the sharp glazed edge is the only point of contact between tesserae. Finally, a comrade finishes off the pieces with a file.

Composition and Assembly

The final step in the production of zellij is the composition and assembly of the pattern in panels. The maalem “khattat” (draughtsperson) first works out the composition of the pattern following the rules of traditional regulating layouts by drawing it with the help of rulers, squares and protractors. Subsequently, one or more maalemin “feragh” (assembly artisans) use this as their template to position the many individual tesserae of different shapes and colours. On a flat surface, usually a concrete floor, the most important guiding lines of the pattern are traced with a pencil, and the frame of the panel is delimited by straight battens.

The tesserae are then placed glazed face down onto this surface. If the pattern includes a central rosette, the artisans start there, and the rest of the composition develops from it. The ferragha know all the shapes, and instinctively recognise where each piece fits. Therefore, they can work in teams, and place the individual tessera at a distance from each other, anticipating what tiles come in between without seeing their hidden coloured faces. This continues until all parts of the puzzle are laid down.

Finally, when the pattern is complete, the maalem “ghabbar” (masonry artisan) wets the pieces and dusts them with plaster and cement to bind them together. If the panel is intended for export purposes, this can be substituted by a layer of resin and fibreglass, which reduces weight while keeping structural integrity. Once dry, the panel can then be lifted off the floor, revealing the colour pattern hidden until then, and transported to the location of its intended installation. There, mortar or tile adhesive is employed to glue it to architectural surfaces such as floors, walls or fountains. As the edges of individual panels are left unfinished, the joint between them becomes no more noticeable than the joint between the tesserae themselves, and large surfaces can be adorned with unbroken, continuous motifs.



2.3. Digital Crafts

Human-Machine-Material relationship

In the chapter “At the Potter’s wheel”[23] Lambros Malafouris leverages the specific example of pottery making to explore the concept of agency in the context of material culture making. He argues that agency is not only a human trait but is actually shared between humans and materials. In the context of pottery, the potter, the clay and the potter wheel influence each other through material affordances, thus creating a dynamic interaction where each element acts upon and responds to the others.

Furthermore, Malafouris introduces the Material Engagement Theory (MET)[24], which hypothesises that cognitive processes are not limited to the brain but also take place in the material world. Because the act of pottery involves a cognitive partnership between the person and the clay, this leads to a non-anthropocentric view of agency. Malafouris also places an emphasis on the process of creation rather than the finished product. He suggests that deeper insights into the concept of agency can be found by understanding the relational interactions that occur during the making process.

Additionally, the development of the craftperson’s skill is described here as a dialogue. According to the author, the potter’s expertise is shaped by continuous reaction to their input by the material – a virtuous feedback loop.[25] Over time, this interaction refines the potter’s perception and techniques, thus demonstrating a co-evolution of human and material capabilities. By challenging traditional views that prioritise human intentionality and instead recognising the active role of materials in shaping human actions and cognition, Malafouris advocates for a non-anthropocentric approach to studying material culture.

As they are based on a traditional craft, Malafouris’ argument can of course also be applied to zellij manufacturing. These are very similar contexts, the materials being substantially the same and the tools of a comparable kind. The brittleness of the fired tiles and the weight and graspability of the manqach inevitably inform the maalem’s chiselling, just as the chemical reactions undergone by the fired glaze influence the patterns which can be composed from them.

23 Carl Knappett and Lambros Malafouris, eds., *Material Agency: Towards a Non-Anthropocentric Approach* (Boston, MA: Springer US, 2008), https://doi.org/10.1007/978-0-387-74711-8.

24 Knappett and Malafouris.

25 Knappett and Malafouris.

This view of the concept of agency could also be extended to the case of digital modelling and fabrication technologies. We also find here the trifecta of the human, the tool (in this case a machine and an interface controlling it) and the material. In fact, I would argue that as the complexity of the tools increases, the dialogue taking place between them is also enhanced. The more options and immediacy of prototyping a system offers, the more dialogical exploration could be promoted by this partnership. In the rapid prototyping loop enabled by these technologies, the same co-evolution of skills takes place as the user learns to engage with the capabilities of the machine, which are themselves dependent on the material which is being manipulated. Furthermore, the tinkering culture associated with CNC machines also enables the tools themselves to evolve over time. In this sense, these machines can also be seen as agents and partners in creation.

Computer Aided Design as Inventive Artistry

In his book “Abstracting Craft: The Practiced Digital Hand”[26] Malcolm MacCullough explores the intersection of traditional craft practices and digital technology. This work examines how the principles and values intrinsic to craftsmanship can be applied to the world of digital design and fabrication, and what digital artisans can learn from the long legacy of making.

MacCullough argues that the essence of craft, characterised by skill, care and manual dexterity is far from lost but actually transformed in the digital age. He postulates that digital media, similarly to traditional materials, require a hands-on approach and a real comprehension of tools and processes.[27] In this context, the author gives a lot of importance to skill and expertise in digital design, and he emphasises that, like traditional craft, this comes only from practice and experience in the form of an intimate understanding of hardware and software. In his opinion, materiality also plays a paramount role in digital work, as digital materials have their own properties and affordances that influence the creative process.[28] In this sense, understanding these digital materials is necessary for effective digital craftsmanship.

Because of these reasons, McCullough argues that an interdisciplinary approach is required to bridge the gap between traditional and digital practices. He advocates for digital designers to examine and learn from the principles of traditional crafts to enhance their work. In doing so, he places significant emphasis on the role of the practitioner, stressing the importance of the individual’s engagement, creativity and problem-solving abilities as integral to crafting quality digital artefacts. Additionally, he also touches on the ethical and aesthetic dimensions of digital craftsmanship, saying that digital artisans should be mindful of the implications of their work in terms of their impact on culture and society.[29]

When it comes to digital fabrication processes in particular, I believe that these considerations are of undeniable importance. As a bridge between digital and material worlds, they especially cannot be dissociated from the constraints linked to the material agency we touched on earlier. It is therefore necessary for users of these technologies to stand on the shoulders of giants and learn from the history of making to be able to effectively leverage modern fabrications methodologies.

Inversely, traditional crafting practices also stand to gain a lot from incorporating digital tools. Not only are there efficiency gains to be made, but these tools come with their own set of affordances and abilities which in certain cases go beyond what can be done by hand, or at least makes certain results much more attainable. As McCullough puts it, this does not represent a loss of skills, but rather a shift in focus, and a broadening of horizons for anyone who can combine both approaches.

Duality of Parametric Design and Digital Fabrication

In the paper “Mass Customization: A Critical Perspective on Parametric Design, Digital Fabrication, and Design Democratization”[30] Mateus van Stralen describes the ability of parametric design to generate variations and custom products, combined with the capability of digital fabrication to materialise these variations. Together, these techniques enable the mass production of non-standard objects, which is known as mass customisation, a term attributed to Stanley Davis in his book Future

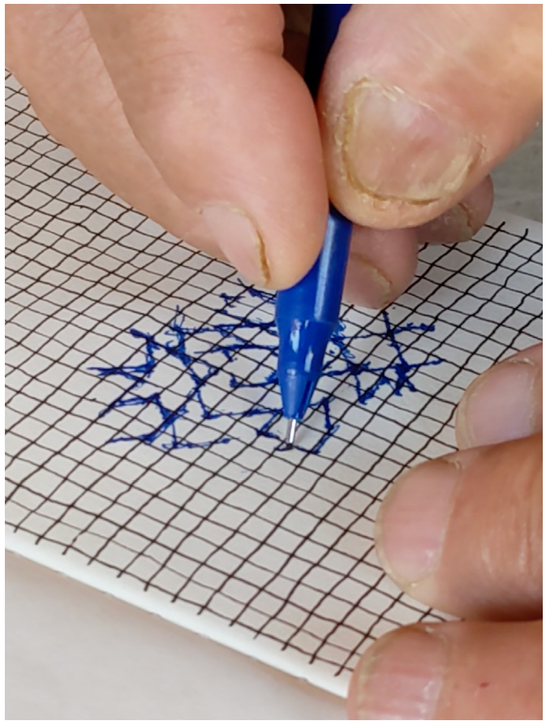
26 Malcolm McCullough, *Abstracting Craft: The Practiced Digital Hand* (Cambridge, Mass: The MIT Press, 1998).

27 McCullough.

28 McCullough.

29 McCullough.

30 Mateus Van Stralen, ‘Mass Customization: A Critical Perspective on Parametric Design, Digital Fabrication and Design Democratization’, in *Blucher Design Proceedings* (XXII CONGRESSO INTERNACIONAL DA SOCIEDADE IBEROAMERICANA DE GRÁFICA DIGITAL, São Carlos, BR: Editora Blucher, 2018), 142–49, https://doi.org/10.5151/sigradi2018-1770.



Perfect[31] and further popularised by Joseph Pine[32]. This concept has different implications in various sectors, including design and architecture, where standard mass-produced components can be combined to generate personalised designs.

The author defines parametric design as a process where a digital model can be manipulated dynamically without sacrificing consistency, enabling designers to explore variations more easily than traditional methodologies.[33] These parametric models link input and output through geometric relationships, permitting the modification of parameters which impacts the entire model. These characteristics dovetail perfectly with the capabilities of digital fabrication technologies, which leverage digital data to control fabrication processes, and therefore enable the rapid production of customised objects. Some early examples of such systems include Gramazio and Kohler's mTable[34] and Assa Ashuach's Co-design[35] which allow users to customise products by changing parameters such as size, colour, and pattern.

These systems have been described as a democratisation of design[36], as they enable untrained users to more easily compare alternatives and make design decisions. Approaching the topic from a critical perspective, van Stralen claims that many such interfaces do not truly democratise the design process, but rather turn users into consumers who can only make choices between predefined options.[37] To avoid this trap, he advocates for empowering users by giving them the ability to innovate and create their own custom designs by using systems that enable trial-and-error learning and direct communication with manufacturing equipment.

31 Stanley M. Davis, *Future Perfect* (México: Addison-Wesley, 1992).

32 Pine II B J, 'Mass Customization: The New Frontier in Business Competition', *Choice Reviews Online* 30, no. 09 (May 1993): 30–5097, https://doi.org/10.5860/choice.30-5097.

33 Van Stralen, 'Mass Customization'.

34 Fabio Gramazio, Matthias Kohler, and Jan Willmann, *The Robotic Touch: How Robots Change Architecture : Gramazio & Kohler Research ETH Zurich 2005-2013* (Park Books, 2014), https://www.research-collection.ethz.ch/handle/20.500.11850/93821.

35 Branko Kolarevic and José Pinto Duarte, *Mass Customization and Design Democratization*, Mass Customization and Design Democratization, 2018, https://doi.org/10.4324/9781351117869.

36 Pine II B J, 'Mass Customization: The New Frontier in Business Competition'.

37 Van Stralen, 'Mass Customization'.

2.4. Predisposition of Islamic Art for Digitalisation

This research comes not necessarily from the identification of a problem for which a solution could be proposed, but rather the intuition that fruitful parallels can be made between Islamic art and digital fabrication technologies. These connections lie within the following facts: firstly, on a conceptual level, both worlds are analogous in terms of their endeavours in the materialisation of abstraction. Furthermore, on a technical level, mathematics is a core foundation of Islamic art, as its patterns are based on geometric principles, which predisposes it to digitalisation. Both are also agnostic in terms of their medium of expression. Finally, the consequences of the introduction of paper into the pattern-making process represent an opportunity for digital fabrication to reunite the design and manufacturing aspects of Islamic craft.

Mathematics as Core Principle

In the geometric canon of Islamic art, most patterns are created through mathematical operations related to rotation, symmetry and tessellation. A recognisable interest in the study of these patterns is present in the field of mathematics and attempts have been made to describe them in modern mathematical terms[3839]. This fact makes these patterns very applicable to digitalisation, as both paradigms share the same language.

Materialisation of Abstraction

As we saw earlier, the spiritual and philosophical roots of Islamic art lie in the pursuit of a materialisation of abstract concepts of a transcendental cosmic order. This harkens back to the platonic concept of the realm of forms and its relationship to the material world we inhabit. I strongly believe that this relationship between ideas and matter, which islam connects with the relationship between the divine creation and its expression in Islamic art, is analogous to the relationship between the digital world and the physical. In this sense, digital fabrication technologies which act as a bridge between both worlds represent an undeniably adequate way to explore novel approaches to giving shape to Islamic art.

Agnosticism of Medium

Another perspective from which Islamic art and digital fabrication technologies can be seen as analogous is their agnosticism in terms of medium.

In Islamic art, the three stylistic canons can be applied to a variety of mediums, among which wood carving, plaster carving, metalwork and mosaic. While of course, certain patterns might lend themselves more easily towards certain techniques, as plaster carving might be better suited to calligraphy than cut zellij is, most types of patterns still find a materialisation is most traditionally crafted materials.

The same can be said of CNC machines, as they are in essence simply a system to numerically position and actuate a tool in 3 dimensional space. What that tool is doesn't change the fundamental workings of the machine, as demonstrated by the common programming language they share in g-code. Employ a laser, and you can engrave or cut your material of choice. Install an extruder, and any material of adequate viscosity, be that achieved through prior processing in the case of clay or simultaneous melting for polymers, can be 3D printed. Here also, certain materials and tools are better suited to certain applications, such as the limitations in terms of overhangs of concrete and clay 3D printing, but in principle, these machines can translate the same design into a variety of mediums, each having a specific expression.

Reconnection of Design and Manufacturing

As we saw earlier, the introduction of papermaking technology to the Islamic world had a tremendous impact on the production and dissemination of Islamic patterns.[40] This chinese invention resulted in the separation of design and manufacturing processes by enabling drafting prior to working on the final material of the piece. I see the combination of computer aided design and digital fabrication as an opportunity to bring these aspects back together into one integrated framework, where patterns can be generated in a digital format which is able to control the manufacturing process directly.

Unexploited Opportunity

The benefit of digital fabrication technologies for traditional Moroccan crafts has already been recognised by craftspeople as CNC machines are

38 Jean-Marc Castera, 'Persian Variations', *Nexus Network Journal* 18, no. 1 (1 April 2016): 223–74, https://doi.org/10.1007/s00004-015-0281-5.

39 Wichmann and Wade, *Islamic Design*.

40 Wichmann and Wade.

at present in use in many Moroccan workshops. Plasma cutters are being employed to cut patterns into metal sheeting for the manufacturing of fences, sun shades and doors. Similarly, CNC milling machines are present in wood workshops and aid carpenters in the carving of wooden tables, ceiling ornaments and mashrabiya (latticework). This is not yet the case for mosaic work, and therefore an opportunity is present.

Parametric Patterns

In Morocco, innovation in the creation of new Islamic patterns has slowed down considerably in the last 70 years. After the country obtained its independence from France in 1956 and the modern Moroccan state was created, the Fassi craftsmen who represented the local bourgeoisie started sending their sons to study abroad in more lucrative fields rather than taking over the family businesses of craft production. This led to the mantle of the trade being taken over by the workers who were part of the industry, and the pattern designing aspects of the craft were lost to a large extent in this transmission. The repetition of already established patterns became the norm and this continues until today. Some innovation did happen, especially under the influence of foreign architects and designers like Michel Pinseau, who worked extensively for King Hassan II. He would for example take traditional patterns and scale them up dramatically to add more intricate variations within these extended surfaces. In the last 30 years, a new wave of Moroccan designers such as Ghalia Sebti and Tawfik Bennani of Aït Manos or Salima Filali, also started innovating on traditional patterns, but this mainly resulted in a simplification of the patterns and colours to adapt them to a western audience's palate and facilitate the export of tiles produced in Morocco.

In conversations I had with contemporary Moroccan architects, and especially Jawhar Kodadi, a sentiment that the implementation of digital technologies into the design of Islamic patterns could bring an infusion of new life into this discipline was expressed. In his words, "our ancestors would have gone crazy if they had this technology". Instead of tending towards simplification, parametric design methodologies could represent an opportunity to push the complexity of traditional patterns even further, and also adapt them to considerations present in the contemporary architectural discourse of having situational and functional data influence the design.

2.5. Research Questions

The main questions which lead me to conduct this research are related to how digitalisation can benefit the work and lives of traditional Moroccan craftspeople and help safeguard an essential part of Moroccan cultural heritage in the digital age. That is why I am specifically interested in how digital planning and fabrication tools can enhance the current working methods of maalemin, as well as what new use-cases for their work can be generated by the introduction of these tools.

Coming into the world of zellij as an outsider and a technophile, I am wary of bringing a techno-solutionist approach to the topic. I feel that those who are versed in digital tools have a great responsibility to put this knowledge to use in a respectful and uplifting manner, rather than purely seek automation in the name of efficiency and modernity. At the same time, having witnessed the, from my perspective, horrible working conditions of zellij manufacturers in Morocco, I am torn about the idea of romanticising ancient ways of working in the name of tradition. That is the reason why one of the main foci of this research is to see where and how digital tools can enhance and support the established working methodologies of maalemin without denaturing their craft. Taking into consideration that CAD tools and CNC machines are already present in a number of craft sectors in Morocco, but have not yet found a strong foothold in the traditional mosaic industry, I am interested in which parts of the zellij manufacturing process could benefit from a certain degree of automation and possibly alleviate the pain points of this type of labour. From this, questions about which technologies are appropriate to incorporate into local conditions and methodologies, and in how they could be conveyed to stakeholders in this industry arise.

Additionally, as a Moroccan raised and living in one of the wealthiest countries in the world, I feel indebted to my compatriots to aid in economically developing my country of origin. As I am aware of the power of digital tools, I feel it is my duty to put these tools to use to benefit people who do not necessarily already have expertise and access to them. That is why I am specifically interested in what new use-cases for the traditional craft can be generated by the introduction of these tools, or in essence, how these tools can provide new opportunities to craftspeople.

As I will expose further into this thesis, I see a strong relationship between Islamic art and parametric design, and a deep potential for innovation in the hybridisation of these working methods. There is an opportunity here to bring zellij into a new step in its evolution and that is why I want to find out how human-machine collaboration can help create new design methodologies that fit into the lineage of Moroccan and Islamic cultural heritage and what implications this hybridisation has for the legacy of traditional moroccan craft. To this end, I am interested in exploring how to enable a dialogue about the future of Islamic art to take place between relevant stakeholders such as craftspeople, architects, designers, and the general public.

2.6. Motivation

Ghost in the Shell

I really enjoy working with machines. They give me a certain feeling of being able to shape the world, to make my place in it, to mould it to my needs. The work is often extremely frustrating, consisting of long periods of hitting my head against a wall trying to solve an unseen bug or finding the right consistency of clay, until suddenly, I climb out of the fog and a ray of sunshine hits my face full blast.

I live for those moments of euphoria.

My seminal experience with CNC machines was back in 2014, during my freshman year at the École Polytechnique Fédérale de Lausanne (EPFL). During that summer, I participated in the Treehouse Project workshop organised by Edouard Cabay at Valldaura Labs in collaboration with the Institute for Advanced Architecture of Catalonia (IAAC). There, we were taught about the basics of Rhino and Grasshopper, and we designed and constructed a parametric structure which would snake around a tree in the surrounding forest. I remember vividly the fascination I felt watching the huge CNC milling machine shredding through wood like butter, and promising to myself that I would use it one day. While those three weeks felt like a revelation, it would take years until I would dip my toes into that world again.

The first 3D-printer I owned, which I bought in 2020 was, like many, a Creality Ender 3 – the VW beetle of FDM printing. I used it from time to time throughout the pandemic but mostly stuck to printing upgrades for the machine itself, although it proved useful to print the external sunshades on my Bachelor thesis Learning Center project. That machine was too frustrating: the results were disappointing and I never really got the hang of it. When one of the limit switches broke as I disassembled it in preparation for moving, it ended up staying in its box for years to come.

When I moved to Zurich for my first internship at an architectural firm, the waking dream I had been immersed in for the last 6 years of my life came crashing down. Since childhood, I had professed to anyone willing to listen that I would become an architect. It seemed like the obvious and only choice to me, a way to combine my interests in art and technology. It became the lens through which I built up my entire identity. After two months at the firm, reality smacked me squarely across the face: I realised the work was not at all what I had expected and it seemed like what I was doing now was light-years away from what I had studied. Looking at my colleagues who had been there for 10 years really made me question if this was the path I wanted to pursue. This pushed me to start looking for an escape, something that would scratch the itch I felt in my gut.

With my first pay-checks came my first plotter: an Axidraw A3/V3. That was a blast! The beast came pre-assembled and ready to go. Those first few months of experimenting with it were exhilarating: I would come home exhausted from work and jump onto it immediately to try out my newest acquisitions from the craft store. At first I built stuff in Rhino and vectorized them into SVGs, and later moved on to learning to program in p5.js to create my first generative pieces. At that time, I discovered a whole community of like-minded artists online, and after sharing some of my initial experiments on Instagram and reaching out to some of my role-models, I was invited to join a slack channel where all my idols were exchanging their experiences and their work-in-progress. It was the NFT boom of 2021 at the time, and a lot of them were finally making bank after working in the shadows for years. That's when I started to think that this might be a viable alternative to the job I had wanted all my life up to that point and that I now felt so disillusioned about.

Most of the people I wanted to walk in the footsteps of seemed to be publishing projects on artblocks.io, a back then up-and-coming platform dedicated to the sale of Ethereum network-based generative NFT artworks, and so that became my goal as well. I set to work on ZIGGURAT, the project that would later become the initial impulse of the present thesis. It gave me a chance to dig into something one of DIY YouTuber and architect Ben Uyeda's professors had reportedly told him: the fact that "architects don't create buildings, but rather drawings and plans that instruct and inspire" – visions of a possible future. This took shape for me in the form of phygital objects which could be materialised in a variety of 2D and 3D mediums by means of digital fabrication tools. The project advanced as I learned the necessary programming skills, which proved rather frustrating, as my ideas vastly surpassed my capabilities. I nonetheless managed to create a first sketch of what I envisioned the project could become and, as soon as the opportunity presented itself as a new application window opened, I sent my portfolio and proposal off to the curation team.

At the Crossroads

It was at this time that I first became aware of the field of interaction design. As my doubts about my plans of pursuing a MSc in Architecture at the ETHZ grew, I started looking into how I could delve deeper into this new obsession for creative coding. ZHdK and the Master program I am currently enrolled in came up and soon became my new lighthouse. The next few months were dedicated to preparing my application folder. I would work on it every morning from 5 to 7am before going to work. At the time, my understanding of interaction design was limited to UX/UI design, and so I was convinced that I needed to show that I had experience developing wireframes and working prototypes of a smartphone app. ZIGGURAT took on a new aspect, that of a commercial platform for collections of 3D printed generative ceramic homeware. This development was inspired by my rather spontaneous participation in the Eazao Zero clay 3D printer Indiegogo campaign, as well as my interest in artists Olivier van Herpt and Tom Lauerman's practices. I thought customisation might be a motor to make objects more valuable and therefore less disposable.

At first I didn't realise that implementing the project was not quite necessary yet before the start of the MA, so I decided that I had to actually build the system I was envisioning. I tackled this by enrolling in Bruno Simon's very popular Three.js Journey online course and learning to use WebGL for this purpose. While I was able to lay the foundations of the 3D version of ZIGGURAT, time would not suffice to achieve a satisfactory implementation. Although my skills in Javascript were not up to the task at the time, this became a chance for me to dip my toes back into Grasshopper. There I was able to create a version of the system which I could use to produce visualisations of the generated ceramics. Using those, I would soon pivot to building the Figma prototype that would end up in my application portfolio. Oh what a joyful discovery Figma was: its parametric rules and systems adding even more to the satisfaction layout work already provided me.

In November 2021, after finally applying to the MA program, I was invited to the interview that would determine my fate. During that conversation with Karmen Franinovic, Max Rheiner and Stella Speziali, I remember vividly that the latter asked me why I didn't go to study at ETHZ. While at the time, it was because I was convinced that I had to leave architecture and its toxic work culture behind to find a more fulfilling path, I realise now that I was never able to let go, and that this former field of study had a tremendous impact on my approach to craft, art and design. Looking back, I recognise that I simply wasn't aware that ETHZ was (and still is) one of the best places in the world to pursue my interest in digital fabrication technologies. I was worried that I would have to struggle through two more years of working on classical architectural projects before I would be able to dedicate myself to my particular field of interest. Therefore, being able to jump into a project of my choosing at ZHDK seemed like a worthy alternative. In hindsight, it also had the valuable side-effect of greatly nuancing my approach to my practice. Studying interaction design exposed me to notions that had lacked cruelly in my previous studies. It was the first time I heard of human-centred and more-than-human design. Furthermore, my views about the boundaries between art and design became much less rigid as I realised these disciplines had much more in common than I thought. My experience in the Shared Campus Transcultural Collaboration program especially enabled me to position myself as an artist and be free of certain constraints I had hitherto imposed myself.

Soon after this conversation, I was accepted within the program and I started my studies in February 2022. I started researching mass customisation and parametric design, and continued developing ZIGGURAT. By the end of the semester, I had a working prototype of my ceramic homeware generator, and I was able to generate and 3d print a small curated collection of cups. To ensure printability, I restricted the parameters to only six fixed heights along the base cylinder at which it could have one of two set diameters, resulting in 64 possible combinations. I chose 7 of these, and set to work in the ceramic workshop where I had recently installed and started experimenting with my personal printer. A light stoneware clay and a thin white glaze were combined to produce an airy result which would showcase the manufacturing process. These first few prints enabled me to get familiar with the machine, and to better understand the differences between Fused Deposition Modelling and Liquid Deposition Modelling printing.

Throughout that first semester, I struggled to find a justification for the topic I was pursuing. Most of the research on Mass Customisation that I could find was obviously business related, and aiming to leverage this technology to sell more. In the context of the current climate crisis, this seemed contradictory to my idea that customisation might help make objects more personally meaningful to consumers and lead to them being kept longer and cared for. My fascination for these technologies felt like it was clashing with my conviction that sustainability is the most important wicked problem we all have to tackle in a way that I couldn't reconcile. Ultimately, I had to abandon that angle to be able to focus on what really mattered to me about this topic: the craft.

