PROCEEDINGS

Estonian Academy of Arts
Faculty of Architecture

SPACE AND DIGITAL REALITY: IDEAS, REPRESENTATIONS/ APPLICATIONS AND FABRICATION

10/2020

CONFERENCE: SPACE AND DIGITAL REALITY

IDEAS, REPRESENTATIONS/ APPLICATIONS AND FABRICATION

11 September 2019
Estonian Academy of Arts

Programme

8:45 Registration and coffee

9:00 Opening addresses

9:30 Keynote: Mario Carpo — The rise of computational brutalism

10:15 Questions and coffee

10:30 Gilles Retsin — The case for a fully automated timber architecture

10:45 Siim Tuksam — Modulated modularity: From mass customisation to custom mass production

11:00 Dagmar Rainhardt — Robotic braille: Combining tactile and visual narratives

11:15 Sille Pihlak — Protocolling prototypes / prototyping protocols

12:00 Lunch

12:45 Keynote: Roland Snooks — Strange behaviour

1:45 Roemer van Toorn — The new normal: A goodbye to language

2:00 Annarita Papeschi — Transindividual urbanism: Novel territories of participatory practices

2:15 Adria Carbonell — The solid matter(s) of digital nature

2:30 Wolfgang Schwarzmann — How does new technology provided by industry 4.0 change the job of a carpenter?

2:45 Questions and coffee

3:00 Keynote: Antoine Picon — Atoms and bits: Taking their hybridisation seriously

3:45 Keynote panel and discussion

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This conference was part of the Tallinn Architecture Biennale TAB 2019 programme

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HOW NEW TECHNOLOGIES CAN PROMOTE THE REINTRODUCTION OF TRADITIONAL KNOWLEDGE IN THE PROFESSION OF A CARPENTER

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Abstract

The ongoing transformation process driven by industry 4.0, will affect almost each and every thing in our environment. This change may take several decades; however, already today an impact on the daily work of a carpenter can be observed.

In Central Europe, new CNC robots are installed in many carpentry workshops. These machines provide quality and productivity using the current state-of-the-art technology. Emerging from this technological change, benefits to production according to speed, precision and reliability can be expected. Besides these advantages, a process of transformation with regard to knowledge and tradition will occur that can be understood as the beginning of a radical transformation. Embedded in the theoretical foundation of Actor-Network Theory (ANT), the profession of a carpenter has to be interpreted as being part of a constantly shifting network of relationships. Based on this social theory, it is possible to interpret the technological change as a new driving force, which changes the perspective of this profession. In this paper we compare two case studies from different centuries. By taking a closer look at the manufacturing process of a 'zig-zag' joint, old and new techniques are compared and evaluated, focusing on the integration of a CNC-joinery machine. Only by making use of these new technological solutions was an economic reintroduction of this 'zig-zag' joint possible. Furthermore, the successful adaption of this joint was only possible because the carpenter could provide specific knowledge, crucial for programming the robot and later assembling the material. Technology will make a carpenter faster and more cost-efficient, but without doubt, the core elements of his profession will be affected by the change. This research will promote further discussion for future developments in how digital technologies and physical production might act together.

Keywords: carpenter, Industry 4.0, digital transformation, tradition, handcraft, actor-network theory

1. Introduction

In Central Europe, the costs of erecting a building were constantly rising in recent decades. For example, in Germany, wooden components produced by a carpenter increased by 2.7% between August 2018 and August 2019 (Statistisches Bundesamt 2019, 8). Since the end of this development is not possible to predict, industry is forced to find new solutions for how to deal with these rising costs. One approach to lowering these increasing prices is a reduction of manual labour by shifting to automatic solutions. Nowadays, these technological solutions are already common in the car industry but might be surprisingly new in manual labour jobs like carpentry.

