How can computing increase the productivity of the construction industry?

A philosophical approach to the symbiosis of computers and human brains…

Over time, many processes in the design and production phase of buildings and constructions were and are still being replaced by computers. Such as in the past, we were producing plans of buildings through drawing by hand, meanwhile the common hand drawings are almost fully substituted by computers through e.g. Computer-Aided-Design (CAD). Regarding engineering calculations the situation is quite similar: Performing an engineering calculation is nowadays done through using specific software, whereas in the past these calculations were conducted manually by hand. Many tasks and functions are overtaken by computers, showing that computing is already indispensable. Thereby the question arises, if are already replacing or will one day substitute the human brain. Is the development going into the direction of automatically designed and constructed buildings through computers and robots? Can computers take up the position of human brains? What is the relation between human brains and computers?

Nowadays nearly every designer uses a computer for the creation of 3D models, spreadsheets or documentation. Due to the development of computational tools, an architect for instance, almost needs to know as much about the software itself as about designing and structures. Nevertheless, computers and computational tools have many advantages. Until the final design of a building is defined, many ideas are thrown away and different solutions are tried out – an iterative process with a significant time-effort, where computing represents great support. Computational tools are very useful in generating and optimizing solutions as well as creating various design options. Especially when complex geometry is desired, the automation of repetitive tasks through parametric modelling represents a considerable advantage. Moreover, computing enables the conduction of various simulations such as daylight analysis as well as an assessment of the energy performance. For structural engineers parametric modelling plays a crucial role, since they can make changes in the column grid as often as they wish until they find the optimal version, by only changing the input parameters [Kilkelly, 2016]. We must not forget about Building Information Modeling, which is "…an integrated, structured, virtual graphic database [...] that consists of three dimensional parametric objects and allows interoperability." [Kensek, 2012]. BIM is also only enabled through computers, promising to provide consistent and computable information about a building project in design and construction. Moreover BIM offers to work interdisciplinary thereby contributing to the ability to make better decisions faster by helping raise the quality and increase the profitability of projects [Cory and Schmelter-Morett, 2012].

It is alleged that computing can already replicate more than 75% of human`s nervous system [RodriguezRamos, 2018]. Many functions of human's are already replicated by computers. One of these functions is information processing and memory, which was the initial reason for creating computers. In the last decades we have seen a huge development regarding storage of information by computers such as audio or video data. However, some mechanisms of the human's memory are still not explored in the way that the ability of remembering episodes is not given to computers yet - an ability which would improve the efficiency of computers even more. Another function in which the human brain is already overtaken by computers is sensory

and motor inputs and outputs. The process of e.g. receiving signals originated in the brain and delivering them to muscles or organs is replicated with "effectors" (systems like motors) and "sensors" (receiving signals) by computers. In some areas in which computers are still competing with human brains, but still did not overtake the function of the brains yet are: complex movement, visual processing, auditory processing and language and reasoning and problem solving. Since 1980s repetitive and routine movement was enabled with industrial robots. However, complex moves of humans could not be repeated. In the last years the development in this area has shown great progress, such that competent walking robots and autonomous cars are already existing, but still robots do not have the ability to learn and adapt their motor skills. Basic vision tasks such as perceiving light or darkness are already easily conducted by computers. Even object recognition was enabled to recognize cats through deep learning (Google algorithm). The recognition of writing and emotions needs some time to be developed in the way that it can compete with humans. Some of the language-related tasks are already conducted by computers such as automated translations. Further developments would enable and improve a wide range of automated processes such as answering to phone calls in call centers (which is already used, but only in small extent) and editing text. Computers have the ability for structured problem solving and information processing. However, humans are capable of problem solving in poorly defined and multidimensional areas such as business, love and war, an ability which is not comparable with any computer yet. Creativity, emotion, empathy, planning and executive function as well as consciousness are areas in which brains (frontal lobe) still win against computers. Computers are able to generate ideas, by mixing existing concepts, however, the creation of new ideas and the ability of knowing what is worth creating, is a task which cannot be conducted by computers only. Reading emotions by computing is already possible, however, the generation of emotions and showing real empathy is not enabled in computing yet. Taking right decisions and making complex planning still requires human-support. Consciousness is a huge mystery for all humans, which is not solved neither by neuroanatomy nor by psychology [RodriguezRamos, 2018].

The above mentioned developments in computing are also relevant to the design-process of buildings and should be considered by the AEC (Architecture, Engineering and Construction)-industry in order to define which processes could be automated through computers and which processes still need human interactions. Above all, computing can increase the productivity in the design stage through e.g. automated processes and parametric modelling. On the one hand computing allows fast generation of plans and models, on the other it enables straightforward creation of multiple design options. Without computational power, the creation of design variants would be more effortful and time-consuming, whereby the creativity of designers would be limited due to time-pressure. Not to mention simulations and assessments, which would hardly or not even be possible without computing, facts that underline the importance and strengthens of computers. Another fact is, that already 75% of the human brain's functions can be replicated by computers and that some of them perform even better than the brain, and this percentage is growing fast! Despite all these facts, in my opinion human brains still are not replaceable by computers. Firstly, because the human brain represents the core of creativity, enabling the creation of the desired design. Moreover, computers are still not able to generate original ideas and to identify which idea is worth creating. In fact, many processes still need human interactions since every building is unique and is tailored for a specific place and for a specific owner. Therefore the productivity can only be increased through a balanced symbiosis of computers and human, whereby computers play a crucial supportive role, but cannot replace the humans' interaction. For sure the use of computing will grow more and more in future and the use of robots will facilitate some tasks, but still it seems

that we have to wait for the perfect buildings designed by computers and constructed by robots for a while…

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