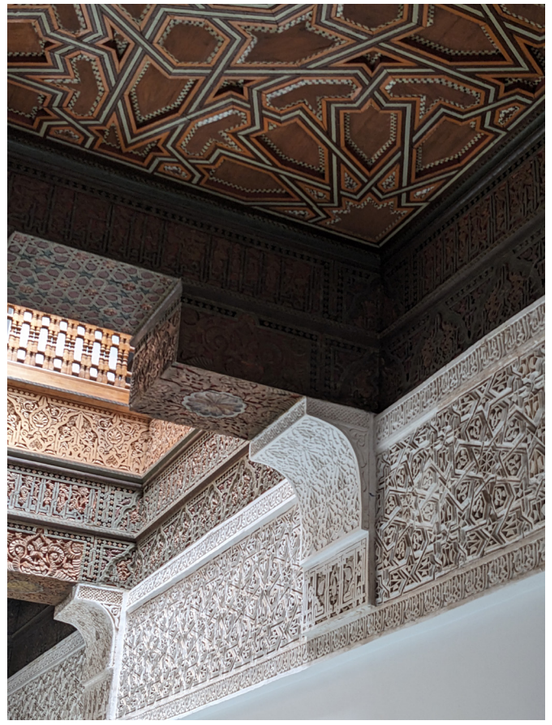
Back to the Roots

This pivot towards combining traditional craft and digital fabrication technologies came as a result of the Shared Campus Transcultural Collaboration program I was a part of in autumn 2022. This 3 and a half months program brought together a group of 30 participants from all arts and design disciplines, half of us studying at ZHdK, and the other half at the school's partner universities in Hong Kong, Singapore, Taipei, and London. While we were at first supposed to spend two months in Taipei, the swan song of the covid pandemic led to a last minute shift towards Yogyakarta, Indonesia. Hoping to use this experience to further my research, I decided to bring with me the latest addition to my collection of CNC machines: the Makelangelo 5 Huge. It is once

on location that I would figure out how it could come into play.

Once in Yogyakarta, I started to get interested in traditional Indonesian craft, and especially Batik. Batik is a technique of wax-resist dyeing of textiles producing vibrant patterns of cultural significance. It is traditionally done by hand using a tool called a tjanting or carved wood stamps, but the technique has also been mechanised and industrialised. A series of discussions on what craft is with our host Arham Rahman at Galeri Lorong led me to wonder what would happen if I adapted my plotter to use a tjanting rather than a pen. This questioning ultimately didn't pan out, as the necessities of the program led me to work on other topics, but the seed had been planted.

Back in Zurich, the idea of hybridising traditional craft and digital fabrication technologies continued to intrigue me, and I realised that this might be the thread I had been looking for all along. Having Moroccan origins but having never lived there, this seemed like it could be an excellent opportunity to delve into my cultural heritage. At the same time, considering my academic background in architecture, working on a craft with architectural applications made the most sense. That is why I ended up focusing on zellij. It is once I delved into the topic that I truly realised how much Islamic art and digital fabrication have in common.



3. Concept

3.1. Pattern Generation Tool

The aim for this project is to create an integrated digital system enabling the generation of zellij inspired patterns and their materialisation through digital fabrication technologies as well as traditional techniques. This tool should enable an explorative approach to designing patterns through a tangible interface which draws inspiration from the traditional zellij manufacturing process.

By reacting in real-time to the users' input, it should visualise the pattern at scale and in colour, thus permitting a better understanding of the final output. Additionally, an in situation visualisation would further support this endeavour. Beyond visualisation, the tool should allow the direct control of digital fabrication machines, and present the pattern in a format that can be integrated into a further traditional, digital or hybrid fabrication workflow. By including a parametric aspect, the system should also provide a basis for innovation in the design of zellij patterns, while still staying true to the rules of tradition.

All these aspects should allow the tool to act as a basis for conversation about the future of zellij, tackling questions such as:

- What are the rules of tradition?
- What is and isn't traditional craft? Where are the limits?
- Where can innovation in patterns be generated?
- How does tradition change if digital tools are introduced?

3.2. Related Works

Hybrid Basketry

With his “Hybrid Basketry” project[41], Amit Zoran explores the combination of contemporary 3D printing and traditional craft to create a hybrid basketry medium where 3D-printed structures support the development of hand-woven patterns. This blend aims to merge the aesthetics of digital and traditional techniques, thus providing a unique organic appeal. In this way, the author aims to generate a dialogue between the two which respects both paradigms. The paper demonstrates the feasibility and artistic value of integrating digital and traditional practices. It calls for more creative makers to engage in this hybrid approach, preserving and innovating traditional craft through digital technologies.

This project forms the basis for my approach to combining traditional zellij manufacturing techniques with digital fabrication tools. My aims align with Zoran’s in that both frameworks should inform and influence each other to enable the creation of novel material aesthetics while remaining true to the cultural heritage of traditional patterns.

Hybrid Embroidery

The “Hybrid Embroidery” project[42] by Yi-Chin Lee and Daniel Cardoso Llach combines generative design methods, computer vision and computerised embroidery machines to create a system of interactive fabrication. The framework puts an emphasis on open-ended exploration, improvisation, and play, allowing for real-time, direct manipulation of materials and a close human-machine collaboration. The project aims to integrate human dexterity with computational design, thus creating a novel embroidery experience where users interact with algorithms to produce unplanned embroidered pieces.

Similarly to Lee and Llach, I am interested in how an explorative and hands-on approach to a tangible computer aided design interface can produce unexpected results influenced by the dialogue between humans and machines. On a technical level, the use of computer vision as a method of communication between the user and the system, as well as a real time feedback of the consequences of the users actions is of particular relevance.

Zellij Evo

Jawhar Kodadi’s “Zellij Evo” project[43] is an attempt at creating a web-based system for the generation of parametric zellij patterns. This tool aims to make the traditional art of zellij accessible to a broader audience, allowing for easy and engaging creation of custom patterns. In this framework, patterns are generated by a grid of shape outlines of which the overlap generates geometric repeating patterns. It provides a straightforward process for users to experiment with different design options by manipulating parameters such as the number of points of the shapes, their size, their rotation, and their stroke’s width. Through the additional implementation of an attractor parameter which enables the modification of the pattern based on its position, innovation in the design of zellij patterns is achieved. It also enables the export of the generated patterns in a digital format which can be further implemented in a digital fabrication workflow.

This project is the starting point from which I base my own prototyping off of in terms of the method by which zellij-inspired patterns can be generated by a grid of overlapping primitive shapes. Additionally, I also aim to further explore the possibilities of parameterising this type of patterns, and to render them more accessible to a wider audience.

Aït Manos Tile Configurator

Aït Manos is one of the leading Moroccan zellij manufacturing companies today. Founded in 1995 by Ghalia Sebti and Tawfik Bennani, they export all over the world from their production site in Casablanca. In 2023, they made a tile configurator[44] available on their website, which is, to my knowledge, the only such commercial tool specifically tailored to zellij mosaic to date. This page enables clients to choose one of six of the patterns they manufacture and assign up to six different glazes from their catalogue to individual tiles within the pattern, according to a pre-configured arrangement. Furthermore, the tool visualises the generated pattern in real-time in a variety of indoor and outdoor settings, and this visualisation, as well as the pattern’s specifications can be downloaded and shared.

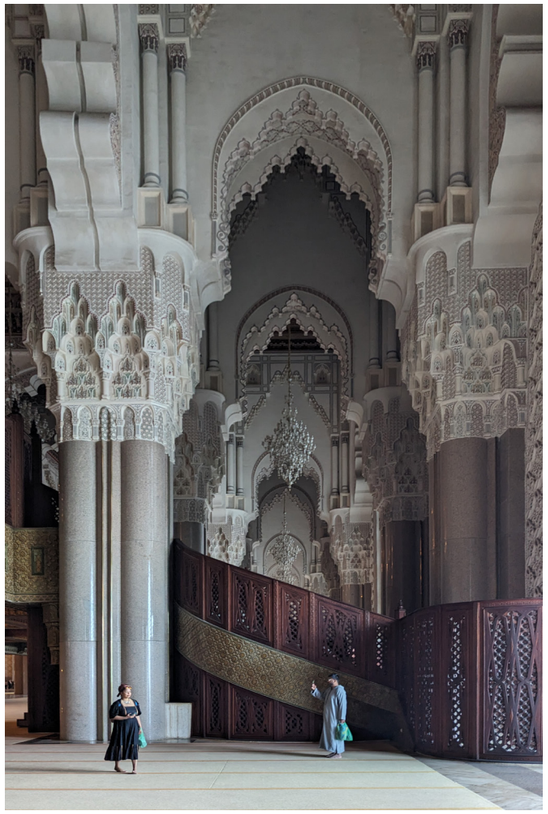
While it is still limited in terms of creative potential, this tool serves as a concrete example of what is currently implemented in the zellij manufacturing industry. The visualisation aspect especially is of relevance when it comes to developing my own research.

41 Amit Zoran, ‘Hybrid Basketry: Interweaving Digital Practice within Contemporary Craft’, in *ACM SIGGRAPH 2013 Art Gallery* (SIGGRAPH ’13: Special Interest Group on Computer Graphics and Interactive Techniques Conference, Anaheim California: ACM, 2013), 324–31, https://doi.org/10.1145/2503649.2503651.

42 Yi-Chin Lee and Daniel Cardoso Llach, ‘Hybrid Embroidery: Exploring Interactive Fabrication in Handcrafts’, *Leonardo* 53, no. 4 (July 2020): 429–33, https://doi.org/10.1162/leon_a_01931.

43 Jawhar Kodadi, ‘Exploration de l’art génératif et du zellige marocain: un outil de génération de motifs’, *Jawhar Kodadi* (blog), 31 March 2023, https://jawharkodadi.com/exploration-de-lart-generatif-et-du-zellige-marocain-un-outil-de-generation-de-motifs/.

44 ‘Aït Manos Tile Configurator’, accessed 4 February 2024, https://configurator.aitmanos.com/.



3.3. Field Research

During the course of this research, I made three trips to Morocco to talk with different experts, visit historical monuments and zellij manufacturing sites and discuss my prototypes with my cooperation partners. All transcripts of the conversations we shared are available in the appendix of this thesis.

First Trip

My first trip to Morocco, which took place from June 19 to July 7, 2023, was an opportunity to establish a first contact with local stakeholders and practitioners. I contacted architect Rachid Taj, who provided me with documentation about all traditional craft practices in Morocco, and especially zellij manufacturing.[45] He also amicably proposed to accompany me to Fes, where the brunt of the Moroccan zellij industry lies, to meet with the experienced maalem Abdul Ali Kandri and Samir Bouslham, one of the workers who apprenticed under him. The former graciously hosted us for the two days of our visit and would become my main cooperation partner in the industry.

Mr. Kandri toured me around his facilities at the "Coopérative Córdoba des Arts du Bâtiment Traditionnel" and enabled me to have a first look at the zellij production process which is described in a previous chapter. Because the Eid al-Adha festivities took place at the end of June 2023, workers were sadly not present at the facility, but I was still able to gather some information and samples. Through our conversations, he provided me with a deep insight into the traditional craftsmanship of Moroccan artisans, highlighting their meticulous approach, long apprenticeship period, and the complex yet rewarding nature of their work. He also touched on the blend of tradition and innovation in their craft, the economic realities they face, and their enduring passion for creating intricate and beautiful works of art.

Back to my family's hometown of Marrakech, I also contacted the artisans of the Ateliers d'Ailleurs, and especially the maalem Hassan Amdgar who was able to give me a crash-course in the chiselling and assembly process of zellij panels. This gave me a better hands-on understanding of the dexterity, precision and patience necessary for their practice, as well as the current state of zellij manufacturing. I also took the time to visit the Ben Youssef Madrasa, an important historical Islamic college dating from the 16th century CE where my grandfather Abbes Ben Brahim Taarji studied and taught for many years. This visit, among others, gave me an opportunity to witness and document the diversity of expressions of Islamic patterns in an array of traditional Moroccan crafts and to connect with my cultural heritage.

45 'Metiers Du Patrimoine Marocain: Mosaïste'.

Second Trip

My second trip to Morocco took place from the 5th to the 24th of February, 2024. During this time, I had a chance to meet with practitioners in the Moroccan architecture field, and delve deeper into the zellij manufacturing scene.

I first contacted the architect Jawhar Kodadi, who developed the Zellij Evo[46] project which would act as the main inspiration for my own work. When I visited him in Rabat, Morocco's capital city, we had a long conversation about his work and the potential he sees in the duality of parametric design and digital fabrication to push Islamic art towards a new step in its evolution. He shared with me his view of the relationship between modern architecture and traditional craft, his own interactions with and deep admiration for Moroccan craftspeoples' skill, as well as what implications he thought the introduction of digital tools in craft practices entailed and his belief in the need to breathe new life into the design of zellij patterns. During this interview, we bonded over our shared passion for the topic, and our exchange reassured me that there was interest for my project among practising Moroccan architects.

My next stop was at the University Mohammed VI Polytechnic's (UM6P) in Ben Guerir. There, I met with Prof. Dr. Hassan Radoine, the director of the School of Architecture Planning and Design (SAP+D), as well as members of his team Salwa Aomorali and Amine Ennawaoui. After sharing some of his own considerable experience working on Islamic patterns, Prof. Dr. Radoine reacted very enthusiastically to the research I presented to him and expressed interest in my joining his team as a Phd candidate so that we could write a book on the topic together. He would later become a key facilitator in this thesis by allowing me to organise a workshop with architecture students at UM6P. I also had the opportunity to tour their extensive facilities, and especially the Design Fabrication Lab lead by Amine Ennawaoui, with whom we exchanged on the possibility and steps necessary to integrate ceramic 3D-printing into their capabilities.

During this trip, I also travelled to Casablanca, the economic capital of Morocco. There, I attempted to organise a meeting with Ghalia Sebti and Tawfik Bennani, the founders of Aït Manos, as they are one the most innovative and successful zellij manufacturing companies active nowadays. Sadly, this did not pan out, but I was still able to visit their showroom and collect some samples of their production. On this occasion, I also went to visit the Hassan II Mosque which is the second largest active mosque in Africa. Designed by French architect Michel Pinseau under the guidance of King Hassan II, it was built by Moroccan artisans from all over the kingdom and construction finished in 1993. This served as an opportunity to see a modern implementation of traditional craft, pushing refinement of materials and ornament to the highest degree at a monumental scale.

Finally, I drove back to Fes to meet with Abdul Ali Kandri and Samir Bouslham again. The latter brought me to Ben Jelliq, an industrial area on the outskirts of Fes where most zellij tile manufacturing takes place. There, I was able to visit an active workshop to witness and document the challenging working conditions of young craftsmen producing the glazed tiles from which tesserae are cut. The owner of the workshop toured me around his facility and showed me every step from the forming and cutting of raw tiles, first firing in traditional kilns, glazing and second firing in modern gas kilns. He also graciously gifted me some clay, and gave me a place to work with the clay 3D-printer I had brought with me. This will be further exposed in detail in a later chapter.

46 Kodadi, 'Exploration de l'art génératif et du zellige marocain'.

3.4. Technology Inquiry

Processing

Processing is a widely used cross-platform platform for creative coding which was created in 2001 by Casey Reas and Ben Fry while they were both students at the MIT Media Lab.[47] It is an open-source flexible software sketching environment and a language for learning how to code within the context of the visual arts and design. Additionally, it is built on Java and provides a simplified development environment to create visual art and interactive applications. Because of its ease of use and the wide availability of examples and libraries to expand its capabilities, it is a useful resource to base my work off of.

P5.js

P5.js is a JavaScript library that aims to make coding accessible for artists, designers, educators, and beginners.[48] Created by Lauren McCarthy in 2014, it is a reinterpretation of Processing for the web, using JavaScript instead of Java, and was created to bring the benefits of Processing to the browser environment. Similarly to its predecessor, it is relevant to my work in terms of accessibility and feasibility considering my current programming abilities.

ReacTIVision

ReacTIVision is an open-source, cross-platform computer-vision framework designed for creating table-based tangible user interfaces.[49] The framework is primarily used for tracking fiducial markers in real-time video streams, allowing for interactive installations and applications. It is optimised for speed and robustness, and allows for accurate detection of marker position and orientation. As it simplifies integration with programming environments like Processing, this would be a great ressource to easily prototype a tangible interface within this framework.

P5.beholder

Similarly to reacTIVision, the p5.beholder library, developed by Enric Granzotto Llagostera[50], is an extension for p5.js designed to facilitate the integration of Augmented Reality (AR) into p5.js sketches. It allows creators to overlay their p5.js graphics onto the real world as viewed through a device's camera, enabling interactive AR experiences directly within a web browser. It uses ArUco fiducials, a widely used computer vision framework, to recognise the position and rotation of physical markers. This system should enable me to rapidly prototype a tangible digital interface.

P5.axidraw

The p5.axidraw library, developed by Owen Trueblood[51], is an extension for p5.js designed to facilitate the control of the AxiDraw, a pen plotter created by Evil Mad Scientist Laboratories which I own. This library allows users to generate and send drawing commands to the AxiDraw plotter directly from their p5.js sketches. This should act as an achievable first step towards materialising the patterns generated by my system.

P5.fab

P5.fab, as detailed in the paper by Blair Subbaraman and Nadya Peek[52], is a system that integrates digital fabrication machines directly with the creative coding environment p5.js. This library allows users to programmatically generate and control toolpaths, visualise them, and send commands to fabrication machines like 3D printers, directly from their browser-based code. This could represent a further step towards materialising generated patterns in a 3-dimensional space.

47 Casey Reas and Ben Fry, *Processing: A Programming Handbook for Visual Designers and Artists*, Second edition (Cambridge, Massachusetts: The MIT Press, 2014).

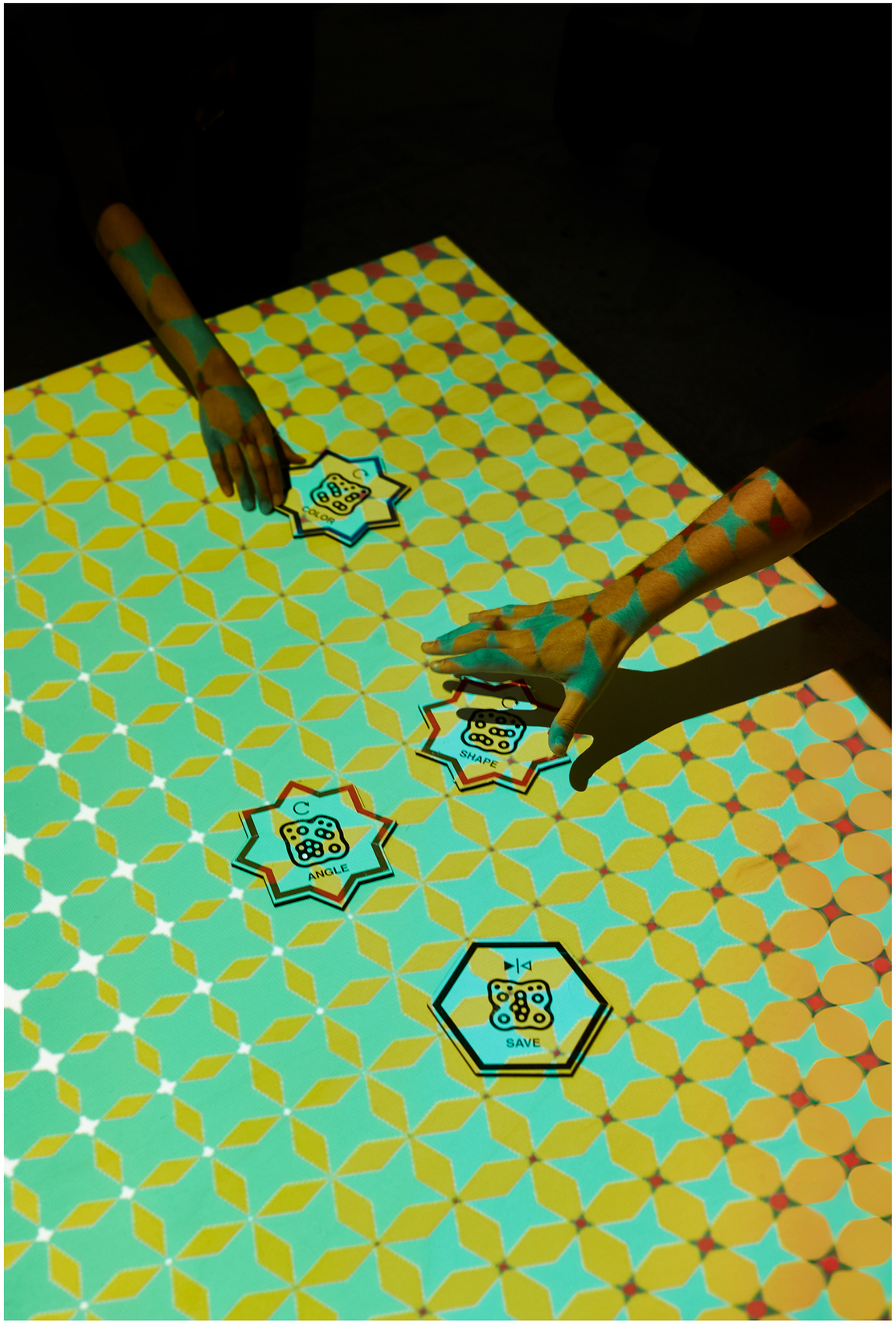
48 Lauren McCarthy, Casey Reas, and Ben Fry, *Getting Started with P5.Js: Making Interactiv Graphics in JavaScript and Processing*, First edition, Make (San Francisco, CA: Maker Media, 2016).

49 Martin Kaltenbrunner and Ross Bencina, 'reacTIVision: A Computer-Vision Framework for Table-Based Tangible Interaction', in *Proceedings of the 1st International Conference on Tangible and Embedded Interaction* (TEI07: Tangible and Embedded Interaction 2007, Baton Rouge Louisiana: ACM, 2007), 69–74, https://doi.org/10.1145/1226969.1226983.

50 Enric Granzotto Llagostera, 'Enricllagostera/P5.Beholder', JavaScript, 14 July 2023, https://github.com/enricllagostera/p5.beholder.

51 Owen Trueblood, 'Jmpinit/P5.Axidraw', JavaScript, 9 January 2024, https://github.com/jmpinit/p5.axidraw.

52 Blair Subbaraman and Nadya Peek, 'P5.Fab: Direct Control of Digital Fabrication Machines from a Creative Coding Environment', in *Proceedings of the 2022 ACM Designing Interactive Systems Conference*, DIS '22 (New York, NY, USA: Association for Computing Machinery, 2022), 1148–61, https://doi.org/10.1145/3532106.3533496.



4. Project Development

4.1. Prototypes and Workshops

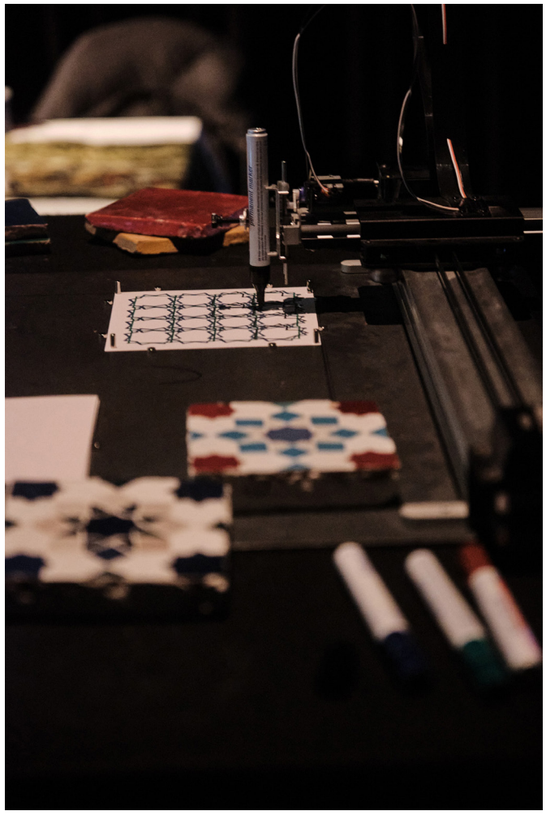
When it comes to prototyping this project, I laid my focus on two main aspects, which were developed in parallel with the intention of combining them at a later stage. On one hand, I experimented with ways of materialising Islamic patterns with digital fabrication technologies available to me like pen plotting and 3D-printing different materials. On the other I prototyped a tangible interface leveraging computer vision to create a tool which would allow the generation of zellij-like patterns. As the project advances, I decided to focus mainly on the latter because of time constraints and programing ability, while keeping the output of the tool open to be further implemented in a fabrication workflow.

3D-Printing Zellij Tiles

After my first trip to Morocco, I initially attempted to replicate what I had seen craftspeople do using digital fabrication I had access to. This resulted in a series of 3D-printed artefacts based on the iconic traditional zellij pattern I had an opportunity to learn to fabricate under the guidance of maalem Hassan Amdgar. I modelled the required pieces in Rhinoceros 3D with a bevelled underside, as well as a frame into which they would fit. This model was printed at different scales, first in PLA polymer and then out of clay. Here I realised that trying to create a replica of handmade tesserae was not necessarily relevant, as the precision of the print was not up to my expectations, and I am not interested in trying to replace the craftspeople's work through automation. Nonetheless, I saw that the negative frame could have more potential as a mashrabiya type of scaffold, into which handmade pieces could potentially be inserted. At this point, I imagined this could lead to a system of 3D-printed modular bricks bringing the complexity of zellij patterns into volume which could act as a translucent wall or facade system akin to Erwin Hauer's Continua sculptures[53].

During my second trip to Morocco, I brought my clay 3D-printer with me and made further attempts to print this pattern on location using local clay provided to me by the owner of the Ben Jelliq workshop. Furthermore, I modified the frame to incorporate geometric modifications such as rotation in the Z-axis such as rotation, scaling and different heights. Working on location proved rather difficult,

53 Erwin Hauer and John T. Hill, *Erwin Hauer - Continua: Architectural Screens and Walls*, ed. Clare Jacobson, 1. paperback ed (New York, NY: Princeton Architectural Press, 2004).



as achieving the right consistency of clay – which is always a tedious part of clay 3D-printing – was hindered by the lack of infrastructure, even after retreating to my hotel room. Additional difficulties were posed by the clay I had acquired not being free of impurities, which resulted in improper extrusion and a lot of air bubbles making longer prints impossible. This led to results which were neither clean nor precise. This fact, as well as the considerable amount of time required for prints to be achieved, made communicating the opportunities represented by this approach to the craftsmen difficult.

