Will artificial intelligence kill architects? An insight on the architect job in the AI future

Dario Trabucco,
Department of Architecture and Arts, Iuav University of Venice, Italy
trabucco@iuav.it

Abstract. Artificial Intelligence's (AI) impact is already visible in several aspects of our life: when we ask for a car insurance, when we consult the weather forecast or when we plan the best route on a car trip, we are actually using AI tools. Jobs are also being affected in many fields, and studies predict AI's dramatic impact will be clear in the near future. The present study analyses the application of AI to architecture by reviewing the most recent achievements in the automation of architectural design. The study then adapts existent methodologies to predict AI's impact on the work-related activities carried out by architects. The results show that some disciplines will experience a massive impact of AI technologies with the need to adapt the way architects are trained at universities.

Keywords: Artificial Intelligence; Architecture; Job Losses; Automated Design; Work Activities.

Background and statement of the research problem

The author of this paper is coordinating a research1 to investigate the evolution and prospected future developments of construction robots. While searching for such a definition, it appeared clear that many pieces of equipment labelled as such by their own producers do not meet the most advanced idea of robot as a 'free-willing' machine. According to the Japan Industrial Robot Association robots can be divided into 6 classes, but only the highest one, class 6, features "intelligent robots", i.e., a robot that has «the means to understand its environment, and to successfully complete a task despite changes in the surrounding conditions» (Coiffet and Chirouze, 1982).
In recent years, thanks to the evolution of Artificial Intelligence (AI), robots have evolved from extremely advanced and precise machines into machines that are capable of making decisions on their own, of self-adapting, and of anticipating events based on their perception of the external environment, thus integrating robotics and Artificial Intelligence. AI is thus significantly impacting manufacturing and construction sectors, and this aspect is being investigated as a focal point of the commissioned research. Changes in the way a building is constructed can only be implemented if the way it is being designed changes as well.
The scope of this paper is to understand the impact AI will have on the architect's job by analysing AI's possibility to replace the human architect in all the various aspects of the building process. A few studies described in the paper have focused so far on the possibility of AI to assist (or replace) architects during the design phase. This initial study will consider the architect's job with all its tasks, from design to construction and testing of the finished building. The objective of the research is to understand what parts of the profession are at risk to see a more pervasive automation of the various activities they include.

Artificial Intelligence

AI can be defined as «a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible ada tation» (Kaplan and Haenlein, 2019). In simpler terms, AI can be seen as a computer program that improves itself to perform a specific task, learning from previous experience to perform better at each iteration. Like humans, AI needs to 'practice' to achieve improvements and the more it practices, the better it becomes. When enough data is fed to the algorithm to optimise it, AI can become better than humans in a number of extremely complex tasks, such as image recognition[2], natural language recognition, etc.
Artificial Intelligence currently exceeds human capacity in playing difficult games, such as chess, go, recognising images, etc. but also in performing tasks such as calculating mortgage risks, diagnosing diseases or predicting weather.

Human jobs in the AI future

Several studies try to understand the impact AI will have on jobs. A job can be looked at as a sequence of tasks (Autor et al, 2003). The premises to understanding the possibility of AI substituting a human worker are set out by Levy (Levy, 2018) and they are based on two observations:

1. all human jobs involve acquiring and processing information;
2. a computer processes information by executing instructions.

Consequently, the capacity of computers to replace humans has to be found in their capacity to execute either deductive instructions (i.e., if-then operations) or data-driven instructions based on statistical analysis of large quantities of input data. A deductive set of instructions can be generated when it is easy to subdivide a task into conscious decisions and actions. If-then computer programs have existed for a long time, but they have been able to displace only a small range of human jobs. Artificial intelligence – through machine learning – is capable of automating tasks where the relevant information process rationale is unclear or happens unconsciously in the human brain (Levy, 2018). Thanks to this capacity to mimic the natural processing phenomena of the human brain, the possibilities of AI are far more impactful.
A comprehensive study was conducted at the Oxford University in 2013 (Frey and Osborne, 2013). The study analysed the likelihood of jobs being displaced by AI, resulting in an astonishing 47% of jobs currently (as of 2013) in danger of being substituted by AI in the foreseeable future.
A WPC study (Hawksworth et al., 2018) subdivided potential job losses across industry fields, professions and countries, distinguishing three technological waves (caused by major breakthroughs in AI and automation). Jobs at risk of automation range from less than 10% in "education" (where social relations and human-to-human communication are of the utmost importance) to a 50+% rate in the sector of "transportation and storage" (with autonomous driving vehicles disrupting most of the jobs) with "professionals" risking a marginal 15%.

