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DECISIONS WE SHOULD PUT IN THE ALGORITHM

Mapping architects' attitudes towards computational and AI-powered tools for practice

PNAGIOTA POULIOU[1,2], GEORGE PALAMAS[1,2], ANCA-SIMONA HORVATH[1] *Aalborg University[1]; Malmö University[2].*
yotapouliou@gmail.com https://orcid.org/0000-0002-8069-3382, georgios.palamas@mau.se, ancah@ikp.aau.dk https://orcid.org/0000-0001-5371-5657

Abstract. Artificial intelligence has gained widespread popularity both inside the profession and outside of it. Much work has gone into creating new tools for AI-powered workflows that can go into architectural design, yet the field of architectural computing has focused less on attitudes that practicing architects have towards these tools. In this article, we present a qualitative analysis of interviews with eight practicing architects on their understanding, use of, and attitudes towards AI for architectural practice. We structure our findings in three categories: ***matters of fact*** (how architects use technology now, and their use and understanding of AI tools), ***matters of concern*** (what participants view as problematic in terms of AI-powered tools for design), and ***matters of time*** (how the future of the profession is seen and imagined). Participants believe their work has gained vastly from digitalization in terms of speed, precision, communication across disciplines and with clients, and simply designing things that were impossible before. There are however also perceived limitations on creative expression imposed by technological tools, a sense of anxiety about keeping up to date in a constantly shifting technological landscape, and a serious lack of trust, expressed by all participants, in AI-powered systems.

Keywords. Artificial Intelligence, Machine Learning, Architectural design, Architectural Practice, Digital Construction

1. Introduction

Artificial intelligence (AI) has gained widespread popularity across fields in the last years and has occupied a large place in public discussions as well. In architecture, both Neil Leach (2022) and Phil Bernstein (2022) have described a new age, that of artificial intelligence, theorizing on how the role of the architect evolves along with technological development. A lot of work has gone into designing new tools and especially new design frameworks making use of AI for architectural design purposes (Brown, 2023), yet fewer studies have focused on how architects understand and relate to this 'new age'.

In this paper, we investigate how practicing architects perceive the emergence

of AI tools as it can relate to their work, and what opportunities and challenges they identify regarding these tools. We aim to shed light on the nature of the transformations that arise from digitalization in general and AI in particular for architectural design. We employ semi-structured interviews with eight practising architects and conduct qualitative thematic analysis on them. Methodologically, the work presented here borrows from the field of human-computer interaction and responds to the call of Vite et al. (2021) to *'bring human-centeredness to technologies for buildings'*.

2. Digital and computational methodologies in architectural design and practice

The two *digital turns* (Carpo 2013, 2017) in architecture have transformed architectural design workflows, from conceptualization to representation, construction, and evaluation (assessment and testing of architectural designs). AI can be applied in any of these design phases, and to a large number of design problems. The relationship between machines and creativity in architectural design has been discussed for example by Hansmeyer (2017), who suggested that architects should view machines as muses, design partners, or tools that extend imaginative capacities. Tamke et al. (2018) proposed that contemporary architectural design practices should pivot towards machine learning (ML) approaches to effectively harness data-rich environments and workflows. Numerous ML algorithms have been embedded in tools for architectural, civil, and environmental engineering applications and while early ML applications primarily centred on the analysis of real-life and existing data, recent trends indicate an expansion into creative domains (Belem et al., 2019). Notable instances include the utilisation of Deep Neural Networks for generating conceptual designs by As et al. (2018), Del Campo et al. (2020), or Palamas (2022).

Within the broad field of Human Computer Interaction (HCI), some have called to '*interface HCI with Architecture and Urban Design'* (Alavi et al., 2019) as necessary elements in *'the messy work of making technology useful for architecture, engineering and construction teams'* (Dossick et al., 2019). There is less research dealing with the experiences of architects regarding the technological tools they employ in their design processes (Møller et al 2017). Architects' use of digital technologies for design can be understood as a socio-technical process. There is a need for comprehensive investigations into the intricacies of how architects, and other specialists involved in building design navigate, adapt, use, mis-use, and potentially resist technological tools. This is important not only for understanding the impact of technology on architectural practice but also for informing the development of future tools that align with the needs of professionals. Addressing this gap can contribute to the broader

conversation on the ethical, social, and professional implications of technologies, as socio-technical constructs, and their integration in architecture.

3. Materials and methods

To gain a better understanding of how architects feel about the emergence of computational methodologies and especially AI-powered tools, we conducted semi-structured interviews with eight practitioners. In the interviews, we collected demographic data, and continued with questions about the tools used in their work, as well as reflections on how these tools affect work at all design stages in which they are involved. We also asked participants to reflect on the opportunities and challenges that computational and AI-powered tools could offer for the practice, and on the future of the profession as it relates to technology in general. The interviews lasted between 25 and 40 minutes and were collected between October and December of 2023, by two of the authors. We subsequently carried out a qualitative analysis of the data, where two of the authors spent time getting familiar with the transcribed texts and employed an emergent coding approach (Lazar et al., 2010) to collect and code the answers. After this initial stage, we discussed our individual analyses and through negotiations, we refined emergent codes into a final list of primary themes around which we structure the ***Findings and Discussion*** section.