The lack of convincing outcomes resulted in my defensively trying to convince them and their disregarding this technology as something they "could do much better and faster by hand". Nonetheless, they saw the potential of applying handmade pieces into the scaffold, but my goal of using these prints as a basis to kickstart a discussion about other potential implementations of clay 3D-printing technology into their workflow was unsuccessful, as they reacted by telling me I should "tell them what I want to do with it and they'll do it". One additional insight which surprised me personally, was that Mr. Kandri was not necessarily opposed to innovation in terms of the production aspects of their craft: he told me that "if the machine can do it as precisely and as fast as us, we'll use it". However, in terms of the patterns themselves, he was much more rigid: "the shapes have to be at fixed angles, if not, it is not zellij."

Back in Zurich, I continued attempting to print patterns I designed using the tool I was developing in parallel at a bigger scale, but I soon realised I would need to develop my own slicing system and generate custom g-code rather than use an already available slicer to be able to obtain satisfying results. As this proved to be beyond my current capabilities and time constraints, I abandoned this line of inquiry.

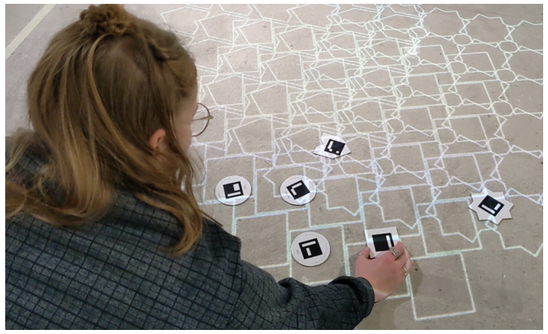
Pattern Generation and Plotting Tool

In parallel to the experiments in 3D-printing described above, I started developing a system to generate zellij-like patterns digitally. My approach was largely based off of Jawhar Kodadi's Zellij Evo project[54] and I chose to focus on creating a tangible alternative to his browser-based input interface which should give users an experience closer to that of a maalem composing a zellij pattern, and adding direct control of a digital fabrication machine.

I began by replicating Zellij Evo's basic functions of rendering vectorised primitive shape outlines in a grid which could be modulated by parameters

54 Kodadi, 'Exploration de l'art génératif et du zellige marocain'.

of their type, size, and rotation angle in the p5.js framework[55]. Then I implemented the p5.beholder library[56] to be able to control these parameters using computer vision by mapping them to the presence, position and rotational angle of ArUco fiducials detected by a webcam. This would enable the pattern to be Finally, I applied the p5.axidraw library[57] to be able to plot the generated patterns directly from this interface.



This first iteration was presented in January 2024 on the occasion of the Good Enough prototype exhibition at ZHdK. In this instance, one of three 3d-printed PLA shapes marked with ArUco fiducials in the form of tiles commonly found in zellij patterns could be chosen and placed under a camera pointing down at the table the prototype was placed on. When a "Draw" button was pressed, the system would recognise which shape was chosen and its orientation, and start the connected axidraw pen plotter into which visitors could install a pen colour of their choice. To maintain the drawing time short enough, the pattern was limited to a 4 by 4 grid. After around five minutes, visitors could retrieve the drawn 21 by 21 cm card which they could keep as a memento.

Through this first user testing opportunity, I realised that live feedback was necessary to give people enough information to make effective design decisions and have a better understanding of the outcome. The choosing of a shape also proved to be confusing, as users expected to be able to assemble the different shapes together to compose the pattern. Finally, the waiting time was too long for most visitors without being mitigated by an expectation of the eventual output.

During my second trip to Morocco, I brought this iteration of the pattern generation tool with me, but sadly couldn't test it with craftspeople because the axidraw's control board was damaged in transit. However, they reacted positively to the concept, expressing they would welcome the ability to create new patterns and test them visually. Therefore, this seemed like a better avenue to pursue in view of further collaboration.

Pattern Generation and Live Visualisation Tool

Decisive Pivot

To implement the insights gathered in the first round of user testing, I decided to pivot from using the

55 McCarthy, Reas, and Fry, *Getting Started with P5.Js*.
56 Llagostera, 'Enricllagostera/P5.Beholder'.
57 Trueblood, 'Jmpinit/P5.Axidraw'.

pen plotter as an output to a projected visualisation. This was achieved by mounting a laser projector under a sheet of acrylic glass setup on two trestle supports and onto which a white cloth was draped. This setup, which I presented at our March 2024 colloquium, provided a projection surface which was unobstructed by manipulation of the fiducial markers. This proved more effective to enable users to understand the consequences of their actions, but the scale of the pattern was still limited by the height and size of the table constraining the projection distance and surface.

To mitigate this issue, I opted to reverse the setup and place the projector above the projection surface. Additionally, in an effort to make the experience closer to the way in which maalemin work traditionally, I decided to project the visualisation and interact with the interface directly on the floor. I also added the functionality of recognising multiple markers at the same time into the system to give the ability to compose multiple shapes into a more complex pattern. This proved to result in patterns which were too chaotic and strived too far from the rules of tradition, but it paved the way to using multiple markers as input parameters.

In a next step, because the outlined shapes' visual aspect was too flat and did not render the colourful aspects of traditional patterns, I filled the projected shapes with colour and added a blending mode which would render different colours depending on the number of overlapping layers of the shapes. This gave enough visual appeal to the projection to simulate the aspect of zellij tiles adequately. I also pivoted towards using different markers, assigning each of them to a different parameter of the pattern. These include angle, scale, spacing, shape type (an array of primitive polygons and shapes present in common zellij tiles), grid type (square or hexagonal), primary and secondary colours, colour scheme (chequered pattern and alternating rows) and swapping the primary and secondary colours, with certain parameter being mapped to the rotation angle of the markers, and others to the presence or absence of them (these being placed on opposite sides so that the marker need to be flipped). This increase in option complexity led me to add labels on each marker describing its function in one or two words.

At this point, I recognised that the projection overlapping with the fiducial markers themselves interfered too much with the computer vision algorithm's ability to detect them. The resulting visualisation was twitchy and rather unpleasant. This led me to switch the framework I was using to Processing[58] in conjunction with reacTIVision[59]. This proved to work much better, provided that the lighting conditions were adequate. To mitigate this problem, I also implemented a spotlight function, which would project a white circle on top of the marker, but this worked only moderately well depending on the calibration of the system. I also added a saving function to be able to export the generated patterns as fully coloured raster images as well as vector files useful for further fabrication purposes.

Workshops

This is when I realised that I needed to test this iteration of the prototype with my collaboration partners, and therefore had to go back to Morocco for a third time. I contacted Prof. Dr. Radoine who graciously accepted that I could organise a workshop with architecture students from UM6P. To prepare for this, I conducted a first workshop in Zurich with students from ZHdK in May 2024. The structure of the workshop was as follows:

- Introduction: overview of Islamic Art and Zellij, introduction to Parametric Design, arguments for Digital Craft.

- Group Discussion: Engage with initial thoughts on digital craftsmanship and parametric design applications in traditional crafts.

- Design Tasks in parallel:
    - Generating Patterns: hands-on session either solo or in groups to generate Zellij patterns using the developed tool.
    - Imagining Applications: participants brainstorm and sketch potential applications of generated patterns in various scales and contexts, discussion of design and architectural implications, iIdeation of quick prototyping approach.

- Group Sharing: participants share their designs and conceptual ideas with the group for critique and further refinement.

- Feedback Session: collection of feedback on the workshop experience, the utility of the tool, and additional resources needed for further exploration in digital craft.

This led to a series of valuable insights, most notably that people invariably put their hands on top of the fiducial markers, thus obstructing them from view of the ceiling mounted camera. Beyond this, the difference between markers that need to be rotated or flipped was unclear.

Before travelling to Morocco again, I decided to additionally implement the attractor function, which would be the only marker of which the position also has an effect. If it is present, this marker would influence the size of each individual shape based on its distance to the marker's position. This would enable patterns to become truly parametric and exhibit a gradient of varying intensity.

When I travelled to Morocco from May 13 to 21, 2024, I first showcased the prototype to Rashid Taj, who recognised and appreciated the explorative and dialogical nature of the interaction. I then went to Ben Guerir, where the difficulties of installing the system without having the possibility of easily mounting the equipment to the ceiling led to a new variation on the setup: we mounted both camera and projector to a large tripod, and the setup became mobile! I also created a new set of markers, this time attempting to use shape and colour to differentiate between the different functions and modes of interaction. Additionally, this further iteration of the markers saw the introduction of icons to distinguish between flipping and rotating, the attractor being the only option to include both.

The next day, a second iteration of the workshop I had test in Zurich took place, with an added step taking place before the group sharing to take advantage of the Design Fabrication Lab's infrastructure:

- Materialisation: practical application using CNC machines (laser cutting, 3D printing, CNC milling) to materialise designed patterns and imagined applications.

This time, a class of about fifteen third year Moroccan architecture students, as well as their teacher Fréféric Bekas whose session was put at my disposal. Time proved to be too short for the materialisation aspect, as a second session would have been required, but all groups produced patterns and visualisations of their ideas of implementation.

The insights gathered during this workshop were that while they appreciated the setup, the student required more information as to the options available to them when designing the pattern. The shape of the markers also proved to be confusing, as they were too similar to the shapes present in the patterns. They also would have needed more concrete examples of the deliverables I expected from them, rather than the total freedom I gave them. Finally, the obstruction of the markers still proved to be a problem for most, even with repeated instruction.

After this, I travelled to Fes again to present the prototype to my cooperation partners in the zellij manufacturing industry. They were interested in this

58 Reas and Fry, *Processing*.
59 Kaltenbrunner and Bencina, 'reacTIVision'.

approach, and felt that such a system could have potential to discuss options with clients in a showroom, or on the location of installation. The system also sparked the discussion I was hoping for about what innovation might be achieved within the rules of tradition. When I showcased the parametric attractor functionality to them, they were surprisingly open to this variation on traditional patterns. However they were still adamant that shapes had to be aligned and following 45 or 90° angles for the patterns to be considered Moroccan and not foreign. This was not truly achievable in that iteration of the system, because of precision issues and a complete freedom of rotation.

With the final presentation in mind, I had previously sent a few patterns generated using the tool to Samir Bouslham and commissioned him and his colleagues to manufacture them by hand. Two of these patterns were more or less traditional, while the third was parametric, meaning that every tessera was of a different size and shape. This proved much more difficult and time consuming, and therefore costly. He explained to me that to manufacture this particular pattern, he had had to print it out and cut individual stencils for each piece. He then sequentially cut each tile and immediately placed them in their place within the pattern rather than cut all of them at the same time following the same stencil like he usually would. I then learned that this is something he already did for custom orders which do not follow traditional patterns such as signage and figurative imagery. I was surprised, because this type of work had until then been in my blind spot, but this discussion led to new insights into how the digital system might support traditional manufacturing.

Final Prototype

Once I came back to Zurich, I tackled the implementation of the insights from this last trip in preparation for the diploma exhibition and final presentation.

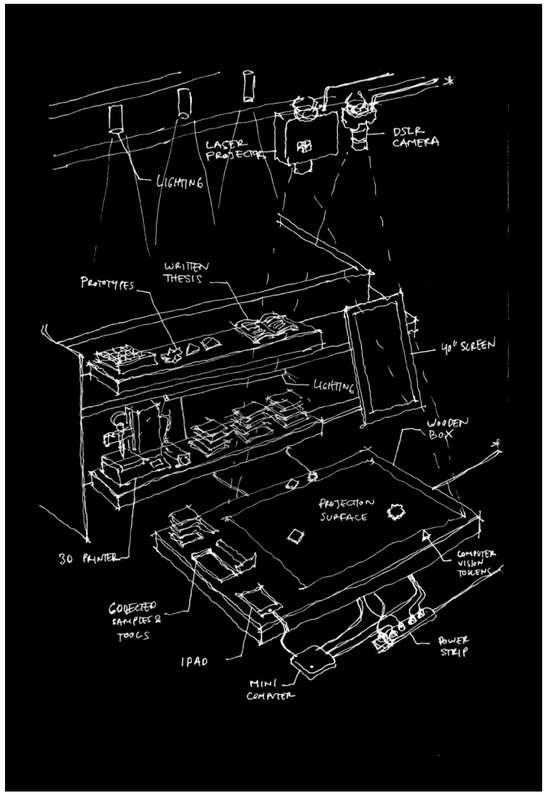
First of all, I implemented a reset function to be able to return the system to a more neutral state from which to gradually increase complexity, which was something I had to do manually between groups during the workshops. This function would be tied to a marker's flip state, as well as happen automatically after a set period of inactivity of the interface.

Then, I tackled the overall simplification of the markers to render their use more comprehensible. To this end, I simplified the markers to all have both the ability to be flipped and rotated: in case both actions don't apply to the controlled parameter, both sides of the marker have the same effect when no mode switching is needed, and the rotation has no impact if the marker only acts as a toggle. Additionally, I changed the shape of the markers to be uniform, and decided to use uncut tiles with printed stickers applied to them to further enhance the connection to the traditional working method by the introduction of materiality. At this point, the only differentiation in terms of colour of the label would be for the save and reset functions, which are the only two that do not directly affect the pattern but are necessary at the beginning and end of a session.

Furthermore, I changed the behaviour of rotation based markers so that the rotation would be calculated incrementally rather than the absolute angle being mapped to the associated value ranges to prevent confusing behaviour when the values rolled over. Additionally, I fixed the ability to rotate the shapes to 15° increments which still gave a lot of design freedom while providing the ability to be more precise.

The final functionality I added to the system is that of a second screen showing a visualisation of the pattern that was generated integrated into an architectural space. While at first, I attempted to have this react in real time to modifications to the pattern, this proved too taxing to the system. Therefore, I implemented it so that it would update when a new pattern was saved, and thus create a collection of patterns, which I made accessible for download by automatic upload to a cloud service.

4.2. Exhibition Setup



The concept for my exhibition setup is to showcase the whole research process, as well as create a frame for visitors to be able to immerse themselves into the zellij pattern design process and transport them into a maalem's workshop. Visitors are invited to generate their own zellij pattern and add it to a collection available for download while discovering the traditional and hybrid manufacturing processes.

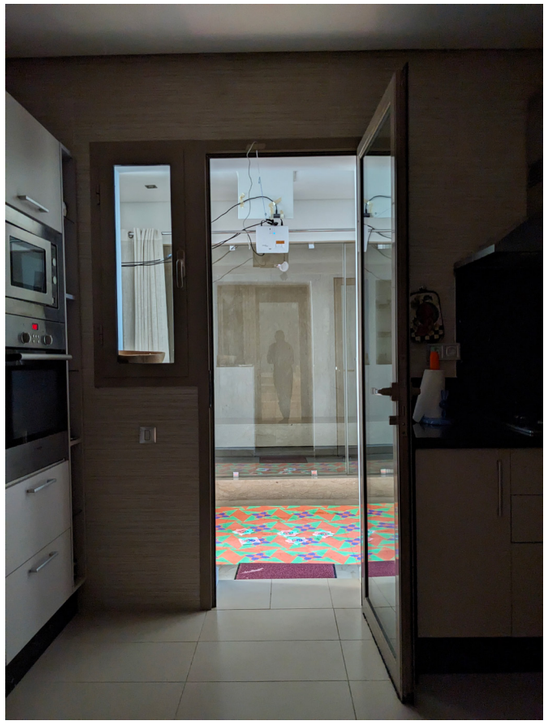
The spatial arrangement is inspired by a photo I took at Abdul Ali Kandri's workshop in Fes during my first trip to Morocco. It aims to replicate the combination of the large surface of the pattern in progress on the concrete floor and the collection of materials and completed panels leaned against the patinated wall. To achieve this, I built a wooden platform to demarcate the projection area slightly and avoid visitors stepping into it, as well as two shelves connected by backing walls which integrate into the exhibition space's architecture. The wood was left untreated and screws were kept visible to transmit the atmosphere of a workshop, and additional screws were used as feet to mitigate the concrete floor's slope.

The projection surface is dimensioned to be as big as possible within the constraints of the exhibition space. Above it, a laser projector is mounted to the ceiling on the interior side of the exhibit to minimise interference caused by people standing around. Additionally, the camera is affixed to an adjustable arm which places it squarely centred above the projection surface at the right height to maximise the camera's coverage of the surface. A second camera is also positioned on this arm to enable documentation of the visitors' interaction with the system. All around the platform, a call to action as well as instructions as to how to use the tool are pasted to the floor to facilitate engagement.

The shelves, which are placed at the backside of the projection surface while leaving a channel for circulation in between, take the form of two identically sized bleachers. On them, an array of objects and documents gathered and produced throughout the research process are displayed leaning against or pinned to the back walls. These include, in no particular order, reference books, tiles from various parts of the manufacturing process, 3D-prints and plots, sketches, digital fabrication machines, this thesis, a manqach, photocopies and the commissioned zellij panels. Furthermore, two screens are installed on the shelves: one TV leaned vertically against the wall showing a looping video cut from a selection of the footage gathered throughout the research process and one computer screen showcasing the collection of generated patterns put into context in a visualisation of an outdoor pool setting. The lower shelf also serves as a location to hide and store the technical equipment required to run the system. Finally descriptions of the individual objects

are scribbled onto the wood to further enhance the rough work in progress aesthetic.

4.3. Outcomes



The outcome of this project is a digital tool which enables the generation of zellij-like patterns in a hands-on explorative fashion inspired by the way zellij patterns are traditionally composed.

At the core of the system lies a tangible interface leveraging computer vision to track the presence, position and rotation of fiducial markers materialised by zellij tiles. These control parameters of the pattern, which is composed by superposition of primitive polygonal shapes arranged in a two dimensional grid. The parameters include, among other variables, the type, spacing, scale and colours of the shapes. Most importantly, it enables innovation in pattern design by implementing a parametric aspect.

This input method is coupled with a real-time at scale visualisation of the pattern projected onto the floor, as well as an in situ visualisation in an architectural space, which in conjunction enable adequate picturing of the manufactured results. After conception, the tool allows users to save the generated patterns in digital formats which can be further implemented into hybrid fabrication workflows.

In an exhibition context, this tool can serve as an engaging introduction to the topic of zellij pattern design to an unfamiliar audience. In a commercial context, it may serve as a communication tool between designers, craftspeople and clients to accurately discuss potential outcomes. In a wider Moroccan cultural context, it should serve as a basis for discussion about the future of the centuries-old craft that is zellij mosaic.

5. Conclusion

5.1. Contributions to the Field

The main contributions to the field of zellij pattern design brought by this project are as follows:

- Visualisation - The tool enables the real-time visualisation of zellij-like patterns on any surface by projection, at a true scale, thus enabling adequate understanding and communication of intended outcomes.

- Digital - the tool produces patterns in a digital format ready for implementation into CAD and Digital Fabrication as well as hybrid workflows.

- Tangible: the method of interaction, which is inspired by traditional manufacturing methods, enables a hands-on explorative introduction to traditional craft practices.

- Parametric: the inclusion of parametric aspects allows for innovation in the design of zellij patterns worthy of their intrinsic complexity.

5.2. Future Steps

I see many avenues along which this project could continue to be developed. Some of them include:

- Plans and stencils for traditional fabrication: the system has the potential to support craftspeople in the traditional manufacturing of more complex patterns. Plans could be generated automatically, naming each piece in the process and digitally printed and cut into auto-adhesive stencils. This would enable maalemin to streamline the production of parametric or non-repeating patterns by avoiding the tedious step of constant back-and-forth between cutting and composing of the panels.

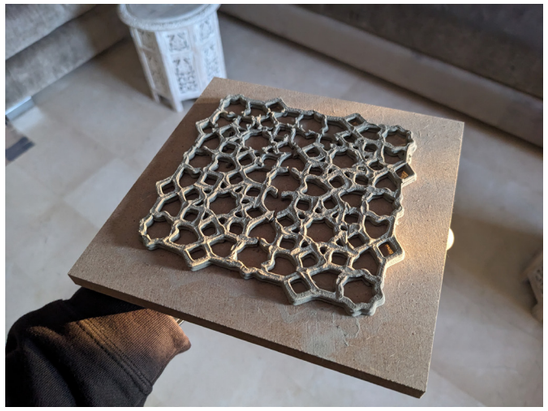
- Mobile setup with flexible projection mapping: hardware could be developed to integrate the projection aspect into a more flexible mobile setup which would enable visualisation of the pattern in situ at the installation site and facilitate communication between stakeholders.

- Integrated digital fabrication: the system could be expanded to include direct control of digital fabrication machines, thus creating a complete production workflow from design to manufacturing.

- Parametric connection to dataset: the parametric aspect of pattern generation could be linked to any number of dataset, such as sun illumination or frequency of foot traffic, thus potentially giving the pattern a functional aspect beyond purely aesthetic considerations.

- Bring zellij into the third dimension: the digital format of the pattern generation presents an opportunity to push the boundaries of zellij pattern beyond the limitations of the plane in conjunction with digital fabrication workflows.

- Potential as animated image: as a digital visualisation, the generated patterns could be animated and become reactive to external outputs.



Bibliography

‘Aït Manos Tile Configurator’. Accessed 4 February 2024. https://configurator.ait-manos.com/.

Bickel, Bernd, Paolo Cignoni, Luigi Malomo, and Nico Pietroni. ‘State of the Art on Stylized Fabrication’. Computer Graphics Forum 37, no. 6 (September 2018): 325–42. https://doi.org/10.1111/cgf.13327.

Bloom, Jonathan Max, and Sheila Blair. The Grove Encyclopedia of Islamic Art and Architecture. Oxford: Oxford university press, 2009.

Castera, Jean-Marc. ‘Persian Variations’. Nexus Network Journal 18, no. 1 (1 April 2016): 223–74. https://doi.org/10.1007/s00004-015-0281-5.

Davis, Stanley M. Future Perfect. México: Addison-Wesley, 1992.

Ettinghausen, Richard, Oleg Grabar, and Marilyn Jenkins-Madina. Islamic Art and Architecture 650 - 1250. 2. ed. Yale University Press Pelican History of Art. New Haven, Conn.: Yale Univ. Press, 2001.

Frazer, John. ‘Parametric Computation: History and Future’. Architectural Design 86, no. 2 (March 2016): 18–23. https://doi.org/10.1002/ad.2019.

Gramazio, Fabio, Matthias Kohler, and Jan Willmann. The Robotic Touch: How Robots Change Architecture : Gramazio & Kohler Research ETH Zurich 2005-2013. Park Books, 2014. https://www.research-collection.ethz.ch/handle/20.500.11850/93821.

Hafez, Ziad. ‘Review: The Islamic Worldview, Islamic Jurisprudence: An American Muslim Perspective, Vol. 1, by Azizah Al Hibri’. Contemporary Arab Affairs 10, no. 3 (1 July 2017): 443–46. https://doi.org/10.1080/17550912.2017.1343929.

Hauer, Erwin, and John T. Hill. Erwin Hauer - Continua: Architectural Screens and Walls. Edited by Clare Jacobson. 1. paperback ed. New York, NY: Princeton Architectural Press, 2004.

Jabi, Wassim. Parametric Design for Architecture. London: Laurence King Publishing, 2013.

Kaltenbrunner, Martin, and Ross Bencina. ‘reacTIVision: A Computer-Vision Framework for Table-Based Tangible Interaction’. In Proceedings of the 1st International Conference on Tangible and Embedded Interaction, 69–74. Baton Rouge Louisiana: ACM, 2007. https://doi.org/10.1145/1226969.1226983.

Knappett, Carl, and Lambros Malafouris, eds. Material Agency: Towards a Non-Anthropocentric Approach. Boston, MA: Springer US, 2008. https://doi.org/10.1007/978-0-387-74711-8.

Kodadi, Jawhar. ‘Exploration de l’art génératif et du zellige marocain: un outil de génération de motifs’. Jawhar Kodadi (blog), 31 March 2023. https://jawharkodadi.com/exploration-de-lart-generatif-et-du-zellige-marocain-un-outil-de-generation-de-motifs/.

Kolarevic, Branko, and José Pinto Duarte. Mass Customization and Design Democratization. Mass Customization and Design Democratization, 2018. https://doi.org/10.4324/9781351117869.

Lambert, Élie. ‘L’architecture musulmane d’Occident [Georges Marçais, L’Architecture musulmane d’Occident. Tunisie, Algérie, Maroc, Espagne et Sicile]’. Journal des Savants 1, no. 1 (1956): 19–34.

Le Maroc andalou: à la découverte d’un art de vivre. Deuxième édition. Aix-en-Provence, France: Edisud, 2010.

Lee, Yi-Chin, and Daniel Cardoso Llach. ‘Hybrid Embroidery: Exploring Interactive Fabrication in Handcrafts’. Leonardo 53, no. 4 (July 2020): 429–33. https://doi.org/10.1162/leon_a_01931.

Llagostera, Enric Granzotto. ‘Enricllagostera/P5.Beholder’. JavaScript, 14 July 2023. https://github.com/enricllagostera/p5.beholder.

Loos, Adolf. ‘1908: Ornament Und Verbrechen’. In Programme Und Manifeste Zur Architektur Des 20. Jahrhunderts, 15–21. DE GRUYTER, 1981. https://doi.org/10.1515/9783035602784.15.

McCarthy, Lauren, Casey Reas, and Ben Fry. Getting Started with P5.Js: Making Interactiv Graphics in JavaScript and Processing. First edition. Make. San Francisco, CA: Maker Media, 2016.

McCullough, Malcolm. Abstracting Craft: The Practiced Digital Hand. Cambridge, Mass: The MIT Press, 1998.

‘Metiers Du Patrimoine Marocain: Mosaïste’. PNMA, n.d.

Pine II B J. ‘Mass Customization: The New Frontier in Business Competition’. Choice Reviews Online 30, no. 09 (May 1993): 30–5097. https://doi.org/10.5860/choice.30-5097.