The profession of a carpenter can rely on a rich and long history. This job was always been in a close and direct relationship to the processed material. In recent years, more and more workshops have started to invest in CNC-joinery machines. By implementing these new technologies in existing structures, former processes start to shift. The presence of a CNC-joinery machine certainly changes the relationship between a carpenter and the processed material. In this paper, we are going to make a comparison that will examine how this shift in the structures can lead to new possibilities in the profession of a carpenter.

2. Background

2.1 The profession of a carpenter

The profession of a carpenter can be described as being an expert on structural wood constructions. In comparison to a joiner, whose daily work focuses more on interior elements like doors, windows and furniture, the carpenter is responsible for all kinds of loadbearing wooden parts of a building. These parts are mostly of a larger scale and weight, leading to the frequent use of machines like a crane, a forklift and other tools for reducing physical workload (Herres 2016, 38).

2.2 The profile of a CNC-joinery machine

A CNC-joinery machine is a computerised machine-centre with a variety of different manipulation tools. In comparison to a band saw or a circular saw, the machine itself can conduct all kinds of operations relating to the processing of materials. While most of 'traditional' electric tools need a skilled carpenter to guide the machine by hand, a CNC-joinery machine can conduct almost all tasks autonomically (Schindler 2009, 194). These processes are under the supervision of a machine operator. A huge advantage in comparison to manual work is the significant increase in terms of issues like processing time and accuracy of editing. Even though the job-specific programming of the CNC-joinery machine will claim some time, the process as a whole can show a number of economic benefits (mikado n.d.).

Since the early 1980s, machine-suppliers were able to deliver robots that could handle numerous manual tasks normally performed by a carpenter. With more than 5,000 globally shipped machines so far, the self-claimed world market leader for CNC-joinery machines Hans Hundegger AG can prove the high acceptance of their products (Hans Hundegger AG n.d.). These machines are constructed in close collaboration with the end users. The company can be seen as the general contractor in the case of engineering, constructing, installing and implementing a new machine in an existing workshop (Hans Hundegger AG n.d.). Furthermore, they offer a 24-hour hotline service to support local carpenters whenever hardware or software-based problems emerge. Therefore, industry not only targets the goals a carpenter might address, but already has already been meeting their needs for almost 30 years.

2.3 Industry 4.0, in the environment of a carpenter?

The previous description of what a carpenter might require and what a CNC-joinery machine might be capable of, leads to the question of how these two issues accompany topics like industry 4.0. On closer inspection of the solutions that might be available, investigations revealed that software companies already provide solutions to integrate a CNC-joinery machine in the world of the IoT (Internet of Things). Solutions like the platform 'tapio.one' provide services like real-time machine monitoring, material-flow-optimisation or machine-supporting cloud-backups. These applications can be implemented into an existing structure and are later accessed via a smartphone or tablet (Volm and Neumann, n.d.).

The ongoing transformation of processes relating to Industry 4.0 will not only affect single tasks but soon change the whole business process of a company (Vollmer et al. 2017, 44). Even though experts are unsure about when and how this transformation will substitute jobs, there is general agreement on the significant reduction of repetitive tasks (Vollmer et al. 2017, 61). This paper will take a closer look at what kinds of teamwork the new technologies and traditional knowledge might promote.

3. Methodology

In this research, our approach was to describe how technology can reintroduce knowledge, anchored in traditional ways of manufacturing. Two case studies, each from another period in history, are compared in terms of construction and fabrication techniques. This paper focuses on the application of one specific wooden joint, later described as the 'zig-zag' joint. Due to the infrequent occurrence of this joint over recent decades, its recent reappearance has to be seen as a remarkable phenomenon.

3.1 Actor-Network Theory applied to the profession of a carpenter

'The machine is not only a tool, it's more like a partner' (Belliger and Krieger 2006, 15). This quote already reveals fundamental points of 'Actor-Network Theory' (ANT). Following its line of argumentation, it is not possible to draw a strict separation between technology and society. According to Belliger and Krieger (2006), recent developments including *virtual reality, artificial intelligence* and *the process of digitisation*, further promote the blurring between humans and technology. They prefer to use the term 'Actants' (introduced by Bruno Latour) for human and non-human objects (Belliger and Krieger 2006, 15), in a constant process of alteration and movement.

