Parametric joinery. Development of a system of configurable joints

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Abstract

Making joints through traditional methods generally requires time and experience to be made properly and for this reason they are often an expression of quality and prestige. The development of joints is closely linked to design and fabrication technologies available and accessible in a given period. In fact, over the years, the joints have undergone adaptations based not only on specific needs, but also on the development of new tools and machines. Due to the difficulties of making a well-made joint through traditional methods, following the spread of economic fastening means, such as screws, all wooden joints have been partially replaced by joints that require accessories. The connection accessories offer various advantages, such as the realization of joints in less time and they do not require great manual skill compared to the realization of traditional joints. Despite these advantages, this type of joints could be responsible for several critical issues, in particular regarding the environmental impact, the aesthetics, the performance, and the ease of assembly and disassembly of the final product. Nowadays, the diffusion of numerical control production technologies and the development of computerized design techniques offer the possibility of further evolving this field. In fact, thanks to the development of these technologies it is possible to rethink the concept of all wooden joints that could solve the critical issues of the fastening means. However, designing and testing new joints could require time and particular resources. In addition, a new joint is developed based on the characteristics necessary for a given requirement and therefore its adaptation to components with different characteristics could not be immediate. As a result, these solutions could not be easily achievable by many small enterprises. The present research aims to experiment with parametric systems easily adaptable to the characteristics of the various projects and achievable by designers and small enterprises, which could improve their competitiveness.

Author keywords

parametric; joinery; digital fabrication; furniture.

Introduction

The joints between wooden components represent a crucial part for a piece of furniture. They are closely linked to fabrication and design technologies available and accessible in a given period. Over the years, the joints between wooden components have undergone adaptations based not only on specific needs, but also on the development of new processing tools (Bullar, 2013).

However, traditional joints generally take a lot of time and experience to be made in a proper way. For this reason, the development of technologies for the economic production of connection accessories, such as screws, has caused a change in this field. The connection accessories, allowing the creation of joints in less time and not requiring great manual skills compared to the creation of traditional joints, have had a considerable diffusion, going to partially replace all wooden joints.

Despite these advantages, joints that require accessories could be responsible for several critical issues. Firstly, the presence of accessories made of plastic or metal, could adversely affect the environmental impact of products, especially those made of sustainable and renewable materials, such as solid wood. At the same time, thanks to the absence of plastic and metal components, problems related to the disposal and recovery of end-of-life material are also alleviated. Secondly, many accessories, such as screws, could affect the aesthetics of the products and their performance, especially if they undergo more than one assembly/disassembly cycle. Finally, many accessories could make the products less inviting and engaging to assemble.

The development of numerical control production technologies offers the possibility of further evolving this field. In fact, thanks to this development it is possible to rethink the concept of completely wooden joints.

However, according to author's previous experience with the design of a wooden table-chairs set with new all wooden joints achievable through numerical control milling machines, the development of these solutions could require time and many experiments. In the same way its adaptation to the components with different characteristics could not be immediate. In fact, a new joint is developed based on the dimensions necessary for a given requirement and often it is not sufficient to simply scale the joint in various sizes, but it could be necessary to develop it to fit specifically each time. This is also due to features of the available tools, such as routers bits for CNC machines. This experience leads to investigate the parametric design to simplify the adaptability of new joints to components with different characteristics.

In parallel with the development of production technologies, we are also witnessing the evolution of computerized drawing techniques. Thanks to new design process, such as parametric design, the morphological complexity can be

managed through parameters for the variation of product characteristics, making it easier and faster to apply changes.

State of the art

Over time, several studies have investigated the creation of joints through digital fabrication. However, most of these projects focus on specific solutions for a given project, a process that could be onerous.

Other projects have investigated digital fabrication with the aim to facilitate the design phases. In particular, with regard to the possibility for designers and companies to design products with the help of joints abacuses, which, however, could only be useful on certain occasions. In this context, the following projects are highlighted: "50 Digital Joints", developed by Lab of the Hochschule für Gestaltung Offenbach, German; and "Numerical control joints", developed by the Italian magazine LegnoLab (2018).

Other projects have explored the potential of parametric and generative design to design connection solutions. Among these projects, there are both those that focus on additional pieces made using 3D printing to connect the various components and those that focus on joints to be made directly on the components.

Magrisso et al. (2018) present a project concerning the connection of wooden elements through plastic components made through 3D printing that act as bridges between the components.

However, the present research focuses on all wooden joints systems due to the issues highlighted regarding the accessories.

Zheng et al. (2017) present a project on parametric systems to be made through laser cutting technologies. In this case the field of application is not exclusive to furniture, and the materials can be various.