ISSN online: 2239-0243 | © 2021 Firenze University Press | http://www.fupress.com/techne
DOI: 10.13128/techne-10696

Artificial Intelligence in architectural design

The application of AI to the design of buildings is not new. Efforts to reproduce an architect's design capabilities with a computer date back to the late 1960's (Negroponte, 1970). However, AI research experienced various periods of brisk decay but it is now headed towards a prosperous future (Lee, 2019). Consequently, and thanks to the advanced abilities of present day computers, research into the possible use of AI to automate architecture is experiencing an unprecedented success rate. An extensive literature review of the technical possibilities and different methods offered by AI applied to architecture is presented by Newton (Newton, 2019). In general, the design of buildings is being treated by AI scientists using neural networks. Neural networks are good at comparing images, and at learning from this comparison with the goal of generating new images. For instance, a study conducted in 2018 (Huang and Zheng, 2018) uses a Generative Adversarial Network (GAN) to generate apartment floor plans. Two floor plans - a visual image and its labelled description - are entered in the GAN, and compared to understand if they are the same or not. After the algorithm is trained with hundreds of pairs, it can generate the second image when only one image of the pair is provided. The GAN generates the second image using the information learned during training, and then compares it again to the input image to improve itself. A thesis discussed at Harvard (Chaillou, 2019) uses GAN to process floor plans according to a building footprint in a building lot, creating windows and room subdivisions, and placing furniture. Architectural students are taught to look for design references and to understand the design pattern adopted by the creators of those examples to generate their own designs. GAN learns statistically significant patterns in the input data, mimicking the learning method of human brains with artificial capacity. It can look into as many references as it is fed with, and it can decipher relevant patterns (i.e., a dining room is always close to the kitchen, a dining room always has a natural source of light, the table is always present in the dining room, *sometimes* the table is close to the window, etc.) with analytical rigour.

Another field of application is the integration of AI with simulation software to create the feedback-loop described in a 2013 study on design optimisation (Gerber and Lin, 2013) consisting in the reiteration of design alternatives to identify the most effective one. By learning the consequences of a specific alteration, AI can quickly learn how to modify the input at the next reiteration, achieving optimum results in a short time and gaining a lifetime's worth of knowledge in a fraction of time.

What is missing (in the surveyed applications of AI to generate architectural drawings) is the connection that these drawings have with the future – human – inhabitants of the spaces themselves. AI can only learn from statistically significant phenomena found in the inputs used to train the machine learning model. Such inputs (i.e. building floor plans) were created by humans who had already 'digested' the aspects connecting a floor plan with the behaviour of the people who will occupy the space. Such a connection was achieved in the past by two factors, the human nature of the architect (and thus his implicit knowledge of the average desires of his own kind) and the architect's capacity to learn from de-structured data communicated by other humans.

Architects and Architecture

Architecture is the discipline, and architects are the professionals who practice architecture. Architectural design, despite being seen as the main focus of architects, is only one aspect of a profession that includes a broad number of very diversified tasks: from preliminary design to design and construction supervision, to testing of the finished building. A recent study on AI's capacity to take over humans in architecture (Mrosla *et al.*, 2019) uses the Honorarordnung fur Architekten und Ingenieure (fee structure for architects and engineers in Germany) to highlight the four main design phases that form architects' and engineers' daily job, reviewing literature in each segment. However, the referenced study especially focusses on the design aspect of architecture, providing evidence about how the progress made and expected in AI design abilities may quickly lead to the possibility of substituting human designers with AI algorithms, at least for the most recurrent projects. Conversely, aspects not related to design are not analysed in detail.

In order to understand the likelihood of architects (as humans practicing architecture) to be displaced by AI, one should look not just at the design phase of a building (though this is often regarded as the leading discipline, especially in academia), but at all the tasks an architect is required to carry out to master the entire construction process.