Reas, Casey, and Ben Fry. Processing: A Programming Handbook for Visual Designers and Artists. Second edition. Cambridge, Massachusetts: The MIT Press, 2014.

Shaw, Wendy M. K. What Is ‘Islamic’ Art? Between Religion and Perception. Cambridge University Press, 2019. https://doi.org/10.1017/9781108622967.

Subbaraman, Blair, and Nadya Peek. ‘P5.Fab: Direct Control of Digital Fabrication Machines from a Creative Coding Environment’. In Proceedings of the 2022 ACM Designing Interactive Systems Conference, 1148–61. DIS ’22. New York, NY, USA: Association for Computing Machinery, 2022. https://doi.org/10.1145/3532106.3533496.

Trueblood, Owen. ‘Jmpinit/P5.Axidraw’. JavaScript, 9 January 2024. https://github.com/jmpinit/p5.axidraw.

Van Stralen, Mateus. ‘Mass Customization: A Critical Perspective on Parametric Design, Digital Fabrication and Design Democratization’. In Blucher Design Proceedings, 142–49. São Carlos, BR: Editora Blucher, 2018. https://doi.org/10.5151/sigradi2018-1770.

Wichmann, Brian, and David Wade. Islamic Design: A Mathematical Approach. Vol. 2. Mathematics and the Built Environment. Cham: Springer International Publishing, 2017. https://doi.org/10.1007/978-3-319-69977-6.

Zoran, Amit. ‘Hybrid Basketry: Interweaving Digital Practice within Contemporary Craft’. In ACM SIGGRAPH 2013 Art Gallery, 324–31. Anaheim California: ACM, 2013. https://doi.org/10.1145/2503649.2503651.

Appendices

A. Interview transcripts

A.1. Abdul Ali Kandri, Samir Bouslham and Rachid Taj

June 24, 2023

Maalem, craftsman and architect, Coopérative Córdoba des Arts du Bâtiment Traditionnel, Fes

Translated from Moroccan arabic

Armin Aschenbrenner:

My question is when you are working, what do you think about? What do you do to make sure your work is clean and complete?

Abdul Ali Kandri:

We work like an architect. This is the plan. We follow the plan. We use the patterns as samples and we draw every single pattern and then we cut it precisely. Every piece has to be drawn. We draw everything like an architect. These drawings are our plan.

Armin Aschenbrenner:

You need to remove all the blanks ?

Abdul Ali Kandri:

Yes, all blanks should be removed. We take the measurements on these blanks.

Samir Bouslham:

This is our big boss, Al Haj, Our maalem who brings us the work. He is well known, not only in Morocco but also abroad.

When he has a client and an order, we work day and night to complete the work according to the time indicated by him.

We started learning as kids. It's like going to school. We start by watching and helping. Then we started learning how to draw, then we would sit in a place like to work until we got used to the work. It takes many years. You cannot learn in one day… It took us many years and we were tired by just doing errands and helping…

Armin Aschenbrenner:

Ya! You cannot learn in one day!

Samir Bouslham:

These are broken but we are not going to throw them away. We might need them to do some finishing work. This one is called Al Khatem, this one Al Arja. I will show you. It can be put like this. This one is red, we can use it. This one is blue. This one is called Mahdouda. It is also in white. This is how we put them together. This one is small, this one is big. Al Farrach is the architect. He puts the different pieces of the pattern together. Al Farrach usually has a big plane surface to work on.

The marble is all around and each colour has its own place.

Can you see how we place them?

Armin Aschenbrenner:

Yes.

Samir Bouslham:

Al Hajj, just leave him with us. We are going to teach him until he learns but El Eid is coming soon. If not we would have kept him with us…

Armin Aschenbrenner:

I will come. I will come back.

Samir Bouslham:

Marhaba!

Abdul Ali Kandri:

He wants to make something important.

Samir Bouslham:

You draw, then learn colouring then you start making Dirhams….. A child cannot learn. He cannot sit like this. It is forbidden for us to employ children. It is difficult to sit like this for ten hours or more.. We sit like this the whole day. It is not easy…

Go, go and have a look!

Armin Aschenbrenner:

Can you show me how to draw? How do you do it?

Samir Bouslham:

They write about it. There are books on this.

You need to hold Laklem like this. It is different from holding a normal pen!

Armin Aschenbrenner:

Ok, thank you

Rachid Taj:

Hey the artist, come here!

Armin Aschenbrenner:

I am coming…

Rachid Taj:

You should tell it to him in Darija!

Armin Aschenbrenner:

What kind of paint is this?

Samir Bouslham:

It is a kind of white paint. This one is a white one. This one is blue…

If it is white, we would use blue. If it is yellow or black we would use white. According to the background we would use the right colour so that we can see the drawing.

Samir Bouslham:

Go and see the work of this colleague Chrif. Take a picture.

Armin Aschenbrenner:

Can I take this one? One which you have not finished yet.

Samir Bouslham,

One which already has a drawing? Here it is. This one has the contouring..

Armin Aschenbrenner:

Yes, thank you. With this I can see and understand the process.

Samir Bouslham:

He wants to have a look.

This is Al Khatem. Al Khatem has different colours..

Take this one. It is Mahdoud..

Armin Aschenbrenner:

Thank you.

Abdul Ali Kandri:

Salam alai Koum!

Armin Aschenbrenner:

I am looking at everything..

Abdul Ali Kandri:

That's good.

Armin Aschenbrenner:

For colours, how do you make them or do you buy them?

Abdul Ali Kandri:

We can make any colours we want. We want blue, for example, we make blue.

Armin Aschenbrenner:

Do you buy them?

Abdul Ali Kandri:

We buy them from France. Some we make traditionally. We use stones, herbs and… mix them together and we can make the colour we want.

Armin Aschenbrenner:

Before you bake it, it has a different colour. Does the colour change when you bake the clay? Or does it change a little bit?

Abdul Ali Kandri:

It has a natural colour, like this one.

Armin Aschenbrenner:

No, I mean for example the glaze, you make it? It has one colour but when you bake it, it becomes a different colour.

Abdul Ali Kandri:

No, the colour you make stays the same when you bake it. We try different little pieces with their glaze like this and put them in the oven to see the result. We take the measurement obtained. Say for this one it is half a kilo for 100 litres of water. This one 2 kilos… ect… We make small pieces like this and put them in the oven. We compare the colours obtained and choose one. Then we make what we call «Lahbess», as big as this one. To produce say 10'000 or 100'000 pieces, you need a big mixture of glaze. If the amount of glaze mixture is finished, you need to make another trial to make sure it has the right and same colour. You compare the colour obtained with the first one.

Armin Aschenbrenner:

Is there something you like the most in the process of your work?

Abdul Ali Kandri:

I know the whole process for the fabrication of zellij. I learnt the entire craft profession from childhood starting when I was 8 years old. I learnt from the start, from tracing, drawing, sketching to cutting and assembling in houses of clients then I was able to take the work made in the factory to assemble and decorate at clients'.

Armin Aschenbrenner:

Is there a specific aspect you like the most in the fabrication process?

Abdul Ali Kandri:

It depends on the work at hand. I follow the work I have but for me it is all straight forward.

Armin Aschenbrenner:

What is really difficult?

Abdul Ali Kandri:

Look here is a zellij. The most difficult craft profession in the entire gamut of artisanal work is the making of zellij.

Armin Aschenbrenner:

From start to finish!

Abdul Ali Kandri:

You start with clay, knead it, put it in the oven, take it out of the oven, and give it the desired colour. Then you take it to the "rachaam" to make the drawings, then the cutting. Then as you have seen Samir doing, you assemble together the pattern. Then we glue together with powder and cement and cut in pieces of 30, 40, 60 cm which can be sold and shipped to different cities like Casablanca, Rabat, Marrakech and elsewhere..

Armin Aschenbrenner:

If someone wishes to make zellij. What should they need to know? How long does it take?

Abdul Ali Kandri:

You need to start from zero, if you want to learn.

I learnt the profession step by step: from sketching, drawing to making, cutting and assembling.

It takes about three years.

It depends on your abilities. If you're quick and talented, it may take you one or two years..

In my case, I spent the first year just helping others and carrying things etc... The second year I started to draw and the third year I started learning how to cut all kinds of forms and shapes of things made by the Creator. Then you start to assemble like what Samir does, with cement, different patterns. Then we take the zellij everywhere to decorate interiors in Morocco and different places including foreign countries. We ship from the factory to Switzerland, Holland, Italy, the Gulf…

Armin Aschenbrenner:

Is this also zellij?

Abdul Ali Kandri:

Yes, but special for minarets.

Armin Aschenbrenner:

How do you make it?

Abdul Ali Kandri:

When a minaret is being built, these are used..

Armin Aschenbrenner:

What are we going to do now?

Abdul Ali Kandri:

We are going to eat.

Do you eat fish?

Armin Aschenbrenner:

Yes.

Abdul Ali Kandri:

We made a mosque of 600 to 700 metres but the Iranians made only one verse of the quran, koul wal Allaho Ahad, on the ceiling of the mosque. We finished our work but they didn't finish theirs as we left. They also have a certain style of work they don't do outside of the country…

Rachid Taj:

You remember those days when Algeria made some problems…

Abdul Ali Kandri:

No, it is simply that Algeria tries to compete with Morocco in the fabrication of zellij but it is not their craft profession. The main problem is the « Snaiiya » ou makers, who only want to make

money on a daily basis.They produce to sell and sometimes barely manage to earn enough to make ends meet at the end of the month. But the maalemin work and make good money..

Armin Aschenbrenner:

What is Snaiiya?

Abdul Ali Kandri:

Snaiiya is a person who makes sculptures, who fabricates something.

Armin Aschenbrenner:

Hum.. ok..

Rachid Taj:

Can you see the weather is getting cooler.

Now people often make a Moroccan style living room facing a European style living-room. It looks beautiful. They mix traditional design with modern design. It looks very nice.

Abdul Ali Kandri:

That's right!

Armin Aschenbrenner:

At home we also have two living-rooms.

Abdul Ali Kandri:

The place we went to see earlier which was closed, the owner made the same mix. He has a living room made, which is both beldi or traditional and a western or european design. Hotels do the same, where tradition is mixed with European inspired styles.

Rachid Taj:

The outcome of the mix is beautiful

There is one villa in Amelkis, where the mix of designs was so beautiful. The person who decorated the house was extraordinary. When you come into the house, the facade looks ordinary, normal but once you go into the house, the designs inside are amazing. So when they ask you to make zellij you need to know what you're doing.

Armin Aschenbrenner:

Yes you really need to know what to do!

Rachid Taj:

The person who made the designs in that house is extraordinary!

Abdul Ali Kandri:

The King gave specific instructions to all Moroccan « sifarate » to be in beldi style, traditional design. Specific instructions..

Armin Aschenbrenner:

What are sifarate:

Rachid Taj:

It is an embassy.

Armin Aschenbrenner:

Well… He is right.

Abdul Ali Kandri:

To be able to know Morocco from other countries

We did all the work in the Moroccan embassy in Algiers with a traditional design.

Rachid Taj:

In the United Arab Emirates… to showcase Moroccan culture.

Abdul Ali Kandri:

The Emirates as well as in many other countries.

Rachid Taj:

Hotel Al Mansour Eddahbi, have you been there ?

Armin Aschenbrenner:

No…

Rachid Taj:

There is a video of the Al Mansour Eddahbi..

Armin Aschenbrenner:

I can go and visit.

Abdul Ali Kandri:

You need to visit the Al Mansour Eddahbi hotel as well as the Saadian… Or what is called Saadian Palace or so? It also has some beautiful things..

Rachid Taj:

Al Mansour Eddahbi is like this. You can find some modern designs but It is a mix of traditional old crafts…

Abdul Ali Kandri:

Also the Mamounia… It also has things…

Rachid Taj:

Not really…

Abdul Ali Kandri:

No, I worked there and earned more than 1 billion and 100 million…

Rachid Taj:

There are things to do and see in Marrakech…

Talaa in Fes is the best for traditional crafts, not only for plaster sculpture but also for zellij.

Abdul Ali Kandri:

Nobody masters plaster work like the people in Fes. There are some Snaiiya in Marrakesh as well..

Rachid Taj:

At least for tadelakt, not much work here in Fes.

Abdul Ali Kandri:

No there is work in tadelakt in Fes but I have the impression there is less of nowadays

Rachid Taj:

Not so well..

Abdul Ali Kandri:

No, only if it is not well prepared, if it is not well done, it can start cracking. Some do not know how to make it. You need a good base coating without any holes and a very thin cover of tadelakt of 1 or 2 millimetres to avoid any possible cracks. If it is half a centimetre or more, it starts cracking..

Rachid Taj:

But that is its charm. I have never seen any tadelakt without cracks!

Abdul Ali Kandri:

No, there shouldn't be any cracks.. If the coating is well made, there shouldn't be any cracks.

Rachid Taj:

I have never seen any, in any place, without cracks..

Abdul Ali Kandri:

No it shouldn't have any cracks.

Listen, those people are commissioned to do the work at a certain price but they need to earn a certain amount. So they just hurry up to do the work. You should be able to put water on it and it shouldn't absorb any. For example in a room, or in a hammam, that's where it is mostly used. Some hammams in Fez are 700, 800 years old, you can go and see their tadelakt, it can be washed and it looks just like marble.. the coating should be well made, thin and a bit rough but not more than a millimeter of tadelakt on it so that it won't crack..

Rachid Taj:

Exactly like marble..

Abdul Ali Kandri:

There are paints which imitate tadelakt that are shiny.

Silky or sikage!!

Rachid Taj:

It is rubbish. It has a lot of brilliance.

It has a shinier aspect and is cheaper than tadelakt. Today, there are less craftsmen who can do these crafts as customers want to pay less and look for cheaper alternatives.

Abdul Ali Kandri:

People have money but have no taste.

Rachid Taj:

It is called jawhara, I just remembered the name..

Abdul Ali Kandri:

People have no more taste. You find some people when you tell them the price is so much, they will tell you they had offers at half of the price.

Rachid Taj:

They don't care about tradition…

Abdul Ali Kandri:

I used to go to some traditional hammams in Fes coated with tadelakt. When there is some event, they clean the ceilings and tadelakt becomes shinier. If you take a machette and hit it, it is like hitting a stone.

Rachid Taj:

It is harder than cement.

Abdul Ali Kandri:

Harder than cement! Can you see this house, it is all built with lime. We made that thin coating because stones with snow bring the cold inside houses. So we coat it with lime for insulation.

Rachid Taj:

A lot of people are doing this. You use stones and coat it with lime. If it looks brown, you cannot see whether it is earth or cement.

Abdul Ali Kandri:

What?

Rachid Taj:

I said when it is brown.

Abdul Ali Kandri:

The brown one, yes.. also the red one, but many. You also have white…

Rachid Taj:

It can also have some glue. In one place, they told us to take soil, sieve it and add some glue and hay…

Abdul Ali Kandri:

In Saudi Arabia, there was an Emir. I went there with one of the architects brought by Paccard. He went with him all the way to Ryad and he told him this is what I want to do…

What, yes, It is getting cold and it is dark now. We can go inside and eat some snacks or shall we eat here!

Don't worry, we'll go inside..

Rachid Taj:

They did this earlier, before things changed. This is easy now.

Abdul Ali Kandri:

It is not easy actually. The truth is, when Paccard came, the king made a specific requirement and told him if you are going to do things that our artisans cannot do, fine, you are welcome to stay but if not goodbye.

When Pinson came, he would take our patterns, say one which is 30 by 30, he would enlarge it to 1 m by 1 m. Some of the pieces that are 2 cm he would make it bigger and would decorate it. He brought us a plan for building and made it like a cowboy hat. When you look at it from above, it looked like a cowboy hat and from below he made the entrance…

Armin Aschenbrenner:

What is a cowboy ?

Rachid Taj:

It is a cowboy hat..

Armin Aschenbrenner:

Ah! Cowboy!

Waoua! Are these rghaif?

Abdul Ali Kandri:

Yes, it is. This is al harsha, this is butter, this is oil.. Dounia, can you bring us more oil!

A.2. Hassan Amdgar

July 7, 2023

Maalem, Ateliers d'Ailleurs, Marrakech

Translated from Moroccan arabic

Hassan Amdgar:

Are you working or studying?

Armin Aschenbrenner:

I am studying. I am an architect. I am currently working on a project for my studies in the area of digital fabrication, to research how to combine work by hand and work with computers.

Nazha Benabbes Taarji Aschenbrenner:

Armin has already studied architecture. He is now making investigations on how to use computers in artisanal work.

Hassan Amdgar:

This is the ink we are going to use. It is simply water mixed with paint and we use wool.

Here is a wooden pen we use to draw the patterns of the zellij.

Here you have a sample model we use. There are many and they range from 2 to 5 cm.

Now this is how to draw a line on a square piece of zellij to make a square for example. This sample is very easy to start with.

Once you have drawn the lines, we are going to learn how to cut it with a sharp heavy hammer.

First, we need to sharpen the cutting edge of the hammer on a flat stone on which we have poured some water.

Pay attention to how I cut the piece of zellij with the sharp end of the hammer along the lines drawn. You need a steady hand.

Nazha Benabbes Taarji Aschenbrenner:

What kind of paint do you use?

Hassan Amdgar:

I don't know. We only buy it from the drugstore. Before, for example for the black colour, we used to burn wool. We used natural old paints but at present it is all modern newly produced paints.

Nazha Benabbes Taarji Aschenbrenner:

Does it stain your fingers?

Hassan Amdgar:

Not really. All you need to do is wash your hands with water.

The work is still the same traditionally done as always but the colours have changed.

Nazha Benabbes Taarji Aschenbrenner:

Many colours used to be derived from nature: flowers and berries. Safran for yellow and orange, red from beets, berries etc… The old colours were steadfast but now not so much!

Hassan Amdgar:

Not really. Modern colours and paints are also good and don't change over time.

For cutting, you need a light, relaxed but precise steady hand. We start with easy patterns and then try progressively more difficult ones. We go step by step. Patterns in general have both easy characteristics and more difficult ones.

Nazha Benabbes Taarji Aschenbrenner:

How long have you been in the profession?

Hassan Amdgar:

I started as a young boy, the same age as the son of my colleague here. I went to Casablanca.

Are you from Casablanca or Marrakech yourselves?

Nazha Benabbes Taarji Aschenbrenner:

Our family is an old family from Marrakech and we can trace our ancestors some centuries back…

Armin Aschenbrenner:

How much time do you need to learn the profession?

Hassan Amdgar:

You need a minimum of two years.

A.3. Jawhar Kodadi

February 19, 2024

Architect, Rabat

Armin Aschenbrenner:

Ben, est-ce qu'on peut commencer au début ? Qui es-tu et quelle est ta profession, ta relation avec l'artisanat traditionnel marocain ?

Jawhar Kodadi:

Je suis désolé, mais il y a quelque chose qui me manque. Ça, regarde ça, c'est juste une partie. Il y avait une vingtaine de documents comme ça pour l'artisanat. C'est des trucs dans lesquels j'étais, des photos que je prenais des artisans. Donc je m'appelle Jawhar Kodadi. Je suis architecte. J'ai étudié à l'École Nationale d'Architecture de Rabat. Ce qui m'a mené vers le... Tu veux que je passe directement à ce qui m'a mené vers le zellige ?

Armin Aschenbrenner:

Non, non, tout ton parcours est intéressant, je pense.

Jawhar Kodadi:

Mon parcours, il est complètement atypique. J'ai fait des études à l'ENA jusqu'à la cinquième année. À partir de la cinquième année, je me suis arrêté. J'ai arrêté mes études. J'ai ouvert mon agence de communication. J'ai touché un peu à tout: la création de sites, le développement, la communication, production de vidéos, photo, et avec toujours un penchant vers la programmation, les nouvelles technologies et les arts. Pour moi, l'architecture, c'est ce lien qu'il y a entre la technique, la science et les arts. Un architecte doit, par définition, par essence, être ce lien entre l'art, l'imaginaire et la technicité, les sciences, les nouvelles technologies. Historiquement, l'architecture a toujours suivi ou a été le moteur de la naissance de nouvelles technologies, de nouveaux procédés de fabrication, de nouvelles idées, de nouvelles inspirations artistiques, etc. Donc pendant mon aventure hors architecture, je m'étais trop intéressé à la photographie, c'était une passion. Pendant cette aventure, j'ai eu la chance de travailler avec le Ministère de l'Artisanat pour prendre en photo 300 artisans à Fès et à Marrakech. Ça a duré plus d'un an. Et je me suis baladé d'atelier en atelier. J'ai découvert les artisans, leur histoire, le côté humain, le côté humain m'a beaucoup fasciné. Et cette force de l'homme, de l'être humain, de l'artisan marocain, tu la retrouves dans ses créations. Et j'étais fasciné, évidemment, par les motifs, par le zellige. Mis à part les motifs, le savoir-faire, le savoir-faire du zellige, et pour revenir au côté... Mon côté architecte. Pour moi, le zellige, c'est la meilleure démonstration, la meilleure démonstration de force et de savoir-faire de nos ancêtres, pour montrer leur totale maîtrise, des mathématiques, de la géométrie, et de toute cette sensibilité artistique de créer tout un univers. On ne va pas appeler ça décoratif, mais un univers artistique, jalonné par les mathématiques. Si, comme je t'ai dit tout à l'heure, si les artisans, les artistes, les artistes marocains surtout, devant la contrainte religieuse de la représentation de l'homme, de l'être humain, du vivant, ont trouvé un autre langage de l'univers. Au lieu de représenter le vivant, ils ont embrassé la deuxième langue de l'univers qu'est les mathématiques. Et pour moi, c'est une très belle approche. C'est pour ça que je te dis, pour moi, c'est une démonstration de force, c'est "on ne peut pas faire ça, mais on va faire mieux." On va parler le langage de l'univers, on va maîtriser les mathématiques, la géométrie et avec ça, on va créer quelque chose de beau. Notre univers il est beau parce que l'homme il est beau, la femme est belle, la nature est belle parce que ça répond à des règles mathématiques. Ils ont pris ces règles mathématiques de géométrie, de rotation, de translation et ils en ont créé des chefs-d'œuvre. Voilà, c'est pour ça que le zellige m'a fasciné. Et puis, pour revenir un peu à comment je suis arrivé à zellige-EVO, c'est mon côté un peu, on va dire, technophile, on peut dire technophile, passionné de technologie, de nouvelles technologies. Et pour moi, la révolution qu'il y a eu en termes technologiques, c'est bien sûr Internet, mais c'est les technologies de fabrication. C'est la première fois de l'histoire de l'humanité où des procédés de fabrication qui peuvent rivaliser avec les grandes industries, tu peux avoir ça sur ton bureau. Mieux encore, tu peux fabriquer ça tout seul. Tu peux fabriquer ta propre imprimante 3D, ta propre machine laser. C'est à la portée de tout le monde maintenant. Donc je suis passé par l'impression 3D. J'étais fasciné par ça. Puis la découpe laser. Puis le plotter. Et plus je m'enfonçais dans les possibilités et les limites de chacun de ces procédés, plus je m'approchais du zellige, du dessin, plus je m'approchais de ça. On a eu des conversations avec des amis architectes où on parlait pendant des heures du zellige.

Jawhar Kodadi:

Et de la révolution du zellige. Il y avait un article à l'époque d'actualité qui parlait de la révolution du zellige. Et on a parlé de ça et je leur ai dit que ça c'est pas une révolution, c'est une simplification. On ne peut pas parler de révolution tant qu'on n'a pas inventé une nouvelle façon ou intégré de nouveaux paramètres au procédé créatif du zellige. Enlever des paramètres, ce n'est pas une révolution, c'est une simplification. On peut parler de révolution, le jour où, je ne sais pas, je dis n'importe quoi, tu marches dans un couloir et tu as des motifs de zellige qui te suivent. Le centre du zellige suit la personne qui se déplace dans le couloir. Tu as toute une dynamique, tout un truc. On peut intégrer de nouveaux, des systèmes dynamiques, des paramètres dynamiques, que ce soit pour un changement d'échelle ou de rotation par rapport à la distance d'une ligne, d'un attracteur, d'un point. Et on me disait que c'est de la science-fiction, que j'ai trop regardé de films de science-fiction. Mais aujourd'hui, si nos ancêtres avaient eu accès à nos connaissances d'aujourd'hui, que ce soit en termes de mathématiques, de géométrie, de technologie, des langages de programmation, les algorithmes. Parce que le zellige, c'est quoi ? C'est un algorithme géométrique, c'est une approche algorithmique. C'est un algorithme géométrique qui peut, qui est déjà, traduit en langage de programmation, divers langages de programmation, bibliothèques spécialisées, outils qui te permettent de générer des motifs de zellige. Et je ne suis pas le seul à avoir fait ça. Il y a plusieurs chercheurs qui se sont penchés sur la question et qui ont creusé la question. Moi, j'ai eu la chance de maîtriser un peu les bases de la programmation depuis mon plus jeune âge, donc ce n'était pas nouveau pour moi. Ça a coïncidé avec le lancement de ChatGPT qui m'a beaucoup aidé. Ça m'a beaucoup aidé pour apprendre p5.js. C'est la librairie que j'ai utilisée pour ma petite web app de création de zellige. La version 2 était simple, la version 3 intègre un système dynamique. En gros, c'est ça. C'est ce qui m'a mené vers la création de nouvelles formes, d'explorer de nouvelles méthodes, de nouvelles approches, d'explorer de nouvelles façons de repenser le processus créatif du zellige.

Armin Aschenbrenner:

J'aimerais approfondir sur quelque chose sur quoi tu as touché: c'est la relation, la possible relation entre le zellige ou en général les artisanats traditionnels marocains et la fabrication numérique. Tu parlais du zellige comme un algorithme. Quelles relations tu vois entre l'artisanat traditionnel marocain et les outils digitaux et la fabrication numérique ?