Biber, developed by Klaus Teltenkötter and Sascha Urban in collaboration with Hochschule Mainz, is a plug-in developed for Rhino-Grasshopper capable of making interlocking panels.

However, projects that take into consideration the connection between panels could limits the aesthetics of the products since they will be made from flat components. The present research focuses on systems that can be used on components of various shapes in order to ensure more freedom of aesthetics.

Discussion

The aesthetic qualities and mechanical performance of the products obtained through digital fabrication are constantly growing to the point that these technologies can be used directly for the realization of the final products, and not only for the prototyping phases.

In addition to this, there is a relevant aspect regarding the complexity and accuracy of the shapes that these technologies can achieve. In fact, thanks to numerical controlled machines it is now possible to make shapes that are difficult or impossible to obtain with traditional production methods, offering new opportunities in this context. Parallel to the development of production technologies, there is the spread of new design processes, which can represent a valid tool for designers to achieve new solutions.

An example in the context of wooden joints can be the kinds of stereotomy. In fact, traditional tools, like saws, planes and chisels, stimulated joints that are characterized by flat surfaces that meet forming sharp edges. However, this typology causes the crushing of the fibers and the concentration of stresses at the edges, and as a result, there is the need to oversize the structures. Today, thanks to computerized drawing techniques and numerical controlled machines it is possible to think of rounded joints without sharp edges that guarantee new and more efficient solutions (Ragazzo, Villani, 2018).

The scope of these technologies does not only concern the characteristics of the products but also involves the companies. In fact, the advantages that can arise in terms of environmental impact are also reflected in advantages on the competitiveness of the company itself. Indeed, it has been found that a supply chain that reflects the principles of sustainability is also more resilient in the event of shocks and emergencies. In particular, the consideration of the companies regarding more responsible environmental policies has changed over the years, passing from being perceived as a burden to being used as a factor of competitive advantage (Fondazione Symbola, 2020).

In addition, the absence of accessories and a low number of total components could improve the ease of assembly and disassembly and make the final products more engaging to assemble.

The use of parametric design and digital fabrication technologies could make it possible to obtain advantages concerning performance, aesthetics, environmental impact, ease of assembly and disassembly, and the possibility of adapting systems to projects with various characteristics.

However, these results could not be easily achievable by many small and medium-sized enterprises because of the difficulties related to the development process of these solutions.

For this reason, this research aims to investigate new design and manufacturing technologies in order to develop a tool that makes this kind of solutions more accessible by designers and enterprises with less resources.

Conclusion

The technological evolutions make it possible to solve the problems highlighted regarding both traditional joints and those concerning the use of accessories. However, if on the one hand, the development of new technologies offers the possibility of obtaining various advantages, on the other hand it requires a reconsideration of the geometries of the systems.

In addition, not all wood species have the same properties, and therefore the characteristics of each wooden joint should meet those of the material used. In this case, the parameterization of the systems can make a significant contribution in making the right choices for each specific case.

Considering the advantages that could be obtained from these technologies, it could be important for small and medium-sized enterprises to have the possibility to achieve these solutions in an easy way.

For this reason, the aim of the present research is to investigate the parametric joinery to develop a tool that can help designers and companies to obtain these advantages.

Furthermore, considering that the production technologies considered for this project are already widespread in the industry (Sanela, Atif, 2017), companies are partly ready from this point of view to welcome this development. Finally, a hope is to stimulate greater interest in this concept.

References

Bullar, J. (2013). The complete guide to joint-making. Guild of Master Craftsman Publications Ltd.

Fondazione Symbola. (2020). GreenItaly 2020. Un'economia a misura d'uomo per affrontare il futuro dell'Europa [A human-sized economy for the future of Europe].

LegnoLab, (2018). Incastri da controllo numerico. [Numerical control joints] Available at https://www.legnolab.it/articoli/incastri-controllo-numerico/

Magrisso, S., Mizrahi, M., Zoran, A. (2018). Digital Joinery For Hybrid Carpentry. CHI 2018, Montréal, Canada.

Ragazzo, F., Villani, T. (2018). Il legno tra piacevolezza e deperibilità. Sperimentazioni sui servizi alla balneazione [Wood between pleasantness and perishability. Experiments on bathing services]. AGATHÓN 04 | 2018 International Journal of Architecture, Art and Design, 187-194

Sanela, H., Atif, H. (2017). The use of CNC machines in development of modern furniture.

Zheng, C., EYi-Luen Do, E., Budd, J. (2017). Joinery: Parametric Joint Generation for Laser Cut Assemblies