To achieve the study's goal, this paper proposes a methodology inspired by Frey and Osborne (2013), which consists in:

1. the 71 tasks an architect carries out during the entire building process (from inception to testing) of a public building are identified according to the Italian Ministerial Decree 140/2012;
2. each of these tasks is described using three of the "Work activities" the job of an architect is divided into, according to the O*net database (O*net, 2020), a public database that collects job descriptions, skills required and responsibilities for all jobs available in the United States of America; the database lists 41 work activities for architects; a panel of practicing architects was used in the present research to select the top three activities carried out to perform the tasks described in 1) thus resulting in an array of 213 possible work activities;
3. the same panel of architects was used to select the "Intelligence

Features" of the human brain involved in each work activity used in 1);

4. a score ranging from -2 and + 2 was assigned to each of the 213 identified Intelligence Features resulting from 3); scores are derived by a study that compares AI and Human intelligence (Komal, 2014) according to 19 categories; the study provides a table listing the level of human and artificial brains, pointing out and commenting on the advantages or drawbacks of each one; a score of -2 is assigned when the AI is a clear winner (i.e., Numerical Computation ability; Reaction Time/Speed), while +2 is assigned when the human brain is performing best (i.e., Creativity; Emotional Quotient) with proportionate mid-values;
5. average results are calculated to identify the likelihood of each of the 71 work activities from 1) to be automated;
6. work activities are subdivided according to the various disciplines taught in Italian universities for the "L-17 Scienze dell'architettura" and the "LM-4 Architettura e ingegneria edile – Architettura" courses held in an Italian University.

Limitations of the adopted methodology

The proposed study set the objective to quantify the impact of AI on the future of architects as practicing professionals by modifying the methodology used by Frey and Osborne (2013). Frey and Osborne worked on the possibility of AI displacing all sorts of jobs, while the present study focusses on the various tasks one single job (architect) is divided into. The reference methodology starts from manual labelling of 70 different US jobs, dividing them into those which are automatable and those which are not, and then using the O*net database and a scoring system to correct the previously made subjective assumptions. This study's methodology uses Ministerial Decree 140/2012 to objectively divide the architect's job into various tasks, and then to use a panel of volunteers to subjectively attribute the possibility for each task being done by AI.
The main limitations of the proposed methodology are:

- the comparison of AI and Humans is referred to a 2014 study (Komal, 2014); considering that computing speed is increasing two-fold every two years according to Moore's law, the current (as of January 2020) comparison may be much more favourable for computers;
- the work activities that describe an architect's job in the US job market may differ from those of an architect operating in Europe and, specifically, in Italy;
- moreover, the questionnaire took an average of 4 hours to complete (it consists in assigning the top 3 levels of intelligence needed by each of the 3 main skills of the 71 tasks the architect's job entails); it was, therefore, possible to involve only 10 volunteers. The involvement of a larger panel of architects in the description of their job in steps 2) and 3) of the proposed methodology may lead to different results.

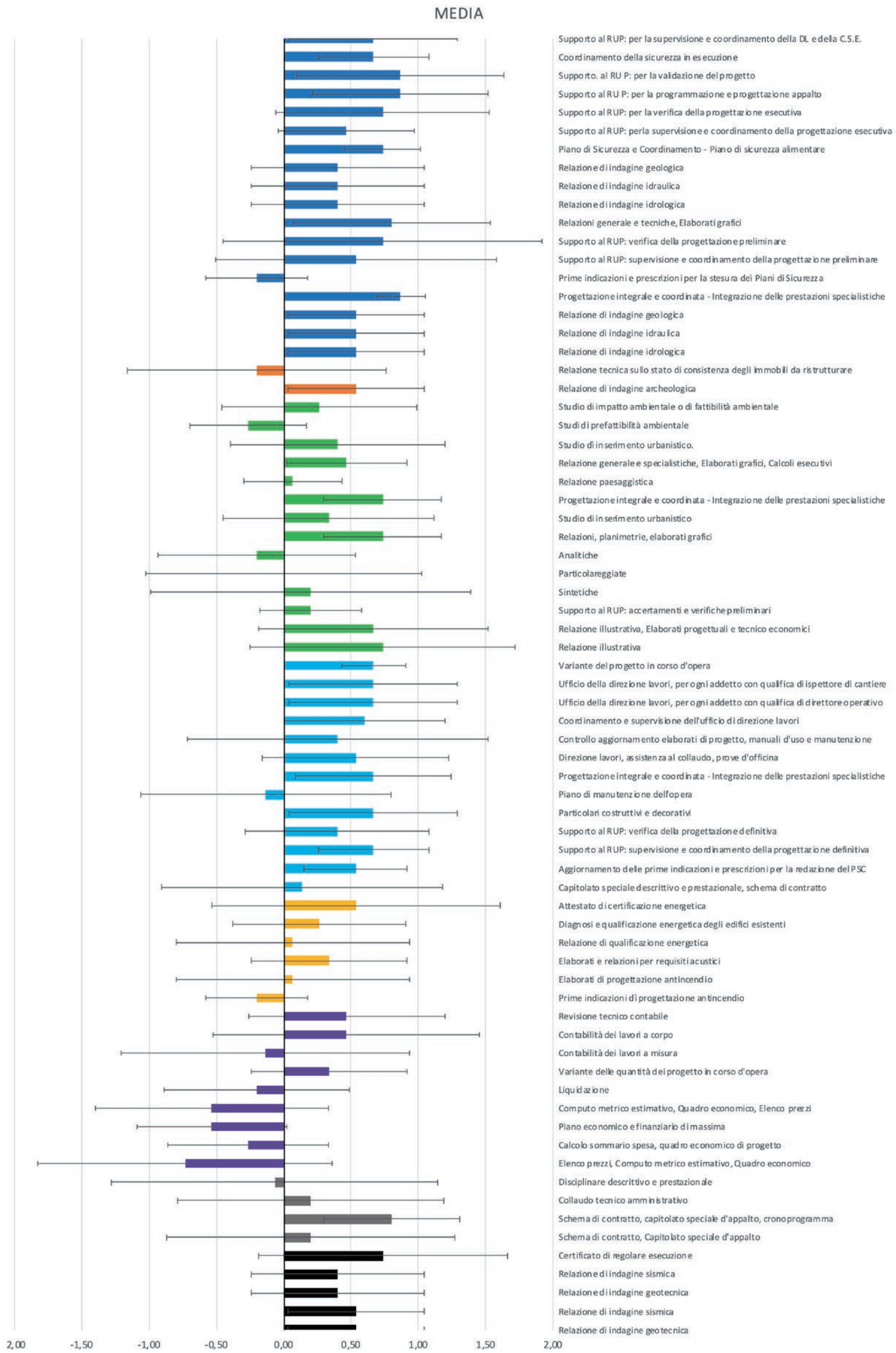
Presentation and discussion of the results