In our research, the profession of a carpenter has to be seen as a node in a constantly changing network, the parameters of which might be culture, geography, nationality, or in our case, new technologies. In this study, we take a closer look at how the interwoven profession of the carpenter might have been influenced due to the new presence of the CNC-joinery machine.

3.2 Two case studies

To provide a better understanding of where this new emerging 'hybrid knowledge' might appear, an example shall be given. In the following sub-section, a comparison is made of two different wooden construction details. The first is a wooden composite beam from 1740 (Fig. 2). The 270-year-old beam was part of a research project and had to be replaced by a new fabricated one (Rug et al. 2012, 29). In 1740, solutions for spanning wide spaces were limited. Whenever possible, craftspeople made use of timber framing. In this case, even more structural strength was needed. As can be seen in the image (Fig. 1), two horizontal beams of wood were stacked directly on top of each other. To further raise their bearing capacity, the flanking planes were interlocked using a specific 'zig-zag' cut. This rare and challenging wooden connection had to be manufactured with the highest possible precision. Only if all the wooden teeth interlocked perfectly, could the static effect be achieved. To secure the pieces in their position, threaded bolts were installed. Their primary function was to keep the wooden parts in place (Fig. 1).

Over time, technologies like glue-laminated wood could evolve. These new wooden materials significantly cut the need for manual labour. New production techniques made it possible to deliver custom-made chunks of wood of the right size, quality and strength for each application. The labour-intensive and hard to manufacture interlocking 'zig-zag' shape became obsolete (Rug et al. 2012, 26).

This leads us to the second case study. For a number of years, industry has been able to mass-produce glulam from beech. Thin layers of veneer are peeled from beech wood and pressed into almost any shape needed (Pollmeier n.d.). Due to its high density as a hardwood, beech can handle a broad spectrum of challenging structural applications. When constructing with wood, one fundamental challenge is where columns and beams meet at one point.

In 2019, the Office 'Hermann Kaufmann + Partner' designed a production building for the SWG Produktion Schraubenwerk Gaisbach GmbH (Jacob-Freitag n.d.). SWG is a company well-known for manufacturing high quality screws. The roof is constructed as a wooden framework made from beech glulam (SWG 2019). The common approach to structures like these is to connect wooden sticks with custom-made steel knots. In this project, the client SWG demanded a reduction of structural steel parts. This requirement forced the carpenter to work out an alternative approach to the joints in the wooden framework.