Jawhar Kodadi:

Pour revenir, on va avoir une petite approche historique. Le zellige a toujours été dessiné avec un crayon, un compas, une règle. Et le maître Zelligier, celui qui créait les motifs de zellige, malheureusement il y en a de moins en moins aujourd'hui, ça a disparu maintenant, on est sur de la reproduction de motifs qui existait depuis des centaines d'années. Donc le processus de création en commençant par un point jusqu'à une composition artistique de zellige, de passer d'un hexagone vers un carré, vers un triangle, puis de faire des rotations. Le passage d'une étape à une autre, c'est un algorithme. C'est un algorithme géométrique. Et l'intégrer, comment est-ce que ça peut être intégré aujourd'hui ? Ça peut être intégré aujourd'hui par la création d'outils, par la création d'applications de génération de formes de zellige. Et aujourd'hui, comme dans tous les arts, en quoi la création du zellige est différente de la création architecturale, par exemple? Ça commence par une idée. Puis après, tu as des outils à ta disposition pour arriver à cristalliser ton idée en réel, que ce soit en maquette 3D, que ce soit en dessin. Par exemple, si on prend l'architecture paramétrique: l'architecture paramétrique, les possibilités qu'elle offre aujourd'hui, c'était impossible de faire ça il y a dix ans, une dizaine d'années, c'était impossible de faire ça. Donc le fait d'intégrer de nouveaux outils pour assister le processus de création artistique, c'est inévitable. La technologie, elle est là pour être au service de ce processus créatif. Et le zellige ne peut pas faire... Comment on dit ? J'ai carrément oublié le terme. C'est pas abstraction. L'usage ne peut pas être... C'est quoi le terme déjà ?

Armin Aschenbrenner:

Faire abstraction ?

Jawhar Kodadi:

Non, pas abstraction. Une expression tatata qui confirme la règle. C'est pas l'exclusion. C'est pas l'intrus.

Armin Aschenbrenner:

L'exception.

Jawhar Kodadi:

L'exception. Je me suis complètement perdu. Le zellige ne peux pas faire exception de ça. Tout est là pour évoluer. Je ne dis pas, attention, je ne dis pas que l'héritage, le patrimoine des motifs de zellige qu'on a, je ne le réduis en rien, je dis juste que si nos ancêtres avaient accès aux technologies d'aujourd'hui, ils auraient fait une démonstration de force. Ils nous auraient montré tout ce qu'ils savent faire. Avec tout le savoir d'aujourd'hui, parce que

ce qu'ils ont créé à l'époque, ils l'ont créé avec le savoir contemporain de leur époque. Voilà ce qu'on sait faire en géométrie, voilà ce qu'on sait faire en mathématiques, voilà ce qu'on sait faire, voilà comment est-ce qu'on peut couper une pièce, voilà les couleurs qu'on peut créer, voilà ce qu'on peut faire, voilà ce qu'on peut pas faire. Donc avec ça, qu'est-ce qu'on peut créer ? Si aujourd'hui tu viens, tu leur dis, voilà, tu as Grasshopper pour... Pour dessiner, pour créer des motifs dynamiques, tu as des librairies Processing, p5.js, tu peux t'amuser avec ça, tu peux intégrer de la 3D, tu peux faire des illusions d'optique, des sortes de volumes qui sortent, qui descendent, ils vont s'éclater. Ils vont s'éclater, ils vont t'inventer autre chose, ils vont t'inventer un truc que tu vois aujourd'hui, tu diras c'est un truc venu de l'an 3000. C'est... C'est... Pour moi, c'est ça, c'est la technologie. La technologie est là pour accompagner le processus créatif. Aussi simplement que ça, elle est inévitable. Mais il faut faire ça, bien sûr, en gardant l'essence même de ce qui définit le zellige. On doit voir ça et se dire, voilà, ça, c'est du zellige. Ça a évolué, ça a changé. Mais c'est du zellige.

Armin Aschenbrenner:

Tu me racontais tout à l'heure qu'il n'y avait plus de création en matière de motifs aujourd'hui. Tu peux m'expliquer pourquoi ?

Jawhar Kodadi:

Ça, c'est une conversation que j'avais eue pendant mon expérience dans le domaine de l'artisanat, les quelques 600 artisans que j'avais rencontrés. Et un vieux monsieur m'a expliqué l'état de l'artisanat au Maroc: que c'était un savoir-faire transmis de père en fils, que malheureusement, depuis l'époque du Protectorat, cette bourgeoisie Fessi et Marrakchi d'artisans envoyaient leurs fils étudier à l'étranger. Ils se sont intéressés au commerce ou à autre chose de plus lucratif. Et l'artisanat était légué au personnel, aux gens qui travaillaient chez ces grandes familles. Donc ça s'est transformé, ils ont gardé les plans, ça s'est transformé en travail de reproduction pendant plusieurs décennies. Et ce n'est que récemment que les choses ont commencé à changer, maintenant on a des filières spécialisées en artisanat, ce qui est bien. Donc maintenant on a pris du retard, l'artisanat marocain a pris du retard de plusieurs décennies. Ça doit évoluer, on doit repartir vers un processus créatif, pas un processus de reproduction de ce qui a été fait. Il faut apprécier à sa juste valeur notre patrimoine architectural, arabo-musulman, andalou, berbère aussi, sans le sacraliser. Il faut que chaque génération de créateurs puisse apporter sa touche qui se doit d'être représentative de son époque. De son époque par rapport aux connaissances, par rapport aux influences, par rapport aux tendances artistiques, culturelles, sociales, ce que les gens aiment, ce que les gens n'aiment pas, et intégrer ces technologies qui aident dans ce processus créatif. Voilà, j'espère que c'était ça. Je ne me suis pas trop éloigné de la question.

Armin Aschenbrenner:

Non, c'est tout très intéressant ce que tu me racontes. Est-ce qu'on peut continuer? Ou tu as encore du temps? Non, j'ai encore le temps.

Jawhar Kodadi:

Tu me poses tes questions.

Armin Aschenbrenner:

Et du coup, toi, dans ton processus de travail, comment est-ce que tu travailles ? Et quels outils, que ce soit des outils numériques ou des machines, est-ce que tu utilises ?

Jawhar Kodadi:

Moi, dans mon processus de travail maintenant, je suis dans la recherche de concepts. Et puis, c'est peut-être mon plus gros défaut, c'est que je passe la majorité de mon temps à chercher de nouvelles idées, à explorer. Et dans tout travail de recherche et d'exploration, il y a beaucoup d'échecs, il y a beaucoup de choses qui ne marchent pas. Et là, je suis dans... Dans cette recherche toujours, je t'ai montré un peu les dessins, tu peux les prendre en photo si ça peut t'aider dans ta documentation. Pour moi c'est important d'essayer des choses même si quand tu commences tu te dis peut-être que ça ne va pas marcher, mais je reste toujours attaché à ce peut-être que ça va marcher. Même s'il y a 1% de chance, 2% de chance que ça sorte quelque chose d'inattendu, d'imprévu. D'imprévu, c'est... D'ailleurs, beaucoup de mes petits essais, c'était des erreurs, des fois. Des fois, je fais une erreur, je me trompe sur un truc et je me dis, c'est intéressant, c'est intéressant, comment ça s'est sorti ? Et donc, maintenant, je suis dans la phase de recherche, recherche conceptuelle, on va dire. Les outils que j'utilise, j'utilise la librairie p5.js, j'utilise Grasshopper. J'utilise plus Grasshopper parce que j'ai un retour visuel plus rapide. Mais p5.js permet de partager ça sur Internet. Les gens peuvent avoir plus d'interactivité. Plus d'interactivité.

Armin Aschenbrenner:

C'est plus accessible.

Jawhar Kodadi:

C'est plus accessible pour voir un peu le résultat, ce que ça donne, ce qu'on peut en sortir. Les gens peuvent exporter ça en SVG, l'utiliser. Rien que pour ma belle-fille, par exemple, pendant une époque, elle adorait quand je lui imprimais juste les lignes de zellige dynamiques, etc. Elle adorait les coloris. Et c'était quoi l'autre question ?

Armin Aschenbrenner:

Oui, s'il y a d'autres outils numériques ou des machines, des processus de fabrication ?

Jawhar Kodadi:

Un processus de fabrication, tu as vu, je t'ai montré des bougeoirs imprimés en 3D, inspirés de la forme du zellige. La machine laser, je l'utilisais pour découper, pour faire des sortes de panneaux, de panneaux en zellige dynamiques négatifs. C'était intéressant. C'est intéressant ce que ça peut donner en termes de jeu de lumière. C'est intéressant ce que ça peut donner en termes de superposition de couches, comme les trucs que je t'ai montré. Et j'ai aussi le plotter. C'est une machine à dessiner que j'ai fabriqué tout simple avec un stylo. On peut s'amuser à dessiner des tableaux de zellige ou autre chose. On peut dessiner ce qu'on veut, on peut dessiner ce qu'on veut avec. Donc c'est les trois. Un, deux, trois. C'est les trois machines que j'ai. Laser, imprimante 3D et plotter. Et l'ordinateur. Et une feuille. Et un stylo aussi. Et des feutres. Et s'amuser. Et essayer.

Armin Aschenbrenner:

Ce sont toutes des machines CNC, machines contrôlées par ordinateur.

Jawhar Kodadi:

C'est toutes des machines contrôlées par ordinateur. Leurs principes de fonctionnement, c'est pareil, elles fonctionnent toutes de la même façon. Tu as une tête, que ce soit un stylo, une buse ou un laser qui bouge sur XY, sauf pour l'imprimant 3D, c'est XY que Z. Donc le processus de fabrication, Le principe de fonctionnement, il est très simple. Et c'est accessible. C'est accessible. C'est vraiment accessible. J'arrête pas de dire à mes amis, je crois que... Dans mon entourage d'architectes, je crois qu'on est... Moi, je connais deux personnes qui ont une imprimante 3D. Et je trouve que c'est dommage. Une imprimante 3D, ça coûte moins cher qu'une imprimante A3. Vraiment, ça coûte moins cher qu'un téléphone, qu'un écran, ça coûte moins cher qu'un frigidaire. À 250 euros, t'as une imprimante 3D. Celle-là, la Anycubic, elle coûte 250 euros. C'est mon imprimante principale. J'ai fait quelques modifications. Elle est contrôlée par un Orange Pi. C'est un équivalent de Raspberry Pi qui est beaucoup moins cher. Avec ça, avec un petit upgrade de 500 dirhams. C'est devenu une imprimante très robuste, très fiable. Tu peux contrôler à distance avec une caméra. Ça coûte rien pour moi dans un monde idéal. Si les imprimantes 3D étaient là à l'époque d'avant les réseaux sociaux, tu aurais eu ça dans toutes les maisons. Tu aurais eu ça dans toutes les maisons. Le début d'Internet, c'était magnifique. C'était l'époque un peu idéaliste où on échangeait le savoir, les connaissances, les tendances. Maintenant, Internet a pris une toute autre influence. Par exemple, Instagram, je m'étais inscrit sur Instagram au début, c'était pour la photo, pour les artistes, pour les créateurs. Et maintenant, Instagram, tu vas ressentir la même chose, tu ne te sens pas à ta place. Tu envoies un truc, tu te dis « qu'est-ce que… pourquoi j'ai envoyé ça ? ». Tu envoies un truc, tu passes des mois à travailler sur un truc, tu partages, tu as 5 likes. OK. Donc, les imprimantes 3D, pour moi, ça doit être dans chaque maison. Les gens disent « ah c'est difficile ». Mon beau-fils, il a 10 ans, il sait utilisé l'imprimante 3D, et je lui expliquais ça pendant une journée. Je lui expliquais le slicer, comment ça marche, d'où est-ce qu'il peut télécharger, il est passionné de Pokémon, d'où est-ce qu'il peut télécharger les STL des Pokémon, comment les imprimer, est-ce qu'il a besoin de support ou il n'a pas besoin de support. Je lui expliquais ça une fois. Une fois, je suis rentré à la maison, j'ai trouvé une dizaine de Pokémon. Voilà, il m'a dit « voilà, j'ai imprimé tout ça ». J'ai appelé sa mère, je lui ai dit « tu l'as aidé ? ». « Non, il a commencé à imprimer tout seul. »

Jawhar Kodadi:

C'est tellement facile à utiliser pour moi, c'est aussi facile qu'imprimer un A4. Donc ces nouvelles technologies de fabrication chez soi, ça a été démocratisé. Ça coûte pas cher. Ça a besoin d'être beaucoup plus démocratisé. Ça doit faire partie du processus de n'importe quelle filière artistique. Elle a besoin ou bien de la découpe laser, ou bien un plotter, ou bien

une imprimante 3D. Même dans le textile, tu peux imaginer de nouvelles formes de textiles. Du textile imprimé en 3D, tu peux utiliser ça en architecture, en industrie, en design d'objets, en packaging, Avec une machine de découpe laser, tu peux t'amuser à faire en une journée dix prototypes de packaging sur du papier. Tu essaies ça. Alors qu'il y a dix ans, pour faire ces prototypes, bonne chance, tu dois partir chez le fabricant qui te fait un moule de découpe et tu essaies ça et il te découpe. Pour chaque itération, t'en as pour 2 jours, 3 jours et des milliers de Dirhams. Maintenant tu peux faire ça chez toi en une demi-journée, voilà, t'as 10 propositions, t'as 10 idées et tu fais des itérations. Tu modifies, c'est surtout ça. En architecture encore plus, parce que ça te permet de visualiser en volume palpable, physique, pas uniquement maquette 3D, images de synthèse. Physiquement, tu as une sensation tactile. Tu vois la lumière, ton bâtiment comment il réagit à la lumière, le rapport des pleins et des vides. Tu peux imprimer ton volume, avec un feutre dessiner dessus, sculpter, imaginer. Donc pour moi c'est important, c'est important d'intégrer ces nouveaux outils, ces nouveaux outils de fabrication. Que ça soit juste dans le prototypage. Bien sûr aujourd'hui tu as plusieurs personnes ou sociétés qui utilisent les imprimants 3D pour une production industrielle. Il faut trouver le bon modèle économique pour ça. Mais moi, ce qui m'intéresse dans ça, c'est surtout le côté prototypage. Faire un élément de façade, le découper au laser, l'imprimer en 3D, voir réellement ce que ça donne, le montrer au client. Ça, pour moi, c'est le plus fascinant. Parce que là, on est passé dans ce processus créatif. d'un monde où on dessinait sur papier ou même sur ordinateur et on devait attendre plusieurs semaines ou plusieurs mois avant de le voir physiquement, concrètement, de pouvoir le toucher. Même au niveau prototypage, même pour la fabrication, je ne sais pas, je vais dire un truc très simple, une souris, le design d'une souris d'ordinateur, passer du dessin au prototype, ça prenait des semaines. Là, maintenant, tu passes du dessin au prototype en une demi-journée. Ça, c'est révolutionnaire à mon sens. Tu sais, ça te permet rapidement de voir, de tester, voir ce que ça donne. Ça marche, ça ne marche pas ? Est-ce que ça fonctionne ? Est-ce que ça peut tenir ? Est-ce que ça ne peut pas tenir ? Est-ce que c'est joli ? Et dans le zellige, pour revenir à la question, dans le zellige, tout est à redécouvrir. Vraiment, tout est à redécouvrir du zellige. Qu'est-ce qui définit le zellige ? Est-ce que c'est la matière ? Est-ce que c'est la matière ou bien c'est le dessin ? Ou bien c'est le processus de fabrication ?

Jawhar Kodadi:

Qu'est-ce qui définit ? Est-ce que c'est l'un des trois ? Ou deux ? C'est trois éléments qui définissent le zellige ? Est-ce qu'on peut parler de zellige si on fabrique ça en béton ?

Armin Aschenbrenner:

Oui.

Jawhar Kodadi:

Est-ce que c'est du zellige ? Est-ce que c'est du zellige si on fait ça en résine ? Est-ce que c'est toujours du zellige ? Pour moi, oui. Pour moi, oui, c'est toujours du zellige. Parce que le zellige, maintenant... Les carreaux que tu vois ici, en Darija marocain, on appelle ça Zelliga. On appelle ça ça, on appelle ça Zelliga. Tu prends ça, tu dessines dessus des motifs de zellige, on va te dire ça, c'est Zelliga. zellige beldi. Oui, il y a zellige beldi, ou c'est imprimé sur un truc. Le grand débat qu'il y a eu l'année dernière ou il y a deux ans, sur le maillot algérien, il y a eu le motif de zellige. On a dit, on parle de zellige alors que c'est imprimé sur un t-shirt. Donc c'est la forme. Est-ce que c'est la forme qui fait que ça soit du zellige ? Et c'est quoi la forme ? Est-ce que c'est le carré ? Est-ce que c'est deux carrés avec rotation de 45 degrés, à partir de là on parle de zellige? Il y a vraiment tout un travail de réflexion à faire et c'est un travail de réflexion qui doit être fait par... Ça doit être pluridisciplinaire, tu dois avoir des historiens, des archéologues, des architectes, des designers, des artisans, des... Des citoyens, c'est un travail qui doit être fait. C'est pour ça que je te dis le zellige, tu peux imprimer des motifs de zellige avec une imprimante 3D, en plastique, en PLA. Du plastique, tu dessines un truc décoratif pour chez toi, des couleurs de plastique différentes, tu fais ça, c'est du zellige. Personne n'a le droit de t'enlever ça, personne n'a le droit de te dire que c'est pas du zellige.

Armin Aschenbrenner:

Tu touches à un point intéressant à mon sens, c'est que dans l'artisanat traditionnel marocain, ces motifs se retrouvent aussi dans d'autres, pas seulement dans la mosaïque, mais dans d'autres artisanats comme le travail du bois, la dinanderie, le plâtre. C'est souvent des motifs similaires qui sont déclinés dans différentes méthodes de fabrication.

Jawhar Kodadi:

Et par rapport aux contraintes de la matière. Par rapport aux contraintes de la matière. Parce que la façon avec laquelle tu vas travailler le bois, ce n'est pas la même façon avec laquelle tu vas travailler le plâtre. Ce n'est pas la même façon avec laquelle tu vas couper tes bouts de gilet. Ce n'est pas la même façon avec laquelle tu vas travailler le cuivre ou l'étain. Donc tout ça, tout ça, ça ne fait que confirmer le point que le zellige, ce n'est pas la matière. Ce n'est pas la matière qui fait que on dit que ça c'est du zellige et ça c'est pas du zellige. Si nos ancêtres se sont offerts la liberté de faire passer le zellige vers le bois, puis vers le plâtre, si à l'époque ils avaient du GRC, ils auraient fait ça en GRC. S'ils avaient de la résine époxy, ils auraient fait ça en résine époxy.

Armin Aschenbrenner:

Ma question c'est est-ce qu'il y a un terme en arabe pour décrire les motifs qui sont déclinés dans les différents matériaux ?

Jawhar Kodadi:

Il y a des termes en arabe mais les termes que tu vas trouver utilisés par les artisans de Fès, ce n'est pas les mêmes motifs, ce n'est pas les mêmes noms donnés par les artisans de Marrakech, par exemple. Tu vas trouver plusieurs documents. Il y a le travail d'une recherche d'une étudiante, je vais essayer de le retrouver, je t'envoie, qui a fait cet exercice de nommer chaque pièce. Chaque pièce a un nom. En Darija, comment ça s'appelle? Mais ces pièces ont un nom parce que dans le zellige, dans le zellige en argile cuit, chaque pièce est unique. Chaque pièce est un objet que tu prends dans ta main. Donc il y a eu le besoin de les nommer. Mais dans le bois, non. C'est des dessins. Donc tu vas retrouver dans le bois des dessins que tu ne trouves pas dans le zellige. Donc le nom, je connais pas les noms, honnêtement. J'avais vu ça, j'avais vu une liste de noms, mais la personne qui va le mieux te répondre, c'est un artisan. C'est un maîtrise zelligier, qui va te dire... Mais tu vas voir qu'il y a une différence. Entre Fès et Marrakech, il y a une différence de nomenclature, on va dire.

Armin Aschenbrenner:

On parlait avant des machines CNC et de la manière dont c'est les mêmes machines, on va seulement changer l'outil qui est bougé, qui est contrôlé dans l'espace. Je vois vraiment une connexion ou une similitude entre d'un côté les motifs qui sont appliquées aux différentes matières et la versatilité des machines CNC à s'adapter aux différents matériaux. Comment est-ce que tu vois l'application de ces différentes technologies de fabrication numérique dans l'artisanat marocain en général, pas seulement au zellige, mais dans toute sa variété?

Jawhar Kodadi:

Tu me reposes la question, j'ai pas bien saisi.

Armin Aschenbrenner:

Alors, comme je disais, il me semble, personnellement, je vois une similitude entre la versatilité des machines CNC, leur capacité à s'adapter aux matériaux en étant contrôlées par le même système et la manière dont ces motifs c'est les motifs de ce que les chercheurs occidentaux ont appelé l'art islamique dans les différents matériaux de l'artisanat, que ce soit le bois, la dinanderie, le métal, le cuir, la mosaïque. Quel potentiel est-ce que tu vois dans cette dans cette application de ces machines à ces motifs.

Jawhar Kodadi:

Donc déjà, ces machines sont là pour remplacer un travail manuel. Elles sont là pour remplacer, par exemple, on va prendre l'exemple du bois, la sculpture sur le bois. Tu as aujourd'hui des machines CNC qui te permettent de faire en une heure ce qu'un artisan ferait en deux jours, trois jours. Donc ces machines représentent un gain de temps. L'artisan, dans cette configuration, doit se concentrer sur le travail créatif de la création, d'imaginer de nouvelles formes, de nouveaux motifs, et d'utiliser cet outil pour lui, pour un gain de temps. C'est vrai que c'est une question très difficile, parce que là on touche un peu à l'éthique de la chose. Est-ce que si on prend une plaque d'argile et on la découpe à la fibre au lieu que l'artisan découpe chaque morceau, à la main. Je ne sais pas, c'est vrai que ça peut enlever un peu le côté magique de la chose, le côté imperfection, la touche humaine. Mais bien sûr, comme pour toute industrie, même pour le textile, il y a une différence entre une industrialisation de l'artisanat, d'un objet d'artisanat et un objet d'artisanat fait à la main. Là, pour parler de ces machines. Évidemment qu'une plaque de zellige faite en CNC avec je ne sais pas quel matériau composite, ou bien un coulage qui peut être fabriqué en masse, bien sûr que ça n'aura pas le même prix qu'un panneau de zellige fabriqué par un artisan à la main. Il y aura toujours des amateurs du travail fait à la main, personnalisé. Ça sera toujours différent. L'avantage qu'il y a du travail manuel des artisans, c'est que c'est du sur-mesure. Et c'est personnel. Et chaque pièce, chaque panneau est unique dans ses imperfections. Alors que dans le côté industriel, tu peux avoir une plus grande quantité, à moindre coût, ce sera plus accessible

pour les gens qui peuvent pas s'offrir un mur en zellige qui coûte 70 000 dirhams, 80 000 dirhams. Tu as des gens qui veulent des panneaux préfabriqués qui vont leur coûter 12 000 dirhams. Donc mais... Ça n'empêche pas, ça ne veut pas dire qu'on doit écarter l'un ou l'autre. Les deux sont là pour répondre à des besoins de marché spécifiques à chacun d'eux. C'est tout. Mais idéalement, les artisans doivent maîtriser les maîtres artisans aujourd'hui. Si tu reviens à Rabat, on ira faire un tour chez les menuisiers par exemple. Tu vas voir, les menuisiers aujourd'hui, ils travaillent avec des ateliers CNC. Ils travaillent avec des ateliers CNC. Voilà, tu me fais ce motif, tu me découpes ce motif, je te découpe ça. Ils gagnent beaucoup de temps, ils font ça. Pour le client, c'est un prix beaucoup moins cher. La CNC, il te dit voilà, c'est 400 dirhams l'heure pour la machine, voilà. On te prend une plaque de, je sais pas... D'hêtre ou zebrano, je ne sais pas quoi, ils découpent ça. Bien sûr, tu as toujours l'artisan qui travaille à la main et ça coûte beaucoup plus cher et tu as des amateurs de ce travail fait à la main. Ils te disent: "Non, moi, je veux quelque chose fait à la main."

Armin Aschenbrenner:

Donc dans le travail du bois, la menuiserie, ces machines se sont déjà imposées ?

Jawhar Kodadi:

Elles se sont déjà imposées aujourd'hui. Elles se sont déjà imposées. On parle des ateliers de menuiserie, que ce soit à Cary ou aux environs de l'Alkhamra, tu peux voir, elles se sont imposées. Et dans d'autres artisanats traditionnels ? Dans la céramique, pas à ma connaissance. Dans la céramique non, ça n'a toujours pas été fait. Tu m'as parlé de l'imprimante que tu as, l'imprimante céramique. Ça, c'est intéressant parce que ça te permet d'essayer de nouvelles choses, d'expérimenter. Ça permet d'essayer de nouvelles choses. Le vase que tu mets deux heures pour imprimer, un artisan le fait en dix minutes. En dix minutes. Ces technologies permettront au grand public d'imprimer leurs propres vases. Ils vont dessiner le vases qu'ils veulent, les formes qu'ils veulent.

Armin Aschenbrenner:

Donc l'automatisation n'est pas toujours plus efficace ou il n'y a pas forcément toujours un remplacement de l'artisan par la machine. L'artisan peut être plus rapide selon le cas d'usage.