The results of the study are summarised in the attached graph (Fig. 1). Work activities with scores in the left part of the graph are likely to be automated, while activities with positive values are less easily automated. An important result is the great variability of volunteers' judgements, as evidenced in figure 1 by the standard deviation bars. The scoring system adopted by the volunteers is subjective and thus the results emphasise this aspect. However, the volunteers used for the study were neither experts in AI, nor did they know much about the various tasks of an architect's job (despite all of them being registered architects in Italy). In a future phase of the research, it would be interesting to see if a volunteer's scores are affected by his/her knowledge level, for instance by attending a short seminar on AI or by selecting only senior practicing architects.
From a general perspective, architects are in a relatively calm area, with AI expected to have a marginal impact on the profession. This is likely caused by the fact that architects have very diversified tasks, involving a broad spectrum of intelligences. It is, therefore, difficult to automate the profession as a whole. On the other hand, some tasks are more likely to be transformed by AI, and the subdivision of the work activities into disciplines points out some interesting findings.
First, the disciplines related with the economic aspects of the profession are more likely to be affected by AI. Cost estimation is a practice where general trends, average costs and project-specific circumstances are mixed together. All the information pertaining to these three aspects are numbers and trends, which make the passage to a computer-controlled field of the discipline very easy. This aspect seems to be confirmed by the widespread application of AI in jobs that use the same "tools", such as banking and insurance.
Also building physics and the sector of law, despite being in the positive area, witness a certain degree of uncertainty due to the good performance of algorithms in these fields.
Unexpectedly, the activities pertaining to the core of the architectural practice (i.e. design), show some concerning results. This is in line with the successful examples of AI-generated architecture presented in the literature review.

Conclusions

AI will likely have a strong impact on all jobs. Architects and other professional figures may experience a weaker impact, if compared with more routine-based jobs. Still, it is important to start a debate within the profession and university professors on how AI will re-shape the future of practicing architects. Of course, the high variability and the artistic content of architecture defends the profession from sudden changes, but «another reason for underestimation of its importance (AI) is the interest (of the architects) in their self-preservation, which is inherent to all professions, therefore also architects. This auto-centric interest can cause general ignorance of one's own sub-

01 |



01 | Results of the research. Likelihood of the 71 work activities that form the job of an architect being replaced by AI

stitutability by machines» (Mrosla *et al.,* 2019).
Architecture universities can start looking into this future, modifying classes and the "spirit" of the profession to incorporate AI to achieve other results than the mere substitution of human intelligence with computer work. «Many computer-aided design studies are relevant only insofar as they present more fashionable and faster ways to do what designers already do. And since what designers already do does not seem to work, we will get inbred bad architecture, unresponsive architecture, even more Prolific» (Negroponte, 1970). This sentence, which dates back to 1970, is interesting to understand how AI and humans can work together in the future, rather than as alternative, competing elements. Computers have the capacity to analyse data in a more efficient, unbiased and much faster fashion than humans. This information can then be used to improve the architect's human capacities to interpret data to either predict trends or to access a variety of information that is not manageable by a human brain. However, it is the author's strong belief that future architects (and thus current programmes in architecture universities) should retain, and even improve, the choice of disciplines that form the current programmes of architecture as a technical-humanistic discipline. At the same time, the understating of the AI revolution, data analysis, ICT etc. has to be significantly enhanced.