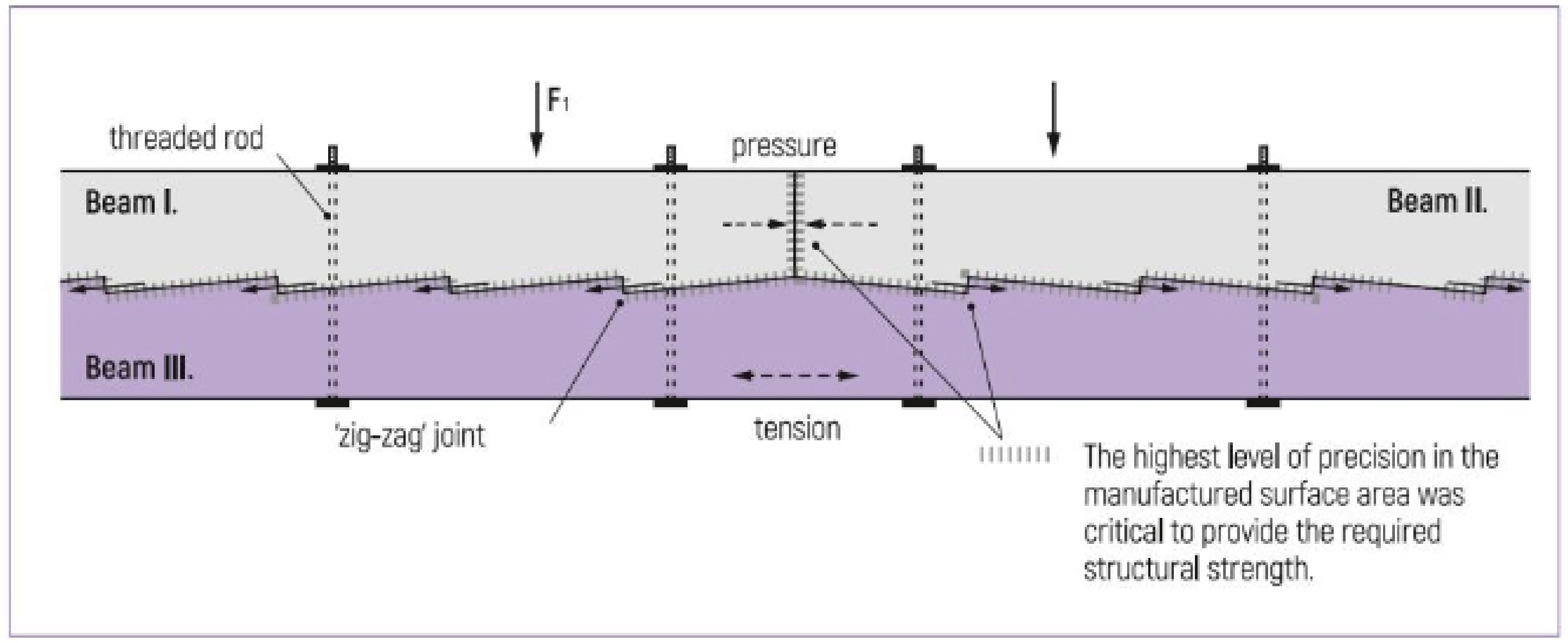

Fig. 1: Characteristics of the described traditional 'zig-zag' joint.