Jawhar Kodadi:

On prend l'exemple des coiffeurs. Je sais que je suis un peu hors sujet. Tu as des coiffeurs qui te font une coupe avec une tendeuse en 5 minutes. Tu as des coiffeurs qui travaillent avec les ciseaux pour la même coupe. Visuellement, c'est la même coupe. Pour une personne qui ne s'y connaît pas, elle va dire voilà, c'est la même chose. Mais tu as des gens qui disent non, pas de tondeuse, aux ciseaux. Ça prend plus de temps. Il y a des gens qui sont prêts à payer plus pour une coupe aux ciseaux. Pour moi, c'est la même chose. Vraiment, c'est la même chose. Tu as des gens qui sont amateurs du travail fait à la main, parce que ça a plus de sens, ça donne une âme à l'objet plutôt qu'un objet fabriqué par une machine. Il y a ça, il y a cette dimension. Il y a des gens qui sont attachés et qui sont attachés à ça. On prend l'exemple d'un vase fait par un artisan qui met toute sa passion, tout son savoir-faire, son amour dans un objet. Tu ne peux pas le comparer avec un objet sorti d'un moule d'une usine en Chine. Tu ne peux pas comparer les deux. L'un gagnera en valeur au fil des années alors que l'autre non. C'est inévitable, ce n'est pas la même chose. Mais c'est là où je vais tracer le trait d'union qu'il y a entre ces deux idées. Maintenant, cet artisan qui travaille à la main, supposant qu'il a une machine CNC ou imprimante 3D ou un logiciel ou peu importe, qui l'aide à faire des recherches, du prototypage, d'explorer de nouvelles choses, d'explorer de nouvelles formes auxquelles il n'aurait pas pensé. Ça nous permettra d'avoir de nouvelles créations. Ça nous permettra de proposer des objets nouveaux qui n'existaient pas et qui sont toujours faits à la main. Qui sont toujours faits à la main ou des pièces uniques. Là c'est compliqué parce qu'on est en train de mélanger deux sujets. On est en train de mélanger le processus créatif qui est... C'est un art. Tu as des maîtres artisans qui ne font que la création, que l'imagination, que le dessin. Et le travail manuel. Lui, le travail manuel peut être remplacé par des machines. Le travail, le processus créatif peut être aidé par de nouveaux outils. Rien qu'lillustrator, c'est un nouvel outil. Illustrator, c'est un intrus dans le monde de la création artisanale. C'est un intrus, mais tout le monde l'utilise. C'est un intrus. Donc tu as ça, tu as tous ces nouveaux outils paramétriques, de géométrie paramétrique avec des systèmes dynamiques, avec tout ça, ça reste une création artistique aussi. C'est un sujet philosophique. Maintenant le trait d'union qu'il y a entre les deux, le trait d'union qu'il y a entre les deux, c'est qu'est-ce qui...

Jawhar Kodadi:

Qu'est-ce qui est artisanal et qu'est-ce qui ne l'est pas ? Pour ça, il faut revenir au terme artisanal. C'est quoi, artisanal ? Travail artisanal. Travail artisanal, c'est un travail fait, c'est un travail réalisé avec des méthodes anciennes, c'est ça ? C'est ça.

Armin Aschenbrenner:

Ça pourrait être une définition ?

Jawhar Kodadi:

Ça pourrait être une définition. Maintenant, on prend le zellige. Le zellige, aujourd'hui, on le regarde, on dit "C'est patrimoine architectural marocain, arabo-musulman, andalou, etc. C'est de l'artisanat." Et pour nous, l'artisanat, ça renvoie toujours vers le passé. Mais il y a un jour où le zellige a été créé, c'était contemporain, c'était moderne. Quand il a été créé, ils n'ont pas dit « c'est de l'artisanat ». Ils n'ont pas dit ça. C'était une industrie. C'est une industrie, c'était pas un truc ancien pour eux. Et pourtant, ils ont fait des merveilles architecturales avec. Et c'était nouveau, c'était récent, c'était représentatif de leur époque, de leur façon de penser, de leur imaginaire, de leur idéal architectural, de leur représentation du bien-être, du confort. Je ne vois pas pourquoi est-ce qu'aujourd'hui... C'est une idée très tordue que je suis en train de prendre maintenant. Je parle, je réfléchis. Qu'est-ce qui fait qu'aujourd'hui, quelque chose de fabriqué, un objet fabriqué, je veux dire n'importe quoi, vraiment, je veux dire un truc complètement déconnecté de la réalité, on sort de la réalité physique. Qu'est-ce qui fait qu'aujourd'hui, on fabrique une forme géométrique collée dans un mur, conçu sur ordinateur. Le matériau, c'est du plâtre mélangé avec de l'époxy, avec un matériau composite, de la fibre de carbone ou un truc. Qu'est-ce que j'en sais ? Est-ce qu'on peut appeler ça de l'artisanat ? Non, il faut attendre 200 ans pour que quelqu'un dise « Ah, l'artisanat marocain de 2024 ». Il faut vraiment redéfinir. Redéfinir c'est quoi l'artisanat ? Est-ce que c'est parce que c'est un travail fait à la main ? Est-ce que c'est pour ça qu'on dit que c'est de l'artisanat parce que c'est fait à la main ? Mais nous, dans notre imaginaire, au Maroc, même les touristes quand ils viennent ici au Maroc, pour eux, artisanat c'est ancien. Mais à un certain moment, les objets qu'on considère aujourd'hui comme artisanat, à un certain moment, c'était des objets ultra-modernes. C'était le nec plus ultra-art en décor. Voilà. S'il y avait Archdaily à l'époque, voilà, Archdaily, tac. C'est ça. Donc aujourd'hui, il faut s'offrir la liberté de tester de nouvelles choses. De tester de nouvelles choses, que ça marche ou que ça marche pas. C'est l'histoire qui répondra à cette question. Parce que eux, quand ils ont fait ça, pour eux, c'était quelque chose qui aurait été là pour durer 10 ans, 20 ans, puis on passera à autre chose. Finalement, c'est resté. Parce que eux, à aucun moment il n'aurait pu imaginer que ce dessin qu'il sont en train de faire, dit toi que le premier jour un maître zelligier, ça n'existait même pas à l'époque, il ne savait même pas ce qu'il était, il a dessiné sur une feuille des formes, une rosace qui tourne, ça te crée des formes géométriques, il a dit ah c'est beau ça. Si on faisait comme les Romains, on faisait ça sur de l'archi, on faisait des carreaux avec, on découpait ça, on me collait ça en miroir, tiens, c'est sympa. Il met ça dans son riad, dans une mosquée sûrement. Tu as une autre personne qui te dit "Ah c'est bien, je vais faire la même chose." Et puis ça évolue, tu as tout un processus créatif, tu as toute une mode qui a commencé à un certain moment de l'histoire, une mode qui a commencé.

Jawhar Kodadi:

Et elle a duré, elle a évolué, comme je l'ai dit tout à l'heure, elle a évolué pendant plusieurs centaines d'années. Plusieurs centaines d'années, elle a évolué. Et récemment, moi, à mon sens, je trouve que ça stagne. Ça stagne par rapport aux connaissances, aux connaissances qu'on a acquis pendant ces 1200 dernières années, le cumul de mathématiques, géométrie, informatique, algorithmes. Rien que le terme algorithme est arabe. Donc c'est limite une responsabilité, un devoir qu'a cette nouvelle génération de créateurs, d'étudiants aux écoles spécialisées dans les métiers d'artisanat. C'est une responsabilité, un devoir qu'ils ont de faire la révolution de ces métiers, de créer une véritable révolution de ces métiers. Moi, quand tu m'as contacté, c'était par rapport à la connexion zellige EVO, j'ai appelé ça, en toute modestie, évolution, parce que je juge que c'est toujours pas assez mature pour parler de révolution. Il y a des gens qui sont plus documentés que moi, plus compétents, qui maîtrisent mieux les... Le monde de la géométrie, des mathématiques, des algorithmes pour pouvoir sortir des choses plus exceptionnelles. Mais c'est un autre devoir, c'est de nous aligner sur les mêmes, pas aspiration, sur le même niveau que nos ancêtres. Nos ancêtres, ils ont utilisé 100% de ce qu'ils savaient à l'époque du monde de la géométrie et des mathématiques. Voilà, 100%. Voilà, on sait ça. On applique tout ça ici pour montrer nos muscles. L'architecture musulmane, elle s'est exportée jusqu'en Andalousie. Et c'est une forme de soft power de toutes les dynasties marocaines, toutes les dynasties marocaines ont mis un pont d'honneur à avoir leur style architectural, à construire des monuments, des mosquées, des palais... Pour que chaque dynastie ait son identité représentative de son savoir-faire, de sa maîtrise. Aujourd'hui, on a besoin de ça. On a besoin de nous aligner sur le même niveau que nos ancêtres. Je suis certains que nos ancêtres, ils viennent, ils voient ce qu'on a fait, et depuis le temps, ils vont dire: "vous êtes sérieux, les gars ? Vous êtes en train de refaire ce qu'on a fait. Si, lâchez-vous. C'est pas sacré, les dessins qu'on a, c'est pas sacré. Les dessins d'art, on a fait ça un jour, je fais ça sur un coup de tête.

J’ai fait la prière de l’Asr, j’étais là, j’ai dessiné le petit truc dans mon riad, le temps passait lentement, j’imaginais ça, mais vous pouvez imaginer autre chose.” Tu viens, tu le prends, tu le mets aujourd’hui devant Grasshopper, tu lui dis voilà, tu prends ça. Il fait une rotation. Je suis certain qu’ils vont sortir mieux que ce qu’on a fait. Le génie qu’ils avaient. Je ne suis pas en train de les idéaliser ou un truc. Pour moi, c’est une réalité. S’ils avaient pu sortir ça à l’époque, aujourd’hui, ils auraient pu sortir mieux. Alors qu’ils avaient énormément de contraintes. Ils avaient énormément de contraintes. Tu avais la contrainte du matériau. Tu vois, la contrainte du processus de fabrication, tu avais la rareté. Il n’y avait pas une grande panoplie de choix de matériaux.

Jawhar Kodadi:

L’argile, c’est disponible, on a un four. Voilà, quel type de peinture on peut utiliser, comment la fixer, les pigments qu’on a. Avec ça, qu’est-ce qu’on peut faire ? Ah, je ne peux pas faire un carreau plus grand que ça parce que ça va casser. Ah oui c’est vrai, donc on fait des petits carreaux, on fait des petites tailles. Donc si on arrive à 30 cm, ça casse. Aujourd’hui on peut arriver à 10 mètres, une plaque 10 mètres renforcée avec de la fibre, c’est un seul morceau. J’exagère, je suis passé du centimètre au mètre, j’ai exagéré. Mais rien n’empêche d’avoir un morceau de cette taille et d’utiliser dans un élément de façade, pas forcément d’argile, mais en métal, en verre. Rien n’empêche de faire ça. C’est une conversation philosophique.

Armin Aschenbrenner:

Un des arguments de ma thèse, c’est que la fabrication numérique est un processus artisanal. Il y a quelques chercheurs qui ont écrit des bouquins là-dessus qui sont très intéressants. Il y en a un, c’est McCullough. McCullough, “The Abstracted Craft”. Il parle de “The Digital Hand”, des programmes de CAD et CAM comme un processus plus proche de l’artisanat que de l’industrie.

Jawhar Kodadi:

À mon sens, ça reste subjectif, ça reste libre d’interprétation. Tu as une autre personne qui va venir, il va dire: “Non non non. Ça c’est pas de l’artisanat. Tant qu’il ne se salit pas les mains, ce n’est pas de l’artisanat.” Il y a une autre personne qui va te dire: “Tant que ce n’est pas fait à l’échelle industrielle, tant qu’on utilise ces machines pour fabriquer une série limitée en termes de production à 10 pièces par jour, c’est de l’artisanat.” C’est très subjectif. Il n’y a rien qui définit ce qui est artisanat et ce qui ne l’est pas. Il n’y a absolument rien. Je t’ai montré les cartes de la Lune. C’est fait avec un moule. C’est la matrice, elle est imprimé. C’est dessiné sur ordinateur, sur Cinema 4D. C’est imprimé en 3D. C’est imprimé en 3D. J’ai coulé du silicone dessus. J’ai créé un moule. Je l’ai rempli avec du béton. J’ai fait le dosage du béton. J’ai fait plusieurs expérimentations parce que le béton ne va pas casser. Je l’ai renforcé. Je l’ai sorti. Dans ce processus, tu as une imprimante 3D, tu as l’ordinateur, tu as du silicone, tu as le moule en silicone, le cadre en silicone, c’est imprimé en 3D aussi. Et l’objet que tu vois là-bas, est-ce que c’est un objet, est-ce que c’est de l’artisanat ? À mon sens, oui.

Armin Aschenbrenner:

Oui, il y a beaucoup de processus fait à la main, beaucoup d’étapes faites à la main dans le processus.

Jawhar Kodadi:

Maintenant tu me dis que tu es d’accord à 100% que c’est artisanal. Maintenant prenons le même objet. Et au lieu de faire un moule en silicone, je fais 100 moules. Et j’ai une capacité de production de 100 par jour. En un mois je suis à 30 000. Est-ce que c’est toujours artisanal? Maintenant, supposons que c’est dans une usine, le même truc dans une usine et ça sort. C’est le même produit. C’est vraiment le même produit. Est-ce que c’est artisanal ? Non. Le processus créatif du premier exemplaire, il est artisanal. Le reste qui a suivi n’a rien d’artisanal. N’a rien d’artisanal. Et moi, en tant que créateur, en supposant que ces pièces, je les vends, je ne sais pas, à x dirhams. Et je produis ça de façon artisanale, entre guillemets, on va dire. Et je produis 30 par mois. Je produis 30 pièces par mois que je vends à x dirhams. Demain, un industriel m’appelle. Il me dit: “Tu me vends ton dessin. Ton dessin industriel, tu me le vends et je vais produire 1000 par mois, je te donne 5% des revenus.” Ah, je vais dire “Oui” et je serai content. Et j’espère la même chose pour tout artisan. Pour tous les artisans aujourd’hui, ils doivent être sensibilisés à cette question de dessin industriel, de propriété intellectuelle parce que l’artisanat, c’est une économie. Il faut leur trouver un modèle économique. Parce qu’aujourd’hui, tu as les artisans et tu as les entreprises d’artisanat. Tu as des entreprises d’artisanat qui font ça à échelle presque industrielle, mais ils appellent toujours ça de l’artisanat. Parce qu’on ne peut pas créer de modèles économiques basés sur une production que tu ne peux pas contrôler. Si on parle d’industrie artisanale d’un pays, du Maroc par exemple, Il faut pouvoir avoir la capacité de sortir certaines pièces,

de sortir en grande quantité, pouvoir exporter, pouvoir ceci et cela. En même temps, bien sûr, garder des pièces faites à la main pour une clientèle très sélecte, très exigeante, avec des prix plus élevés. Donc oui, le plotter, la machine que j’ai fabriquée, pour moi, c’est une machine artisanale. La machine elle-même est artisanale. Il y a des composants électroniques, etc. Mais c’est de l’artisanat. La programmation est artisanale, le montage est artisanale, le système qui lève, j’ai fabriqué ça avec, je ne sais pas si tu connais la référence, MacGyver.

Armin Aschenbrenner:

Oui, oui.

Jawhar Kodadi:

Pour moi, c’est artisanal. C’est une question très, très, très... Très difficile. Je ne pense pas avoir les compétences pour trancher. Je pense qu’il faut vraiment un comité plus multidisciplinaire pour dire, voilà, ça c’est de l’artisanat, ça ce n’est pas de l’artisanat. Et j’espère que ce jour n’arrivera jamais. Tu sais, on ne peut pas. Il faut laisser les choses évoluer toutes seules. C’est compliqué, c’est très compliqué comme sujet. Qu’est-ce que l’artisanat ? Qu’est-ce que l’artisanat ? La meilleure façon de répondre à ça, comme je l’ai dit tout à l’heure, à l’époque, quand ils ont créé le zellige, est-ce que c’était de l’artisanat ? Est-ce qu’à l’époque, eux, ils parlaient de l’artisanat ? En gros, c’était des techniques de construction. Des techniques de fabrication. L’atelier de céramique qu’il y avait, c’est l’équivalent aujourd’hui d’une usine. C’était une industrie. C’est une industrie de fabrication. Donc voilà. T’as d’autres questions ? Si t’as d’autres questions, tu n’hésites pas. Je prétends pas avoir la vérité, mais je pense que dans ce sujet, tout ce que je dis n’engage que moi. C’est purement subjectif.

Armin Aschenbrenner:

Oui, bien sûr. Oui. Donc. Comme je te l’ai dit, moi, je m’intéresse au nouveau cas d’usage que la fabrication numérique pourrait apporter au zellige. Et quand je dis le zellige, je parle des motifs et de la fabrication, des techniques de fabrication traditionnelle. Quelle collaboration ou quelle hybridation est-ce que tu vois ? Quelle opportunité tu vois dans la collaboration entre les techniques de fabrication artisanale traditionnelle et ces nouvelles technologies ? Tu parlais avant de prototypage, du processus créatif.

Jawhar Kodadi:

C’est surtout ça, le prototypage. Mais tu as aussi, on va parler de l’exemple de la CNC et découpe laser.

Armin Aschenbrenner:

Oui.

Jawhar Kodadi:

Et découpe laser, aux fibres, au plasma, au jet d’eau. Pour le cas du zellige, si tu as remarqué, c’est des formes, le zellige marocain. C’est essentiellement des formes, c’est des polylignes. C’est des polylignes, c’est facile à couper avec un coup. Tac. Avec la CNC, on peut s’amuser à intégrer des courbes, ce qui est difficile à la découpe manuelle. Donc ça, ça permettra d’explorer, ça permettra d’explorer de nouvelles formes, d’expérimenter de nouvelles formes. Autre chose que ça peut permettre de faire: une pièce de zellige, elle a une surface plane. Elle est lisse, elle est plane. Avec ces nouveaux procédés, on peut imaginer des surfaces avec un bizutage, en 3D, avec un volume qui sort. Un peu comme... Un peu comme ça. Ça par exemple, à la main, “Bon courage!” Ou alors vraiment sortir en 3D, bizarre, un peu comme... Un peu comme ça ?

Armin Aschenbrenner:

Ouais. Oui.

Jawhar Kodadi:

Un peu comme ça, où tu as chaque pièce de... Je prends une feuille ici. Où tu as chaque pièce de zellige. Je ne sais pas si il marche celui-là. On va faire une trame très simple. Ça, c’est des carreaux de zellige. Et on va placer sur chacune de ces formes un point. Un seul point. Placé aléatoirement quelque part. Chaque fois aléatoire. Et on fait une extrusion vers ce point. Imagine tout ça en 3D. Donc ça, ça peut te donner une dynamique incroyable. Ça, je t’ai fait sur une trame rectangulaire, mais ça, la même chose sur une trame hexagonale ou autre chose, ça peut créer toute autre chose. Bien sûr, ces points, je les ai placés aléatoirement, mais ces points peuvent être placés suivant, je ne sais pas, une courbe ou suivant un attracteur central ici. Avec une distance, plus tu t’approches de là, plus ça s’approche du centre par exemple. Ici c’est au centre et là ça vient ici. Et là ici c’est au centre. Tu es un dégradé, tu

passes de cette forme vers ça. Les possibilités sont infinies. Et ça, cette approche avec les techniques de fabrication traditionnelles, c'est impossible. Tu ne peux pas faire passer le zellige vers ce niveau, vers une nouvelle dimension. Tu ne peux pas faire passer le zellige vers une nouvelle dimension sans révolutionner le processus de fabrication. Ce n'est pas possible. Et ça, ça crée... On est toujours dans du zellige. Ça ajoute au zellige, une troisième dimension. Et ça crée une nouvelle sensation. Ça crée une nouvelle perception, un nouveau ressenti du mur quand tu le vois. Tu vois un mur, tu le vois vivant. Par rapport au soleil, par rapport à l'ensoleillement, tu vois un jeu d'ombre, un jeu de relief, un jeu de volume. Et... Et je pense qu'on doit se diriger vers ça, parce que là, on garde toujours l'essence du zellige, qui est bidimensionnelle. Et avec ça, on passe à... Ça, c'est toujours avec le même matériau. On peut imaginer un autre matériau. Les possibilités sont infinies. Ou bien créer des moules en silicone pour couler de l'argile dedans et peindre les faces, etc. Tout est à refaire. Dans le domaine du zellige, à mon sens,

Jawhar Kodadi:

tout est à revisiter, expérimenter, voir ce qui marche et ce qui ne marche pas. Il y aura de belles erreurs qui vont donner des trucs très intéressants. Soit en argile, en ciment. En résine. Qu'est-ce que... Translucide, carrément. Il y a des choses à explorer. J'espère que je suis toujours dans ta question.

Armin Aschenbrenner:

Oui, oui, oui.

Jawhar Kodadi:

Ça, c'est des choses qui ne peuvent pas exister sans ces nouvelles machines on va dire, ça ne peut pas exister. Bien sûr, ça peut être créé à l'échelle industrielle, etc. Mais le processus créatif de prototypage ne peut être fait qu'avec ces machines. Parce que là, pour faire le moule, par exemple, supposons que tu veux faire ça. Tu veux utiliser un moule pour créer différentes pièces. Tu veux faire appel à une société pour te créer le moule. "Bon courage!" Un artisan ne peut pas se permettre 100 000 dirhams, 200 000 dirhams pour avoir un moule, pour expérimenter un truc qui peut-être va marcher. Mais là, avec ça, il peut expérimenter de nouvelles choses, créer un moule, créer un truc. C'est la prochaine étape. À mon avis, ça doit être la prochaine étape de la révolution. Il faut révolutionner les techniques de fabrication. Technique de fabrication. On enlève même le terme artisanal. Il faut révolutionner le... On ne doit pas rester prisonnier du terme artisanal. On ne doit pas rester... Parce que eux, nos ancêtres, quand ils ont fait ça, ils ne parlaient pas d'artisanat, ils ne parlaient pas de trucs anciens. Pour eux, c'était le nec plus ultra. Le type il a fait ça, c'est le high-tech des procédés de fabrication. Voilà, c'est tout.

Armin Aschenbrenner:

Toi qui as de l'expérience en tant qu'architecte marocain, tu maîtrises ces nouvelles technologies de fabrication, mais tu travailles aussi dans le contexte, tu utilises aussi dans tes réalisations des produits de l'artisanat marocain. Est-ce que je me trompe?

Jawhar Kodadi:

Oui, mais non, non.

Armin Aschenbrenner:

Ma question, c'est comment est-ce que, comment dialoguer avec les artisans? Comment est-ce que cette collaboration peut se mettre en place?

Jawhar Kodadi:

Déjà, pour mes projets d'architecture, j'ai le concept zellige EVO que je n'ai toujours pas réalisé. Pour le moment, comme je te disais, c'est toujours de l'architecture conceptuelle. Mais les artisans marocains, que ce soit les menuisiers ou ceux qui font les faux plafonds en plâtre, c'est des personnes très ouvertes sur les nouvelles technologies. C'est des personnes qui aujourd'hui communiquent avec toi par email. C'est des personnes qui aujourd'hui savent lire un plan DWG. Ils ouvrent ça, ils utilisent Illustrator. Les artisans marocains sont très ouverts sur les nouvelles technologies. Ils ne sont pas réticents à cette idée. Ce qui leur manque, c'est de la formation, c'est de savoir comment faire. C'est tout. Il n'y a aucune réticence des artisans marocains par rapport aux nouvelles technologies. Tu lui fais un dessin, tu lui dis tu me fais ça. Peut-être qu'il doit négocier avec toi le prix. Voilà, c'est difficile. Il va chercher la facilité peut-être. Mais s'il est bien rémunéré, il va te faire ce que tu veux. Les artisans marocains ont beaucoup de savoir-faire. Ils savent s'adapter. Et je pense... Toi ta question: "est-ce qu'ils ont une crainte ? Est-ce qu'il y a une difficulté de communiquer avec eux ?" Non, il n'y a pas. Il n'y a pas de difficulté de communiquer avec

eux. Si tu pars à la Medina de Fès par exemple ou de Marrakech, tu te balades, tu vois des artisans, je ne te parle pas des bazars qui sont des revendeurs, je ne te parle pas de ça. Je te parle des mono-artisans qui sont là dans l'atelier en train de fabriquer quelque chose. Si tu parles de voir et tu montres sur ton téléphone un croquis ou un dessin de quelque chose que tu veux faire, il va te faire une pièce sur mesure. Il va te fabriquer ça. Il va puiser dans ses connaissances, dans les trucs qu'il a expérimenté pour pour répondre à tes besoins à condition que tu mettes le prix. Ils n'ont aucune réticence par rapport à ça. Ils ne sont pas... Les Marocains, en général, ce ne sont pas des personnes bornées qui disent: "non, moi je fais ça comme ça, sinon rien." Non, les Marocains sont ouverts et on a cette chance parce que c'est un pays qui a, historiquement, il a toujours été ouvert sur d'autres civilisations, sur d'autres cultures, sur d'autres langues. Et quand on parle d'un pays ouvert sur culture, langue, c'est automatiquement un pays ouvert sur d'autres façons de penser. Et le marocain est très... Est très apte à s'adapter. Le marocain est très apte à s'adapter aux nouvelles contraintes, aux nouveaux défis. Il y a un truc très simple qui prouve ça. C'est pendant la crise du Covid.

Jawhar Kodadi:

Il y a eu deux événements marocains, deux événements qui sont passés au Maroc, qui sont représentatifs de ce génie marocain, de cette capacité de s'adapter. Le Maroc était parmi les premiers pays à fabriquer ses propres masques, alors qu'il y avait pénurie partout dans le monde. Et comment est-ce qu'on a fait ? Comment les Marocains ont fait alors qu'on n'avait aucune industrie de fabrication des masques ? Là, toutes les usines de textiles qui ont pu, en un temps record, revoir leur chaîne de production pour produire des masques. C'est aussi simple que ça, c'est voilà, on s'adapte. On va pas parler de la logistique, tout ce qui s'est passé derrière la logistique, mais en parlant par exemple des cafés. Les cafés, ils étaient fermés. Tous les cafés étaient fermés. Ah, les Marocains doivent prendre un café. Le café, il est obligatoire. En deux semaines, tu as eu des voitures avec dans le coffre une machine à café. Je ne sais pas si tu vois, encore sur les routes, tu vois ça. Et ça, c'est représentatif de cette capacité de s'adapter à des contraintes, à des voilà, on va sortir, voilà, ça va marcher au gaz, on met ça dans le coffre, on met ça, tac, tac. Il y en a même qui ont des panneaux solaires sur le truc. Donc les Marocains ont cette capacité de s'adapter, d'utiliser de nouvelles technologies. Ils sont pas réticents. Vraiment c'est dommage qu'on n'ait pas eu l'occasion de partir voir les menuisiers pour voir comment ils marchent. Les menuisiers, tu as un catalogue de différentes formes, etc. Ça passe au CNC. Ça passe au CNC, tu as des menuisiers maintenant qui te proposent des meubles 100% CNC, zéro vis. C'est des meubles qui s'emboîtent. C'est des dessins qu'ils ont pris sur internet. Est-ce que c'est artisanal ? Oui, pour moi, c'est artisanal. Ça reste artisanal. Pour moi, non, il n'y a pas de problème de communication, il n'y a pas de réticence. Les artisans marocains ont une approche artistique, bien sûr. L'artisan marocain fait de la direction artistique. Il fait de la relation clientèle. Il fait de la maîtrise d'œuvre. Et il a une approche économique aussi. Il doit pouvoir subvenir à ses besoins l'artisan. Il jongle avec tous ces trois. Donc toi tu lui apportes une nouvelle dimension. Tu lui dis voilà, moi je fais ce dessin, il faut le faire en CNC, il faut faire ça, il faut faire ça. Lui il n'a jamais fait ça avant. Il n'a jamais, il n'a jamais travaillé avec CNC, il sait pas... Je suis certain qu'il va être heureux et content de faire sa première expérience avec toi. Parce que pour lui, il va apprendre quelque chose qu'il va proposer à son prochain client, ça va lui donner des idées, ça va lui ouvrir d'autres perspectives. Donc ils sont pas...