NOTES

[1] The Author is the Principal Investigator of a 2-year research project commissioned by Schindler to the Council on Tall Buildings and Urban Habitat (CTBUH) to explore the present and future uses of robot technologies for onsite building construction activities. Total funds amount to USD 258,000 and the Iuav-based research unit's role is to create a taxonomy of the construction robots and to understand their future applications.

[2] A simple, though very effective, example of AI can be seen at https://quickdraw.withgoogle.com. This Google program uses a neural network to recognise sketches created with the mouse by the website user. As of today, each of the 345 possibilities has been drawn over one hundred thousand times. The neural network learned how humans design apples, paper clips, airplanes, etc. and now it is much faster than humans in recognising what is being drawn.

REFERENCES

Chaillou, S. (2019), *AI & Architecture - An Experimental Perspective*, Harvard University, Harvard.

Coiffet, P., Chirouze, M. (1982), *An introduction to robot technology*, Kogan Page, London, United Kingdom.

Decreto 20 luglio 2012, n. 140, "Regolamento recante la determinazione dei parametri per la liquidazione da parte di un organo giurisdizionale dei compensi per le professioni regolarmente vigilate dal Ministero della giustizia, ai sensi dell'articolo 9 del decreto-legge 24 gennaio 2012, n. 1, convertito, con modificazioni, dalla legge 24 marzo 2012, n. 27.

Frey, C.B. and Osborne, M. (2013 in press), "The Future of Employment", *Oxford Martin Programme on Technology and Employment.*

Gerber, D. and Lin, E. (2013), "Designing in complexity: Simulation, integration, and multidisciplinary design optimization for architecture", *Simulation*, 90(8), pp. 936-959.

Hawksworth, J., Berriman R. and Cameron E. (2018), *Will robots really steal our jobs? An international analysis of the potential long term impact of automation*, PWC.

Huang, W. and Zheng, H. (2018), "Architectural Drawings Recognition and Generation through Machine Learning", Wit, A.J., Del Signore, M. and Anzalone P., *Recalibration on Imprecision and Infidelity*, *Proceedings of the 38th Annual Conference of the Association for Computer Aided Design in Architecture*, Mexico City, Mexico, October 18 - 20, pp.156-165.

Kaplan, A. and Haenlein, M. (2019), "Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence", *Business Horizons*, Vol. 62, pp. 15-25.

Komal S. (2014), "Comparative assessment of Human Intelligence and Artificial Intelligence", *International Journal of Computer Science and Mobile Computing*, Vol. 3, pp. 1-5.

Lee, K.F. (2019), *AI Superpowers China, Silicon Valley, and the New World Order*, Houghton Mifflin Harcourt, Boston and New York, USA.

Levy, F. (2018), "Computers and populism: artificial intelligence, jobs, and politics in the near term", *Oxford Review of Economic Policy*, Vol. 34, pp. 393–417

Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel J., Batra, P., Ko, R. and Sanghvi S. (2017), *Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation,* McKinsey & Company, Brussel.

Mrosla, L., Koch, V. and von Both, P. (2019), "Quo vadis AI in Architecture? - Survey of the current possibilities of AI in the architectural practice", in: Sousa, J.P., Xavier, J.P. and Castro Henriques, G. (Eds.), *Architecture in the Age of the 4th Industrial Revolution – Proceedings of the 37th eCAADe and 23rd SIGraDi Conference - Volume 2*, University of Porto, Portugal, September 2019, pp. 45-54.

Negroponte N. (1970), *The Architecture Machine*, The MIT Press, Cambridge, USA and London, United Kingdom.

Newton, D. (2019), "Generative Deep Learning in Architectural Design", *Technology | Architecture + Design,* Vol. 3(2), pp. 176-189.

O*net Online (2020), *Details Report for: 17-1011.00 - Architects, Except Landscape and Naval*, available at: https://www.onetonline.org/link/details/17-1011.00.