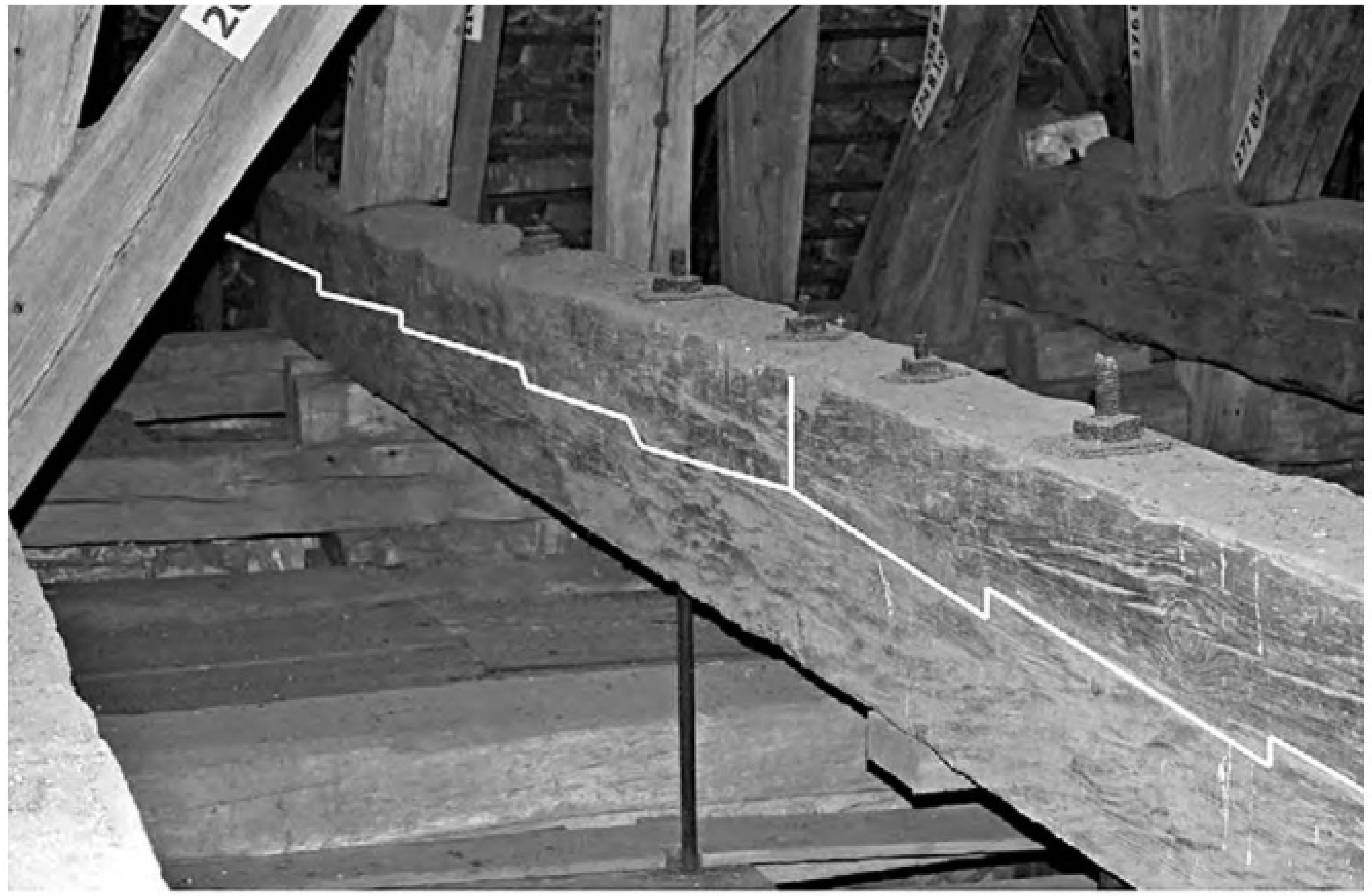

Fig. 2: Original composite beam from 1740 (Rug et al. 2012, 29).