Jawhar Kodadi:

Ils sont pas réticents à ça, c'est juste tu dois lui proposer quelque chose qui fonctionne. Lui, il va te dire, non, ça, ça marche pas. Toi, lui, oui, non, mais si tu fais comme ça, ça peut fonctionner. Il va te dire, ah oui, d'accord, ok. Donc, je sais pas si ça répond bien à ta question, si je suis pas trop hors sujet.

Armin Aschenbrenner:

Non, non, c'est tout à fait ça. Ouais. Ça va, tu...

Jawhar Kodadi:

Tu me donnes un instant?

Armin Aschenbrenner:

Ouais pas de soucis.

Jawhar Kodadi:

Donc avant que tu continues, à mon tour de te poser une question. Si on prend ça, par exemple, et qu'on crée un moule en silicone pour cette forme, et qu'on coule dedans de l'argile, est-ce qu'on peut en sortir un morceau de zellige ?

Armin Aschenbrenner:

Pour ce qui est de couler de l'argile, on travaille plutôt avec des moules en plâtre. Ça se fait beaucoup pour la porcelaine. Les moules en plâtre ont cette propriété à absorber l'humidité de l'argile. J'ai pas les mots en français, mais on appelle ça slip, c'est-à-dire l'argile liquide avec beaucoup d'eau. Et très rapidement, ça crée une... L'argile se solidifie parce que le...

Jawhar Kodadi:

Le plâtre.

Armin Aschenbrenner:

Le plâtre absorbe l'humidité et la pièce devient un peu plus petite. Elle se rétrécit un petit peu et se détache très facilement du moule en plâtre.

Jawhar Kodadi:

Et le moule en plâtre, il est réutilisable ?

Armin Aschenbrenner:

Oui. La seule chose qu'il faut faire attention. C'est de ne pas le griffer. Des particules de plâtre qui se retrouvent dans l'argile parce qu'après tu auras vraiment des problèmes au niveau de la cuisson et ça va éclater.

Jawhar Kodadi:

Et si on utilise du silicone, ça ne peut pas marcher ?

Armin Aschenbrenner:

Le silicone, je suppose que si tu attends assez longtemps, tu auras une évaporation qui va se faire. Mais je ne connais pas d'exemple de ce processus de fabrication.

Jawhar Kodadi:

Il faut expérimenter, tester. Il faut tester.

Armin Aschenbrenner:

Mais en soi, un moule en silicone, tu pourrais aussi venir presser de l'argile moins visqueux déjà, avec une consistance plus solide, et venir presser dans la forme.

Jawhar Kodadi:

Oui. Moi, je suis tenté d'expérimenter un truc comme ça pour voir ce que ça peut donner.

Armin Aschenbrenner:

Tu pourrais venir presser une plaque d'argile aussi dans un moule comme ça.

Jawhar Kodadi:

Il faut essayer.

Armin Aschenbrenner:

Mais avec du plâtre, ça marcherait aussi certainement très bien. Bien sûr, comme avec n'importe quel moule, il faut une forme qui permette de sortir la pièce.

Jawhar Kodadi:

Ah oui, bien sûr. Avec un seul point d'extrusion, ça sort facilement. Est-ce que tu connais des artisans qui utilisent la technique du plâtre pour couler le zellige ?

Armin Aschenbrenner:

Au Maroc, non. J'ai appris dans l'atelier de céramique dans mon université comment couler. On a coulé des vases ou des verres. Ils m'ont montré comment on fait ça pour faire des tasses par exemple. Tu as le moule en plâtre et tu coules la porcelaine liquide. Selon combien de temps tu attends, le mur devient plus ou moins épais.

Jawhar Kodadi:

Le mur devient plus épais.

Armin Aschenbrenner:

C'est-à-dire, oui, tu coules, tu remplis ta forme de la porcelaine liquide et c'est seulement la couche externe qui est en contact avec le plâtre qui commence à se solidifier. Donc plus tu attends, plus cette couche s'épaissit. Et après un certain moment, quand tu as atteint l'épaisseur que tu veux, tu vas venir sortir le reste.

Jawhar Kodadi:

Elle rétrécit plutôt.

Armin Aschenbrenner:

Non, en fait, elle se solidifie sur l'extérieur, tu verses.

Jawhar Kodadi:

Ah d'accord, ok, ok, ok, j'ai compris.

Armin Aschenbrenner:

Et après, quand tu attends un peu plus longtemps, la pièce se rétrécit et tu vas pouvoir la sortir du moule.

Jawhar Kodadi:

Ouais.

Armin Aschenbrenner:

C'est comme ça qu'on produit, voilà, les tasses, les assiettes, beaucoup de choses en porcelaine. Parce que la porcelaine est très compliquée à travailler sur une roue.

Jawhar Kodadi:

Ouais, ouais, je comprends.

Armin Aschenbrenner:

Enfin, c'est aussi possible, mais c'est compliqué.

Jawhar Kodadi:

Tu as d'autres questions ?

Armin Aschenbrenner:

En fait, pour ce qui est de mes questions, on est arrivé au bout. Je trouve qu'on a une discussion vraiment fascinante et je te remercie énormément, vraiment infiniment.

Jawhar Kodadi:

Tout le plaisir est pour moi. Je n'ai pas toujours l'occasion de te parler de ça. Je parle de ça sur Internet avec des inconnus un peu partout dans le monde, on discute un peu. Mais ça fait plaisir de voir un Autricho-marocain, un Austro-marocain, un Austro-marocain qui est étudie à Zurich, qui revient embrasser ses origines au Maroc et redécouvrir la culture, participer à la culture marocaine, participer à sa revalorisation, à son évolution, parce que ça doit évoluer, ça doit évoluer tout. Rien n'est sacré dans ce qu'on fait. Rien n'est sacré dans l'artisanat. Dans l'artisanat, rien n'est sacré. Il faut expérimenter de nouvelles choses. On a le devoir, vis-à-vis de nos ancêtres, d'expérimenter de nouvelles choses. S'ils nous voient, ils seraient furieux contre nous. Ils vont dire: "ça va pas, on a faisait ça il y a 1200 ans, vous étudiez toujours la même chose, mais c'est quoi? Mais qu'est-ce que vous faites? Le zellige, nous on a fait, on imaginait que ça va durer 50 ans, puis on passerait à autre chose." Il faut faire évoluer les choses, de nouveaux procédés, de nouvelles... Peut-être que toi tu as fait ça ? Est-ce que tu as fait une étude comparative par rapport au métier d'artisanat dans d'autres pays ? Par exemple au Japon ?

Armin Aschenbrenner:

Non, ce serait intéressant.

A.4. Abdul Ali Kandri and Samir Bouslham

February 23, 2024

Maalem and craftsman, Coopérative Córdoba des Arts du Bâtiment Traditionnel, Fes

Translated from Moroccan arabic

Abdul Ali Kandri:

He has determination. He will surely make something In cha'Allah.

Nazha Benabbes Taarji Aschenbrenner:

In cha'Allah!

Abdul Ali Kandri:

This is the idea. For example in this case, he says whether the machine can make the frame and the hand what can go inside!

This needs to go to the kiln and be fired..

Armin Aschenbrenner:

Yes, like this one that was fired. I made these to show you what the machine can make.

Abdul Ali Kandri:

I understand the machine can make these. We can make it like this one with zellij.

Armin Aschenbrenner:

My idea is to make a brick for example, which can be in a wall like moucharabieh and the inside we can decorate with zellij.

Abdul Ali Kandri:

Yes, with zellij. That's what I said. The machine can make these and we can make the inside with zellij.

You can fill all the empty spaces with zellij or some leave empty to let the light in. For example, we can make this round pattern…

Armin Aschenbrenner:

Yes we can leave some empty. This is one idea. I want to see how the machine and the hand can work together.

Abdul Ali Kandri:

First, what would you like to drink?

Nazha Benabbes Taarji Aschenbrenner:

Tea, yes some tea will be nice.

Abdul Ali Kandri:

Please, a pot of good tea. Normal tea..

Armin Aschenbrenner:

I wanted to show you these to see if you have other ideas that we can do…

Abdul Ali Kandri:

You want to make these like moucharabieh!

Nazha Benabbes Taarji Aschenbrenner:

This is just one idea. He has many ideas.

Armin Aschenbrenner:

Yes, only one idea…

Abdul Ali Kandri:

You want to make these in a place so the light is in and out…

Armin Aschenbrenner:

Yes, for example for a wall, or stairs…

Abdul Ali Kandri:

Stairs, a fountain or windows… with a frame.

Armin Aschenbrenner:

Yes…

Abdul Ali Kandri:

Yes, that's what I said. These small lines can be made by the machine and inside we can make the zellij for you. We can make the pieces and you can fill them yourself or find someone there to do it for you. We can make the pieces for example for this pattern and you can fill the empty spots you wish and leave others empty…

Nazha Benabbes Taarji Aschenbrenner:

This is one of the ideas he has. He can make an entire wall with different modules with the machine.

Abdul Ali Kandri:

This is similar to what we do… If he wishes to decorate it, he can do it…

Nazha Benabbes Taarji Aschenbrenner:

You can also make it with bricks. You make an entire wall, which already has the pattern and you need only make the pieces to put inside…

Another idea is to make the same pattern which is inclined, a thing that cannot be made by hand.

Abdul Ali Kandri:

I agree with you…

Nazha Benabbes Taarji Aschenbrenner:

It is like a rotation.

Abdul Ali Kandri:

Yes, like a rotation…

Armin Aschenbrenner:

This one starts like this one but it becomes smaller…

Abdul Ali Kandri:

This is what I am saying. It must be empty but he wants to decorate it…

Nazha Benabbes Taarji Aschenbrenner:

His idea is to show what can be done by the machine and cannot be made by hand…

Abdul Ali Kandri:

What cannot be made by hand is this. We make this approximately one centimetre. What you have here is 1 or 2 millimetres. The work by hand is different from the work by the machine.

Armin Aschenbrenner:

2 millimetres by hand would break.

Abdul Ali Kandri:

It will not work. Fingers cannot hold it. If the machine can make this, if you want to decorate it we can make these or the small pieces, a decor in different red or green, according to your own taste or that of your clients..

Armin Aschenbrenner:

I need to explain better the context, why I am working on this project!

Nazha Benabbes Taarji Aschenbrenner:

Armin would like to explain the objective of his current research and what he is studying.

Armin Aschenbrenner:

I am studying how people can control…

Samir Bouslham:

Can make the work easier, less burdensome.

Armin Aschenbrenner:

How people can work with machines. It is called interaction design. There are people working on websites or for example people working with phones. What you see in a computer or a phone, everything that is in it, has been designed by an interaction designer. Every button or feature in the device has been designed by someone with a purpose. If I press a button, it will have a special function… This is what I study…

Abdul Ali Kandri:

This specific work relating to a computer is easy, but work by hand is a little bit more difficult. As I told you you can design a pattern, we can make the pieces that you can assemble only with glue.

Armin Aschenbrenner:

For example, if you made a wall and you want to leave holes to let light in..

Nazha Benabbes Taarji Aschenbrenner:

His idea, what he is studying, is a new field of study. It didn't exist before…

What do they study? They try to understand and see how to make programmes to make things / objects function. For a phone for instance, all we see is that it has different functions but we don't know the work lying behind allowing these various functions. There is an engineer who has developed and made various calculations to make the device have different functions.

Abdul Ali Kandri:

The machine should not only do this but also the design?

Nazha Benabbes Taarji Aschenbrenner:

The example of the phone can be applied to all various fields.

Abdul Ali Kandri:

To zellij as well…

Nazha Benabbes Taarji Aschenbrenner:

Yes to zellij as well!

Armin Aschenbrenner:

My thesis for my Master's Degree..

Samir Bouslham:

For zellij, you can give me the design and the frame, the size, like this one, and I can make it for you. But it will not work with the machine. It will not work with clay.

Armin Aschenbrenner:

Why not?

Samir Bouslham:

You can make a number of the same frame you have made. Only this one, bake them and use it. But you cannot make other things..

Armin Aschenbrenner:

There are many other things I can do with this. This is only one example... This is why I wanted to discuss with you to find out what other things we can do.

Samir Bouslham:

What you are doing right now will not work with zellij. You are making the frames and then you want to put pieces inside. What we do by hand, you need female and male pieces that can click together and make the pattern…

Armin Aschenbrenner:

It can work.

Samir Bouslham:

How?

Armin Aschenbrenner:

I made this as a flat object. I can make it like this. Not on a wall but on a vase or a table which can be like this round..

Samir Bouslham:

I have seen one which is round.

Armin Aschenbrenner:

There are so many other things that I can make.

Samir Bouslham:

Right, you have done this one, it can be small or big or whatever you want. It came nice but what are we going to do with it?

Armin Aschenbrenner:

One idea, we can make a wall with it! With a machine, it is very easy to change…

Samir Bouslham:

It is easy to modify the work, right!

Armin Aschenbrenner:

It is the same whether I make it like this one or a round one.. it can be modified so easily.

Samir Bouslham:

No problem, round or square… Normal. But you are making it with clay. 10 by 10, would not work for us. It will work only for you, say for windows or something else. It will not work for us!

Nazha Benabbes Taarji Aschenbrenner:

Why not?

Samir Bouslham:

Because, for these things, there is no demand. Demand is only for zellij beldi. Make some designs in other materials but not clay. For clay only 10 by 10 or 20 by 20 to make zellij or you bring your sample and ask him to make it for you. Then he can make it for you. This will not work for us.

The time the machine takes, say 60 minutes or 45 minutes, it makes only one sample. We can make a thousand of these in one hour. So the speed is in hand work, not by the machine. The machine can make the frame and you can ask me to produce the same. You can bring it in only 2 centimetres and I can use it to make a bigger frame. Our design, say for this is 20 centimetres …

Armin Aschenbrenner:

I know, this is too small. But it is only a sample to show you what the machine can make

Samir Bouslham:

I can make your pattern with clay. But I don't make it this way. I will use a metal or wooden frame, that is rigid, and will fill it with clay, dry it, add more clay, dry it and then bake it. I can put any colour on it afterwards. The machine can produce something

small like this. This is good as you can show people the design. If they like it then there will be a demand for it.

Armin Aschenbrenner:

Yes…

Nazha Benabbes Taarji Aschenbrenner:

The point is not what the market wants. Armin is making research on how to make progress and develop further the craft making.

Samir Bouslham:

Listen, I understand.

Armin Aschenbrenner:

Something new…

Nazha Benabbes Taarji Aschenbrenner:

He is at a research stage.. He would like to hear your needs, things that you cannot do and if the machine can help you. Afterwards, the question can arise whether this can be sold in the market or not.

Samir Bouslham:

He has to provide me with the idea and I can tell him if it is viable or not.

I cannot do the research he is doing..

Abdul Ali Kandri:

What he is making, we can do with zellij. This is only 10 centimetres. We need to make it 20 centimetres if we want to make it in zellij.

Nazha Benabbes Taarji Aschenbrenner:

These are only samples.

Abdul Ali Kandri:

What he made here, we can make for him in zellij. We can make these pieces, the small one. I can make it exactly the same with empty spaces and filled ones..

Armin Aschenbrenner:

I understand. This is only one idea which is feasible .

Nazha Benabbes Taarji Aschenbrenner:

Yes, only one idea. He wants to hear other ideas!

Armin Aschenbrenner:

My question to you as knowledgeable people is what other ideas you have, that the work made by the machine, triggers in your minds. What other ideas or needs you have, or something new that can be made, which has never been done before.. This is my question..

Abdul Ali Kandri:

We told you. Sorry, you made this as moucharabieh!

Armin Aschenbrenner:

I can make all kinds of things but what ideas do you have that the machine can help you with?

A.5. Abdul Ali Kandri, Samir Bouslham and Rachid Kandri

June 24, 2023

Maalem, craftsman and maalem's son, Abdul Ali Kandri's home, Fes

Translated from Moroccan arabic

Armin Aschenbrenner:

We can start now. I need space.

Samir Bouslham:

You need a bigger space!

Armin Aschenbrenner:

We need to close here. But before, let us see …This is ok. This one needs a bit of adjustment. It should be in the middle.. I am looking at the system

Samir Bouslham:

Yes…

Armin Aschenbrenner:

It is looking at the granite… No problem. It will work. I am opening my program.

Here it is!

Samir Bouslham:

Impeccable !

Armin Aschenbrenner:

We haven't started yet! This is enough for me!

Samir Bouslham:

Not yet. This is enough for me. We need to understand the first lesson, then you can provide us the second one!

Armin Aschenbrenner:

The camera will see these on the floor and will change the pattern

Samir Bouslham:

The camera will change the pattern?

Armin Aschenbrenner:

Yes, you will see. I have two colours: this one is red, the pattern..The corner, how do you want it in which shape? the size? the grid…

This is for the decor and this one is for colour.

How do you call this?

Abdul Ali Kandri:

Slimania!

Armin Aschenbrenner:

Slimania. When it turns, it will change colour…

This is better…

Samir Bouslham:

Please close that door.. There is so much sun coming in..

Armin Aschenbrenner:

Don't ! The light is off..

Slimania, when it turns changes the pattern and the colour..

Abdul Ali Kandri:

It is becoming all white.

Armin Aschenbrenner:

This one will change the pattern. The space…

These things are always so easy. I make very easy patterns: just simple shapes, triangles .. Slimania turns around, this exagon when it fluctuates, something will change like this…

Samir Bouslham:

Ah! The space in between changes!

Armin Aschenbrenner:

The grid!

Samir Bouslham:

There is too much sun! Shall we close the door?

The space changes…

Armin Aschenbrenner:

The octogon changes shape. We can turn it around. When I make the pattern, putting them one on top of the other will change the colour.. I'll show you. Let's take these circles. I'll make them closer slowly and it will…

Samir Bouslham:

Make a third colour!

Abdul Ali Kandri:

Another pattern!

Armin Aschenbrenner:

The pattern changes!

Samir Bouslham:

How beautiful!

Armin Aschenbrenner:

My idea is how to make a new pattern with the computer but work, like you usually do, on the floor and make a pattern that look big, just like being on a wall!

Samir Bouslham:

You can visualise the pattern before making it, its space..

Abdul Ali Kandri:

Its pattern plan..

Samir Bouslham:

Yes, its pattern plan, you're right Al Hajj!

Abdul Ali Kandri:

It is actually the pattern plan as you can see it in its entirety.

Armin Aschenbrenner:

This is just a drawing..

We can make it in one colour like this or..

Abdul Ali Kandri:

This colour is good

Samir Bouslham:

This is what we have at home.

Abdul Ali Kandri:

It is like what we have in the living-room.

Samir Bouslham:

Yes..

Armin Aschenbrenner:

Let us make something new and see what we can get!

Samir Bouslham:

Small, this small pattern… a little bit more to the right. Good..this is an existing Moroccan pattern. To create new patterns you need new shapes. Not to rely uniquely on stars or exagons.. you need to create a square, a rectangle or an exagon..

Armin Aschenbrenner:

Wait! There is. Here it is a square, an octogon, an exagon…

Rachid Kandri:

Right!

Armin Aschenbrenner:

Would you like to create a pattern?

Rachid Kandri:

This is a demonstration… but every time you create a new pattern, you should…

Armin Aschenbrenner:

If we like this pattern, I can push this button and save it.

Rachid Kandri:

Ah! You can save it! Ok..

Armin Aschenbrenner:

Yes,

Armin Aschenbrenner:

Can I make a video now..

Rachid Kandri:

Yes..

It is not working anymore…

Armin Aschenbrenner:

Why! Is there a problem? You need to turn it around. No, this is not Slimania. These fluctuate. You need to flip it.

Rachid Kandri:

You see this pattern, it is a nice pattern but a little bit off!

Are we going to change the colours?

Armin Aschenbrenner:

All the colours are blue.

Rachid Kandri:

Can you see this pattern? It is based on triangles. It is always triangles. For these we can change the colours but… this one..

Abdul Ali Kandri:

No, this one..turn this one to your side..

Armin Aschenbrenner:

This is a problem of light. It is getting dark so you don't see the pattern. The camera needs to see this one.. but it is in the dark and doesn't see it

Rachid Kandri:

Put on the light..

Armin Aschenbrenner:

Yes it is a little bit difficult

Abdul Ali and Rachid Kandri:

Put on the light…

Armin Aschenbrenner:

But then it looks a little bit small with the light.

Rachid Kandri:

But as we are going to have a good drawing and a good pattern, then we can turn off the light and make a recording.

When you are making a recording can you continue to change the dimensions? Continue to reduce or enlarge it?

Armin Aschenbrenner:

Yes, I can

B. Code

B.1. MainApp

```
import TUIO.*;

import processing.svg.*;

import processing.pdf.*;


TuioProcessing tuioClient;


ChildApplet child;

PImage img;

PImage backgroundImg;


// Grid properties

boolean hexGrid = false;  // Set whether grid is square or hexagonal


// Width of the shape

float minSize = 50;  // Minimum shape size

float maxSize = 500;  // Maximum shape size

float targetSize = (minSize + maxSize) / 2;  // Target size that can be modified by TUIO rotation

float currentSize = (minSize + maxSize) / 2;  // Current size to display, will lerp towards targetShapeSize


// Gap between shapes

float minGap = 20;  // Minimum shape gap

float maxGap = 300;  // Maximum shape gap

float targetGap = (minGap + maxGap) / 2;  // Target gap that can be modified by TUIO rotation

float currentGap = (minGap + maxGap) / 2;  // Current gap to display, will lerp towards targetGap

// Scaling factor

float minScale = 0.5;  // Minimum scaling factor

float maxScale = 2.0;  // Maximum scaling factor

float targetScale = 1.0;  // Target scaling factor that can be modified by TUIO rotation

float currentScale = 1.0;  // Current scaling factor to display, will lerp towards targetScale


// Shape angle

float currentAngle = 0;  // Target angle that can be modified by TUIO rotation

float targetAngle = 0;  // Current angle to display, will lerp towards targetAngle

int numAngles = 24;

int currentSetAngle = 0;

float cumulativeAngle = 0; // Cumulative angle for marker 0

float lastAngleMarker0 = 0; // Variables to track the last angle of the marker 0


// Vertices for different shapes

int numShapes = 7;

float[][] triangleVertices = new float[3][2];

float[][] squareVertices = new float [4][2];

float[][] hexagonVertices = new float[6][2];

float[][] octagonVertices = new float[8][2];

float[][] circleVertices = new float[64][2];

float[][] star1Vertices = new float[16][2];

float[][] star2Vertices = new float[16][2];


// Choose shape to draw

float[][] currentShapeVertices = triangleVertices;

int currentShape = 0;
```

```
// Screen properties
boolean iMac = false;
int screen1W;
int screen1H;
int screen2W = 1920;
int screen2H = 1080;
int canvasW = screen2W;
int canvasH = screen2H;


// Colors
int numColors = 20;
color[] primaryColors = new color[numColors];
color[] secondaryColors = new color[numColors];
int currentPrimaryColorIndex = 0;
int currentSecondaryColorIndex = 0;
int numColorSchemes = 4;
int colorScheme = 0; // Set to 0 for uniform color, 1 for checkerboard pattern, 2 for atlernating rows and 3 for staggered alternating rows
boolean colorSwapped = false;
color strokeColor = 255;
color exportStrokeColor = 0;


//Marker logic
int lastSegmentUpdateColor = -1;
int lastSegmentSwitchColor = -1;
int segmentSwitch = 6;


// Global flags to control the swapping action once per marker presence
boolean foundMarker11 = false;
boolean foundMarker12 = false;
```

```
// Global variables for the attractor
boolean attractorActive = false;
float attractorX = 0;
float attractorY = 0;
float attractorImpact = 0;  // Default impact factor
float prevAttractorX = 0;
float prevAttractorY = 0;
float prevAttractorImpact = 0;
float minImpact = - 2;  // Minimum impact when marker angle is 0
float maxImpact = 2;  // Maximum impact when marker angle is TWO_PI
float cumulativeImpactAngle = 0;  // Variable to track the cumulative impact for the attractor
float lastAttractorAngle = 0;  // Variable to track the last angle of the marker 10


// SVG properties
boolean recording = false;
int lastColorScheme;


// Save function properties
boolean showMessage = false;
int messageTimer = 0;
final int messageDuration = 30; // Duration for the message to display (2 seconds * 60 frames per second)


// Save trigger markers
boolean savemarker15Detected = false;
boolean savemarker16Detected = false;
boolean saveTriggeredByMarker1 = false;
boolean saveTriggeredByMarker2 = false;
```



```
// Add flags to track the presence of markers 16 and 17
boolean resetmarker17Detected = false;
boolean resetmarker18Detected = false;
boolean resetTriggeredByMarker16 = false;
boolean resetTriggeredByMarker17 = false;


// Last angles for incremental control
float lastAngleSize = 0;
float lastAngleGap = 0;
float lastAngleScale = 0;


// Last activity variables
int inactivityThreshold = 100000; // 1 second threshold for inactivity
long lastActivityTime = 0;
boolean activityDetected = false;


// Thresholds for detecting significant changes
float angleThreshold = PI / 30; // Example threshold for angle changes (adjust as needed)
float positionThreshold = 10; // Example threshold for position changes (adjust as needed)


// Last known positions for markers
HashMap<Integer, PVector> lastPositions = new HashMap<Integer, PVector>();


boolean marker0Detected = false;


void setup() {
  // Change screen size based on device
  if (iMac) {
    screen1W = 2240;
    screen1H = 1260;
  } else {
    screen1W = 1728;
    screen1H = 1117;
  };


img = loadImage("overlay.png");
if (img == null) {
  println("Image not found");
} else {
  println("Image loaded");
}


fullScreen();
surface.setSize(canvasW, canvasH);
// Change windows location based on device
if (iMac) {
  surface.setLocation(screen1W, 0);
} else {
  surface.setLocation(0, 0);
};


smooth();


// Initialize color pairs
generateColors();


  // Initialize the TUIO client and start listening to TUIO messages
  tuioClient = new TuioProcessing(this);
```

```
  // Create and run the second sketch
  child = new ChildApplet();
  String[] args = { “ChildApplet” };
  PApplet.runSketch(args, child);


  // Delay to ensure the second sketch initializes
  delay(1000);


  // Set the image in the second sketch
  child.setImage(img);
}


void draw() {
  background(255); // Set the background to white
  blendMode(DIFFERENCE); // Set the blend mode to difference

  //image(img, 0, 0);


  updateVertices();  // Define shape vertices
  setShape(); //Set current shape
  setAngle();


  ArrayList<TuioObject> tuioObjects = tuioClient.getTuioObjectList();
  handleTuioObjects(tuioObjects);  // Handle all TUIO objects for various controls


  checkInactivity(); // Check for inactivity and reset values if needed


  // Start SVG recording
  startRecording();

  // Interpolate the attractor’s position and impact smoothly
    if (attractorActive) {
      attractorX = lerp(prevAttractorX, attractorX, 0.1);  // Adjust the 0.1 factor to control speed
      attractorY = lerp(prevAttractorY, attractorY, 0.1);
      attractorImpact = lerp(prevAttractorImpact, attractorImpact, 0.1);
    }


  // Lerp the current values towards the target values
  currentScale = lerp(currentScale, targetScale, 0.05); // Adjust lerp factor to change smoothing speed
  currentAngle = lerp(currentAngle, targetAngle, 0.05); // Adjust lerp factor to change smoothing speed
  currentSize = lerp(currentSize, targetSize, 0.05); // Adjust lerp factor to change smoothing speed
  currentGap = lerp(currentGap, targetGap, 0.05); // Adjust lerp factor to change smoothing speed


  drawShapes();


  // End SVG recording
  endRecording();


  // Draw the spotlight circles
  //drawSpotlight(tuioObjects);


  // Display “SAVED” message
  if (showMessage && messageTimer > 0) {
    // Temporarily reset blend mode to ensure visibility
    blendMode(NORMAL);
    fill(0);  // Black text
    textSize(50);
    textAlign(CENTER, CENTER);
    rectMode(CENTER);  // Ensure the rectangle is centered
    fill(255);  // White rectangle
    rect(width / 2, height / 2, textWidth(“SAVED”) + 20, 60);  // Background for text
    fill(0);  // Black text
    text(“SAVED”, width / 2, height / 2);


    // Restore blend mode if necessary
    blendMode(DIFFERENCE);


    // Prevent message from being saved
    if (recording) {
      endRecord();
      recording = false;
    }
  }


  // Timer logic for “SAVED” message display
  if (showMessage) {
    if (messageTimer > 0) {
      messageTimer--;
      println(messageTimer);
    } else {
      showMessage = false;  // Stop showing the message
    }
  }


  // Display frame rate
  displayFrameRate();
}


// Function to generate file name based on date and time
String generateFilename() {
  String timestamp = year() + nf(month(), 2) + nf(day(), 2) + “_” +
    nf(hour(), 2) + nf(minute(), 2) + nf(second(), 2);
  return timestamp + “_DigitalZellij”;
}


// Function to hangle pressed keys
void keyPressed() {
  if (key == ‘s’ || key == ‘S’) { // Save SVG when s key is pressed
    String filename = generateFilename();
    recording = true;
    showMessage = true;
    messageTimer = messageDuration;
  } else if (key == ‘r’ || key == ‘R’) { // Reset gap and scale when r key is pressed
    resetValues();
  } // else if (key == ‘1’ || key == ‘+’) { // Cycle through the shapes
  //  currentShape = (currentShape + 1) % numShapes;
  //} else if (key == ‘2’ || key == ‘”’) { // Switch grid types
  //  if (hexGrid) {
  //    hexGrid = false;
  //  } else {
  //    hexGrid = true;
  //  }
```

```
  //} else if (key == '3' || key == '*') { // Cycle through the color schemes
  //  colorScheme = (colorScheme + 1) % numColorSchemes;
  //} else if (key == '4' || key == 'ç') { // Update colors
  //  primaryColor = color(random(0, 255), random(0, 255), random(0, 255));
  //  color1 = primaryColor;
  //  secondaryColor = color(random(0, 255), random(0, 255), random(0, 255));
  //  color2 = secondaryColor;


  //} else if (key == '5' || key == '%') { // Switch primary and secondary colors
  //  if (primaryColor == color1) {
  //    primaryColor = color2;
  //    secondaryColor = color1;
  //  } else {
  //    primaryColor = color1;
  //    secondaryColor = color2;
  //  }
  //}
}


// Function to define shape vertices
void updateVertices(){
  float r = currentSize / (2 * cos(PI / 8));  // Radius based on the width 'currentSize'


  // Define Vertices of triangle
  for (int i = 0; i < 3; i++) {
    // Calculate angle in radians, adjusting by -PI/2 to start from the top
    float angle = TWO_PI * i / 3 - PI / 2;
    // Calculate x and y based on the angle
    triangleVertices[i][0] = r * cos(angle);
    triangleVertices[i][1] = r * sin(angle);
  };


  // Define Vertices of square
  for (int i = 0; i < 4; i++) {
    // Calculate angle in radians, adjusting by -PI/2 to start from the top
    float angle = TWO_PI * i / 4 - PI / 2;
    // Calculate x and y based on the angle
    squareVertices[i][0] = r * cos(angle);
    squareVertices[i][1] = r * sin(angle);
  };


  // Define Vertices of hexagon
  for (int i = 0; i < 6; i++) {
    // Calculate angle in radians, adjusting by -PI/2 to start from the top
    float angle = TWO_PI * i / 6 - PI / 2;
    // Calculate x and y based on the angle
    hexagonVertices[i][0] = r * cos(angle);
    hexagonVertices[i][1] = r * sin(angle);
  };


  // Define Vertices of octagon
  for (int i = 0; i < 8; i++) {
    // Calculate angle in radians, adjusting by -PI/2 to start from the top
    float angle = TWO_PI * i / 8 - PI / 2;
    // Calculate x and y based on the angle
    octagonVertices[i][0] = r * cos(angle);
    octagonVertices[i][1] = r * sin(angle);
  };


  // Define Vertices of circle
  for (int i = 0; i < 64; i++) {
    // Calculate angle in radians, adjusting by -PI/2 to start from the top
    float angle = TWO_PI * i / 32 - PI / 2;
    // Calculate x and y based on the angle
    circleVertices[i][0] = r * cos(angle);
    circleVertices[i][1] = r * sin(angle);
  };


  // Define Vertices of star1
  float star1OuterRadius = r * 0.707;  // Adjust this to scale the longer spikes
  float star1InnerRadius = r * 0.541;  // Adjust this to scale the shorter spokes
  for (int i = 0; i < 16; i++) {
    float angle = PI / 8 * i;  // There are 16 vertices, spaced by PI/8 radians
    float radius = i % 2 == 0 ? star1OuterRadius : star1InnerRadius;  // Alternate between outer and inner radius

    star1Vertices[i][0] = radius * cos(angle);
    star1Vertices[i][1] = radius * sin(angle);
  };


  // Define Vertices of star2
  float star2OuterRadius = r * 1.307;  // Adjust this to scale the longer spikes
  float star2InnerRadius = r * 0.707;  // Adjust this to scale the shorter spokes
  for (int i = 0; i < 16; i++) {
    float angle = PI / 8 * i;  // There are 16 vertices, spaced by PI/8 radians
    float radius = i % 2 == 0 ? star2OuterRadius : star2InnerRadius;  // Alternate between outer and inner radius

    star2Vertices[i][0] = radius * cos(angle);
    star2Vertices[i][1] = radius * sin(angle);
  };
}


// Function to switch between angles
void setAngle() {
  targetAngle = (currentSetAngle % 24) * (PI / 12);
}


// Function to switch between shapes
void setShape(){
  switch (currentShape) {
    case 0: // Triangle
      currentShapeVertices = triangleVertices;
      break;
    case 1: // Square
      currentShapeVertices = squareVertices;
      break;
    case 2: // Hexagon
      currentShapeVertices = hexagonVertices;
      break;
    case 3: // Octogon
      currentShapeVertices = octagonVertices;
      break;
    case 4: // Circle
      currentShapeVertices = circleVertices;
      break;
```

```
      case 5: // Star1
        currentShapeVertices = star1Vertices;
        break;
      case 6: // Star2
        currentShapeVertices = star2Vertices;
        break;
  }
}


// Function to switch between color schemes
void setColorScheme(float i, float j) {
  //noStroke();


  color primaryColor =
primaryColors[currentPrimaryColorIndex];
  color secondaryColor =
secondaryColors[currentSecondaryColorIndex];


  // Check if colors need to be swapped (based on
marker presence or another condition)
  if (colorSwapped) {
    color temp = primaryColor;
    primaryColor = secondaryColor;
    secondaryColor = temp;
  }


 // Apply color based on the current color scheme
 switch (colorScheme) {
  case 0: // Uniform color
    fill(primaryColor);
    break;
  case 1: // Checkerboard pattern
    if ((i + j) % 2 == 0) fill(primaryColor);
    else fill(secondaryColor);
    break;
  case 2: // Alternating rows
    if (i % 2 == 0) { // On even rows
      if (j % 2 == 0) fill(primaryColor);
      else fill(secondaryColor);
    } else { // Staggered alternating rows
      fill(primaryColor);
    }
    break;
  case 3: // Staggered alternating rows
    if (i % 4 == 2) { // Every fourth row starting
from the third
      if ((j + 1) % 2 == 0) fill(primaryColor);  // Shift
coloring by one column
      else fill(secondaryColor);
    } else if (i % 2 == 0) { // Other even rows
      if (j % 2 == 0) fill(primaryColor);
      else fill(secondaryColor);
    } else { // Odd rows
      fill(primaryColor);
    }
    break;
  case 4: // Outlines only
    noFill();
    stroke(strokeColor);
    strokeWeight(1);
    break;
  case 5: // Outlines inverted for saving only
    noFill();
    stroke(exportStrokeColor);
    strokeWeight(1);
```



```
    break;
  }
}


// Function to handle various TUIO objects and
their specific roles
void handleTuioObjects(ArrayList<TuioObject>
tuioObjects) {
  boolean marker15Detected = false;
  boolean marker16Detected = false;
  boolean marker17Detected = false;
  boolean marker18Detected = false;
  marker0Detected = false;
  boolean significantChangeDetected = false;


  for (TuioObject obj : tuioObjects) {
    float angle = obj.getAngle();
    int symbolID = obj.getSymbolID();
    int segment;


    // Get current position of the marker
    PVector currentPosition = new PVector(obj.
getScreenX(width), obj.getScreenY(height));
    PVector lastPosition = lastPositions.
get(symbolID);


    // Check for significant position changes
    if (lastPosition != null && PVector.
dist(currentPosition, lastPosition) >
positionThreshold) {
      significantChangeDetected = true;
    }


    // Update last positions
    lastPositions.put(symbolID, currentPosition);


    switch (symbolID) {
      case 0:
        // Map the rotation angle of marker 12 to
switch between shape targetAngle
        segment = int(obj.getAngle() / (TWO_PI /
numAngles));
        currentSetAngle = segment % numAngles;
        //significantChangeDetected = true;
        break;
      case 1:
        // Incrementally adjust targetSize
        float newScale = incrementValue(targetScale,
lastAngleSize, angle, minScale, maxScale);
        if (abs(newScale - targetScale) >
angleThreshold) {
          targetScale = newScale;
          lastAngleSize = angle;
          //significantChangeDetected = true;
        }
        break;
      case 2:
        // Incrementally adjust targetGap
        float newGap = incrementValue(targetGap,
lastAngleGap, angle, minGap, maxGap);
        if (abs(newGap - targetGap) >
angleThreshold) {
          targetGap = newGap;
          lastAngleGap = angle;
          //significantChangeDetected = true;
        }
        break;
```

```
      case 3:

        // Map the rotation angle of marker ID 3 to
control targetShape

        segment = int(obj.getAngle() / (TWO_PI /
numShapes));

        if (currentShape != segment % numShapes) {

          currentShape = segment % numShapes;

          //significantChangeDetected = true;

        }

        break;

      case 4:

        // Switch to hexagonal grid if present

        if (!hexGrid) {

          hexGrid = true;

          //significantChangeDetected = true;

        }

        break;

      case 5:

        // Switch to square grid if present

        if (hexGrid) {

          hexGrid = false;

          //significantChangeDetected = true;

        }

      case 6:

        // Map the rotation angle of marker ID 5 to
control colorScheme

        segment = int(angle / (TWO_PI /
numColorSchemes));

        if (colorScheme != segment %
segmentSwitch) {

          colorScheme = segment % segmentSwitch;

          //significantChangeDetected = true;

        }

        break;
```



```
      case 7:

        // Map the presence of marker ID 13 to set
colorScheme to outline

        if (colorScheme != 4) {

          colorScheme = 4;

          //significantChangeDetected = true;

        }

        break;

      case 8:

        // Map the rotation angle of marker ID 6 to
control primary color

        segment = int(angle / (TWO_PI /
numColors));

        if (currentPrimaryColorIndex != segment %
numColors) {

          currentPrimaryColorIndex = segment %
numColors;

          //significantChangeDetected = true;

        }

        break;

      case 9:

        // Map the rotation angle of marker ID 14 to
control secondary color

        segment = int(angle / (TWO_PI /
numColors));

        if (currentSecondaryColorIndex != segment
% numColors) {

          currentSecondaryColorIndex = segment %
numColors;

          //significantChangeDetected = true;

        }

        break;

      case 10:

        // Switch to secondary color

        if (!foundMarker11) {

          foundMarker11 = true;

          foundMarker12 = false;

          swapColors();

          //significantChangeDetected = true;

        }

        break;

      case 11:

        // Switch to primary color

        if (!foundMarker12) {

          foundMarker12 = true;

          foundMarker11 = false;

          swapColors();

          //significantChangeDetected = true;

        }

        break;

      case 12:

        // Update the target position and impact for
the attractor

        prevAttractorX = attractorX;

        prevAttractorY = attractorY;

        prevAttractorImpact = attractorImpact;

        // Attractor's position and impact factor

        attractorX = obj.getScreenX(width);

        attractorY = obj.getScreenY(height);



        // Normalize the angle change

        float deltaAttractorAngle =
normalizeAngleChange(lastAttractorAngle, angle);

        cumulativeImpactAngle +=
deltaAttractorAngle;

        cumulativeImpactAngle =
constrain(cumulativeImpactAngle, -TWO_PI,
TWO_PI); // Constrain cumulative impact angle

        lastAttractorAngle = angle;

        // Map the cumulative impact angle to
attractor impact

        attractorImpact =
map(cumulativeImpactAngle, -TWO_PI, TWO_PI,
minImpact, maxImpact);

        attractorImpact = constrain(attractorImpact,
minImpact, maxImpact);



        attractorActive = true;

        //significantChangeDetected = true;

        break;

      // Handle removal or absence of the attractor
marker

      case 13:

        // Attractor's position and impact factor

        if (attractorActive) {

          attractorActive = false;

          cumulativeImpactAngle = 0;  // Reset the
cumulative impact angle

          //significantChangeDetected = true;

        }

        break;

      case 14:

        // Marker 1 for saving

        marker15Detected = true;

        //significantChangeDetected = true;

        break;

      case 15:

        // Marker 2 for saving

        marker16Detected = true;

        //significantChangeDetected = true;

        break;

      case 16:

        // Marker 1 for resetting
```

```
      marker17Detected = true;
      //significantChangeDetected = true;
      break;
    case 17:
      // Marker 2 for resetting
      marker18Detected = true;
      //significantChangeDetected = true;
      break;
    }
  }


  // Check save trigger conditions
  if (marker15Detected &&
!savemarker15Detected) {
    savemarker15Detected = true;
    savemarker16Detected = false;
    if (!saveTriggeredByMarker1) {
      saveTriggeredByMarker1 = true;
      saveTriggeredByMarker2 = false;
      startSaveProcedure();
    }
  } else if (marker16Detected &&
!savemarker16Detected) {
    savemarker16Detected = true;
    savemarker15Detected = false;
    if (!saveTriggeredByMarker2) {
      saveTriggeredByMarker2 = true;
      saveTriggeredByMarker1 = false;
      startSaveProcedure();
    }
  } else if (!marker15Detected &&
!marker16Detected) {
    savemarker15Detected = false;
    savemarker16Detected = false;
  }


  // Check reset trigger conditions
  if (marker17Detected &&
!resetmarker17Detected) {
    resetmarker17Detected = true;
    resetmarker18Detected = false;
    if (!resetTriggeredByMarker16) {
      resetTriggeredByMarker16 = true;
      resetTriggeredByMarker17 = false;
      resetValues();
    }
  } else if (marker18Detected &&
!resetmarker18Detected) {
    resetmarker18Detected = true;
    resetmarker17Detected = false;
    if (!resetTriggeredByMarker17) {
      resetTriggeredByMarker17 = true;
      resetTriggeredByMarker16 = false;
      resetValues();
    }
  } else if (!marker17Detected &&
!marker18Detected) {
    resetmarker17Detected = false;
    resetmarker18Detected = false;
  }


  // Update last activity time and flag if a significant
change was detected
  if (significantChangeDetected) {
    lastActivityTime = millis();
    activityDetected = true;
```



```
  }
}


// Function to normalize the angle change to avoid
wrap-around issues
float normalizeAngleChange(float lastAngle, float
currentAngle) {
  float deltaAngle = currentAngle - lastAngle;

  if (deltaAngle > PI) {
    deltaAngle -= TWO_PI;
  } else if (deltaAngle < -PI) {
    deltaAngle += TWO_PI;
  }

  return deltaAngle;
}


// Function to incrementally adjust a value based
on angle changes
float incrementValue(float currentValue, float
lastAngle, float currentAngle, float minValue, float
maxValue) {
  float deltaAngle = currentAngle - lastAngle;

  // Adjust for angle wrap-around
  if (deltaAngle > PI) {
    deltaAngle -= TWO_PI;
  } else if (deltaAngle < -PI) {
    deltaAngle += TWO_PI;
  }

  // Calculate the increment based on the
deltaAngle
  float increment = map(deltaAngle, -PI, PI, -1, 1) *
(maxValue - minValue) / 5; // Adjust the divisor for
finer control

  // Increment the current value and constrain it to
the min and max values
  currentValue += increment;
  currentValue = constrain(currentValue, minValue,
maxValue);

  return currentValue;
}


// Function to start the save procedure
void startSaveProcedure() {
  String filename = generateFilename();
  recording = true;
  showMessage = true;
  messageTimer = messageDuration;
}


// Function to draw rotating shapes on grid
void drawRotatingShape(float x, float y, float
angle, float[][] vertices, float size) {
  pushMatrix(); // Save the current transformation
matrix
  translate(x, y); // Translate to the center position
of the square
  rotate(angle); // Rotate by the given angle

  // Check colorScheme and apply stroke only if
it's the fifth scheme
  if (colorScheme == 4 || colorScheme == 5) {
  } else {
    noStroke(); // This ensures that other schemes
don't get an unintended stroke
```

```
  }


  // Draw the shape centered at the new origin
  beginShape();
  for (int i = 0; i < vertices.length; i++) {
    vertex(vertices[i][0] * size / currentSize,
vertices[i][1] * size / currentSize);
  }
  endShape(CLOSE);
  popMatrix(); // Restore the previous
transformation matrix
}


void drawShapes() {
  pushMatrix(); // Save the current transformation
matrix


  // Calculate effective spacing
  float effectiveSpacingX = hexGrid ? 0.937 *
currentGap : currentGap;
  float effectiveSpacingY = hexGrid ? 0.937 *
sin(PI / 3) * currentGap : currentGap;
  effectiveSpacingX *= currentScale;
  effectiveSpacingY *= currentScale;


  int cols = floor(canvasW / effectiveSpacingX);
  int rows = floor(canvasH / effectiveSpacingY);


  // Draw the grid of rotating shapes using the
current color scheme
  for (int i = - 10; i < rows + 10; i++) {
    for (int j = - 10; j < cols + 10; j++) {
      float x = j * effectiveSpacingX + (hexGrid && i
% 2 == 1 ? effectiveSpacingX / 2 : 0);
      float y = i * effectiveSpacingY;
      setColorScheme(i, j);  // Set color or stroke
based on the current scheme


      float size = currentSize * currentScale;  //
Apply the scaling factor to the size


      if (attractorActive) {
        float distance = dist(x, y, attractorX,
attractorY);
        float normalizedDistance = map(distance, 0,
max(width, height), 0, 1);
        float sizeFactor = lerp(1, 2, (1 -
normalizedDistance) * attractorImpact);  //
Interpolate between 1 and 2 based on distance
and impact
        size = lerp(minSize, maxSize, sizeFactor *
(targetSize - minSize) / (maxSize - minSize));  //
Apply size factor
        size *= currentScale;  // Apply the scaling
factor to the size
        // Ensure size does not go below 0
        size = max(size, 0);
      }


      drawRotatingShape(x, y, currentAngle,
currentShapeVertices, size);
    }
  }


  popMatrix(); // Restore the previous
transformation matrix
}


// Function to generate colors
void generateColors() {
  for (int i = 0; i < numColors; i++) {
    primaryColors[i] = color(random(255),
random(255), random(255));  // Primary color
    secondaryColors[i] = color(random(255),
random(255), random(255));  // Secondary color
  }
}


// Function to swap colors
void swapColors() {
  color temp =
primaryColors[currentPrimaryColorIndex];
  primaryColors[currentPrimaryColorIndex] =
secondaryColors[currentSecondaryColorIndex];
  secondaryColors[currentSecondaryColorIndex]
= temp;
}


// Function to draw spotlight circles
void drawSpotlight(ArrayList<TuioObject>
tuioObjects) {
  for (TuioObject obj : tuioObjects) {
    //if (obj.getSymbolID() == 0) {
      blendMode(BLEND);
      fill(255);
      circle(obj.getScreenX(width), obj.
getScreenY(height), 100);
    //}
  }
}


// Function to start SVG recording
void startRecording() {
  if (recording) {


    // Save the current state of drawing to a TIFF
with the original color scheme
    String tiffFilename = “tiff/” + generateFilename()
+ “.tif”;
    drawShapes();  // Function to draw shapes
using the current color scheme
    save(“data/” + tiffFilename);


    // Change to outline only color scheme for SVG
    lastColorScheme = colorScheme;  // Store the
current color scheme
    colorScheme = 5;  // Set to outlines only mode
    String svgFilename = “svg/” +
generateFilename() + “.svg”;
    beginRecord(SVG, “data/” + svgFilename);
    //clip(0, 0, canvasW, canvasH);


    // Delay to ensure the second sketch initializes
    delay(1000);


    // Load and display the TIFF image in the
second window
    backgroundImg = loadImage(tiffFilename);
    child.setBackgroundImage(backgroundImg);
  }
}


// Function to end SVG recording
void endRecording() {
  if (recording) {
    endRecord();
    recording = false;
    println(“SVG and TIFF saved.”);


    // Restore the original color scheme after SVG
```

```
recording

    colorScheme = lastColorScheme;

  }

}


// Function to display frame rate

void displayFrameRate() {

  fill(255);

  textSize(30);

  text("FPS: " + frameRate, 100, 100);

}


// Function to reset gap and scale values to their
defaults

void resetValues() {

  targetGap = (minGap + maxGap) / 2;

  targetScale = 1.0;

}


// Function to check for inactivity and reset values
if needed

void checkInactivity() {

  if (activityDetected && (millis() - lastActivityTime
> inactivityThreshold)) {

    resetValues();

    activityDetected = false;

    println("Reset due to inactivity");

  }

}


// Required TUIO event handling methods

void addTuioObject(TuioObject obj) {

  if (obj.getSymbolID() == 0) {
```



```
    // Initialize lastAngleMarker0 when marker 0 is
first detected

    lastAngleMarker0 = obj.getAngle();

  }

  redraw(); // Trigger a redraw when a new object
is added

}


void updateTuioObject(TuioObject obj) {

  redraw(); // Trigger a redraw when an object is
updated

}


void removeTuioObject(TuioObject obj) {

  if (obj.getSymbolID() == 0) {

    // Do not reset cumulativeAngle here to
preserve the current value

    marker0Detected = false; // Marker 0 is no
longer detected

  }

  redraw(); // Trigger a redraw when an object is
removed

}


void refresh(TuioTime bundleTime) {

  // Called after all TUIO data has been processed
for the current frame

}
```

B.2. ChildApplet

```
class ChildApplet extends PApplet {

  PImage overlayImage;

  PImage backgroundImage;


  public ChildApplet() {

    super();

  }


  public void settings() {

    fullScreen(); // Make the child window full
screen

  }


  public void setup() {

    background(255); // white background if image
is not found

  }


  public void draw() {

    synchronized (this) {

      if (backgroundImage != null) {

        image(backgroundImage, 0, (height - (height
* 2.2 / 3)) / 2, width * 2.2 / 3, height * 2.2 / 3); //
Draw the TIFF image to fill the screen

      } else {

        background(255); // Fallback to white
background if image is not loaded

      }

      if (overlayImage != null) {

        image(overlayImage, 0, 0, width, height); //
Draw the overlay image to fill the screen

      }

    }

  }


  public synchronized void setImage(PImage img)
{

    overlayImage = img; // Assign the image
passed from the main application

  }


    public synchronized void
setBackgroundImage(PImage img) {

    backgroundImage = img; // Assign the
background image passed from the main
application

  }


}
```