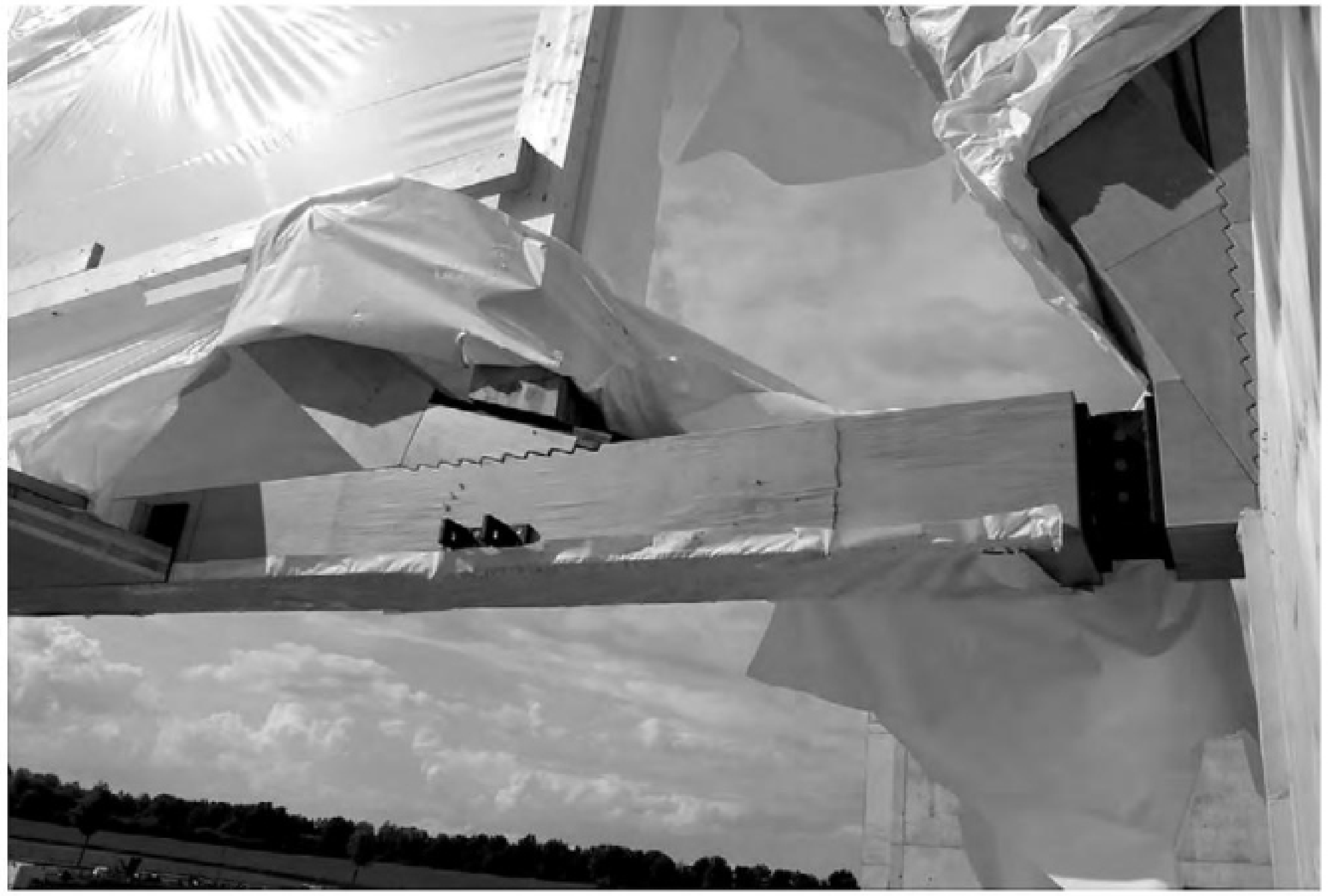

Fig. 3: Timber frame knot with 'zig-zag' joint
(Hermann Kaufmann + Partner ZT GmbH n.d.).

As can be seen in Fig. 3, their solution involved the integration of a 'zig-zag' shaped interlocking design. At some points, screws were needed to secure the wooden components in position. Only when unavoidable, additional steel parts were introduced. Structural and loadbearing functions are almost completely fulfilled by wooden parts.

In a personal interview, the carpenter confirmed that all the wooden processing operations in relation to the 'zig-zag' shape could be performed by their CNC-joinery machine. Furthermore, he mentioned that the milling tasks were carried out using a conventional milling head, normally used for cutting grooves.

3.3 Comparing the two case studies

Characteristics of the historic 'zig-zag' joint (1740):

(++) At that time one of the most suitable solutions for increasing the structural performance of wooden components (Rug et al. 2012, 26)
(+) all parts are easy demountable (reuse, recycling, replacing broken parts etc.)
(o) few metal pieces needed (nuts and bolts for securing the wood in position)
(-) very labour-intensive (multiple steps involving marking, cutting and chiselling)
(-) high precision needed (only skilled carpenter can perform this work)

Characteristics of contemporary 'zig-zag' joint (2019):

(++) CNC-joinery machine able to handle precision and speed in manageable amount of time
(+) overall reduction of steel parts in the framework
(o) knowledge of skilled carpenter for proper implementation of CNC-tool needed
(o) few metal-pieces needed (screws for securing the wood in position)
(-) only suitable for specific applications
(-) still more expensive (time, funds, manufacturing e.g.) than ordering a standard steel-piece

4. Results

When comparing these two case studies, it can be said that the motivation for manufacturing a 'composite beam' in 1740, is different than it might be for the recently erected SWG building. Over time, the manufacturing technique has changed dramatically when we compare the labour-intensive manual work and the machine-aided milling process. New technologies promote the frequent application of glue-laminated wood, and therefore eliminate the manual production of time-consuming operations, such as the 'zig-zag' joint. However, solutions for structural challenges are still an important issue to resolve. Although issues like wide spans can now be solved on a material basis; a robot might not substitute the creative new-combination of expert knowledge. Even though the motivation and background for these two applications emerge from different incentives, the implementation of this wooden joint did provide a suitable solution in both cases.

If we assume that in the first case study, the carpenter was using an axe or a saw as his most frequently used tool, it can be said that in the second case study, the contemporary carpenter mostly relied on the capabilities of his CNC-joinery machine. Following the argumentation of Schindler (2009, 223), the profession of a carpenter always evolved with the technological steps relevant in the surrounding society. These craftspeople are both making use of specific contemporary tools, common at the time they were working. In both cases, a skilled craftsperson made use of the 'zig-zag' shape. What really marks the unique achievement is the recombination of the knowledge to the tools offered, tailor made for a specific problem. Only the ability of an experienced carpenter can create a perfectly interlocking 'zig-zag' shape. Whether the professional makes use of an axe or a CNC-joinery machine need not be a determining factor in this comparison.

5. Summary and conclusion

In this work, we show how a rare wood joining technique can be re-introduced as a construction system in the 21st century. By comparing a traditional 'zig-zag' joint from 1740, and a contemporary 'zig-zag' joint from a recently erected building, similarities and differences in manufacturing can be illustrated. The first case study shows a traditional 'zig-zag' joint manufactured in 1740. It is the product of a labour-intensive process, where the production needed the knowledge and time of a skilled carpenter. The second case study shows a contemporary 'zig-zag' joint produced in 2019 by a carpenter in Germany. This solution was completely processed using a modern CNC-joinery machine. The labour-intensive processes of measuring, milling, and cutting were handed over to a computer-guided robot. The significant reduction in manufacturing time and cost could make this wooden connection compete with conventional solutions. Besides the fact that the carpenter made frequent use of the machine as the first key resource, his specific knowledge must be seen as the second crucial ingredient that finally led to a successful solution in the final product. As described by the carpenter, his specific knowledge caused him to propose this approach to joining wood with a 'zig-zag' shape, which is unconventional in today's industrial context. Furthermore, his particular programming skills and deep understanding of how to make use of a CNC-joinery machine gave him the ability to translate his expertise into a contemporary application of wood joinery. The cooperation of a skilled human and a programmable robot working together made it possible to find new solutions. Thanks to close cooperation, traditional methods of manufacturing might return to more contemporary applications. It can be argued that the establishment of a new application of 'hybrid knowledge' could be observed. Only if both 'Actants' have a deep understanding of their opponents' capabilities, might new applications emerge.

This paper focused on the comparison of how a special type of wood join can be interpreted in accordance with contemporary applied fabrication methods. Focus in this case could only be applied to a small part of this described network. Future work will be directed towards a deeper understanding of how the profession of a carpenter is currently influenced by new technologies to explore more recent applications.

Acknowledgements

I want to thank my Professor Urs Meister, along with Professors Dr Anne Brandl and Dr Christoph Michels, who provided expertise that greatly assisted this research.

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BIBLIOGRAPHY

Belliger, Andréa, and David J. Krieger, eds. 2006. *Anthology: Ein Einführendes Handbuch Zur Akteur-Netzwerk-Theorie*. Science Studies. Bielefeld: Transcript.

Hans Hundegger AG. 'Innovationen Für Den Holzbau: Image Brochure by Fa. Hundegger'. Accessed 9 October 2019. https://www.hundegger.de/fileadmin/Dateien/Web_pdf/Image-Broschures/Deutsch-Englisch/page.pdf.

Hermann Kaufmann + Partner ZT GmbH. 'SWG Schraubenwerk, Gaisbach | Hermann Kaufmann + Partner ZT GmbH'. Accessed 8 October 2019. https://www.hkarchitekten.at/projekt/swg-schraubenwerk-gaisbach/#lightbox-45.

Herres, Uli Matthias. 2016. *Spuren Des Handwerks: Der Einfluss Handwerklicher Herstellung Auf Die Architektur*. https://doi.org/10.3929/ethz-a-010738690.

Jacob-Freitag, Susanne. 'SWG Schraubenwerk, Gaisbach: SWG Baut Produktionshalle Aus Holz Und Eigenen Schrauben'. Accessed 8 October 2019. https://www.hkarchitekten.at/projekt/swg-schraubenwerk-gaisbach/.

mikado. 'Zimmerer Investieren in Die Zukunft: Maschineller Abbund'. Accessed 8 October 2019. https://www.hundegger.de/fileadmin/_migrated/content_uploads/2002-11_mikado_01.pdf.

Pollmeier, Ralf. 'Über BauBuche'. Accessed 8 October 2019. https://www.pollmeier.com/de/produkte/ueber-baubuche.

Rug, Wolfgang, Frank Thomas, Uwe Grimm, Guido Eichbaum, and Stephan Abel. 2012. 'Untersuchungen Zur Biegetragfähigkeit Von Verzahnten Balken'. Bautechnik, no. 89: 26–36. Accessed 8 October 2019. http://www.holzbau-statik.de/ibr/downloads/05_bestand/Biegetragfaehigkeit%20verzahnte%20Balken.pdf.

Schindler, Christoph. 2009. *Ein Architektonisches Periodisierungsmodell Anhand Fertigungstechnischer Kriterien, Dargestellt Am Beispiel Des Holzbaus.* ETH. Accessed 24 April 2019. https://doi.org/10.3929/ethz-a-005956976.

Statistisches Bundesamt. 2019. 'Preisindizes Für Die Bauwirtschaft: August 2019 [3. Vierteljahresausgabe]'. 17/4. Accessed 10 October 2019. https://www.destatis.de/DE/Themen/Wirtschaft/Preise/Baupreise-Immobilienpreisindex/Publikationen/Downloads-Bau-und-Immobilienpreisindex/bauwirtschaft-preise-2170400193234.pdf?__blob=publicationFile.

SWG Schraubenwerk Gaisbach GmbH Produktion. 2019. *Produktionshalle in Holzbauweise: Fertigung Der Haupt- Und Nebenträger*. Accessed 10 October 2019. https://youtu.be/oxfziZIUNcs.

Vollmer, Thomas, Steffen Jaschke, and Ulrich Schwenger, eds. 2017. *Digitale Vernetzung Der Facharbeit. Gewerblich-Technische Berufsbildung in Einer Arbeitswelt Des Internets Der Dinge*. Bielefeld: W. Bertelsmann Verlag.

Volm, Matthias, and Christian Neumann. 'What Is Tapio?' Accessed 8 October 2019. https://www.tapio.one/en/whatistapio.

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ROBOTIC BRAILLE AND SPATIAL MAPS: COMBINING TACTILE AND VISUAL NARRATIVES

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Abstract

Vision and tactility inform our cognition and perception of objects and environments. Yet there exist differentiations as to how perception is processed and formed, depending on unique and personal abilities for sensory cues. For people with low vision or blindness, tactile information processing posits a key approach to engage with and understand spaces, activities and interactions. This competence with tactility provides a rich context for current digital cultural practices that are predominantly informed by the visual, towards informed and complex materiality and space.

The empirical research discussed here explores an understanding of tactility through transfers of images and information, towards surface patterns and textures, and the integration of braille text. In support of tactile literacy for reading and assessing images and letters, the research develops a surface archive of tactile patterns. Scripting code is explored for design variability in terms of points, grids and line configurations and a six-axis ABB robot equipped with different routing tools for milling timber. This surface archive is further extended towards a prototype series of 'hyper-artefacts' — multi-functional furniture objects that integrate different sets of visual or pictorial information that can be 'decoded' by sight, and tactile information to be deciphered by braille experienced readers. By adopting a practice of Universal Design for equitable, simple and inclusive use and by combining tactile and visual narratives for diverse audiences, the research thus contributes to increasing our awareness, knowledge and understanding of other people's conditions, thus supporting positive changes in attitudes and behaviour, towards more inclusive environments.

Keywords: blind, braille, robotic milling, spatial maps