3.1. PARTICIPANTS

In total, eight participants took part in the semi-structured interviews, and they spent between 5 and 15 years finalising their education. Participants studied in five different European countries and worked across six European countries. In this way, the sample gives a snapshot on architects' opinions about and experiences with different technologies and AI-powered tools that is representative for Europe and includes perspectives from both developed and developing countries.

All participants hold at least one master's degree, and some had PhDs or were enrolled in PhD programs. The participants' experience in architectural practices ranged from two to 17 years, and the size (in number of employees) of the architectural practices ranged from architects working individually, to some working in small or medium companies, and others working in large world-renowned practices of up to 750 employees. The architects that took part in our interviews are relatively young (between 27 and 37), and in this way, they represent a generation of 'digital natives' - meaning they used software tools for architecture from the very start of their education, and all are proficient in a wide range of software families, from drafting to BIM, to rendering software, 3D modelling, and image and vector graphics (see Table 1).

P1	12	6	Romania	1	Bsc+Msc in Architecture, Technical University of Cluj-Napoca (RO)	Nemetsheck, Archicad, Sketch-up, Adobe Suite, Chat-GPT
P2	12	15	Romania	5-15	Bsc+Msc, PhD in Architecture, Technical Univer-sity of Cluj-Napoca (RO)	Nemetsheck, Archicad, Artlantis, Lumion, Adobe Suite, Chat-GPT
P3	7	5	Czech Republic	5-15	Bsc+Msc, PhD in Architecture Democritus Uni-versity of Thrace (GR)	Autocad, Revit, Sketchup, En-scape, V-Ray, Adobe Suite
P4	2	6	Denmark	750	Bsc+Msc in Architecture, Aristotle University of Thessaloniki (GR)	Autocad, Rhino3D, V-ray, Ado-be Suite, 3D Scanning, AR/VR, Chat-GPT
P5	4	7	Denmark, Greece	750	Bsc+Msc in Architecture, Aristotle University of Thessaloniki (GR); Master of Advanced Architec-ture, Bartlett School of Architecture (UK)	Revit, Rhino3D, Adobe Suite, VR, Grasshopper, C#, Python, AI, Chat-GPT
P6	17	6	Portugal, Denmark	150	Bsc+Msc in Architecture, Luzia University (PT)	Autocad, Archicad
P7	5	7	Greece	1-10	Bsc+Msc in Architecture Democritus University (GR); Msc in Architecture, National Technical University of Athens	Archicad, Adobe Suite, Lumion, Chat-GPT
P8	3	10	Greece, Spain, Denmark	5-20	Bsc+Msc in Architecture Aristotle University of Thessaloniki (GR); Master of Advanced Archi-tecture Institute for Advanced Architecture of Catalonya (ES); PhD in Architecture, Technical University of Valencia (ES)	Autocad, Revit, Rhino3D, Adobe Suite, Chat-GPT

Table 1. Participants taking part in the interview: [years of experience in architectural practice; years of education; countries where active; office size; education level and school; software tools and computational methods used]

4. Findings and discussion

The participants provide diverse reflections on the potentials, limitations and challenges of computational tools and AI-powered frameworks for architecture. We structure this section in three subsections, based on the themes we identified in our analysis: ***matters of fact*** (how the respondents use technologies now, and where they feel that their work could be made more efficient through automation), ***matters of concern*** (what participants worry about in relation to technology and AI-powered frameworks), and ***matters of time*** (how the future of the profession is seen or imagined).

4.1 MATTERS OF FACT

In general, respondents are open to trying AI-powered tools for architectural design, want to keep up to date with technological developments, and see whether these could be useful: *'I am open to discover what AI tools could do to help me in my work. I feel that I am unproductive in many ways and am looking to improve my efficiency: to work better, and faster.'* (P1). All participants had some knowledge on AI, and only one did not experiment explicitly with any AI-powered tools at the moment we interviewed them. One of the respondents (sometimes) designs machine learning systems that are later used in a large architectural practice, and reports using ChatGPT also as help when programming, while the others experimented with image generators such as MidJourney as well as with language models, and tried them out for example to help in ideating for a new name for a company, to help with academic writing, or to generate images about *'this idea in the mind'* (P4).

4.1.1. How technology enhances architects' work currently

All of the participants note that digitalization has changed architectural practice for the better, helping with productivity and efficiency: *'It is much faster to produce designs. [...] because now everything is in sync.'* (P7) and in terms of communication across fields and with clients: *'It greatly improves the perception the customer has of what will be built.'*(P7). It also helps to design things that are impossible to conceptualize without the use of technologies: *'It's more than a tool [...] it's a collaborative relationship. [...] You can have a complex understanding that considers several dimensions of reality, which would be almost impossible without this tool.'* (P8)

4.1.2. Workflows across company sizes

The participants we interviewed worked in companies of different sizes and the workflows employed across companies vary: **small, one-person companies** in developing countries report issues related to productivity due to a lack of coordination in software used by architects, structural and building services engineers. Here, prices of software packages determine the choices of software to be used, although these choices will have long-term impacts on work productivity: '*Unfortunately we don't work on a shared model. I send them the architectural proposal as a .dwg file, and also as a pdf. Then we discuss, and they send their proposal [...] I get back .dwg files and then overlap them on my architectural drawings, because I check everything again myself.*' [...] *'So there is no coordination. Everyone works with their own software'.* (P1)

Medium-scale companies report currently transitioning from CAD to BIM, or have recently done so, and describe challenges in this re-tooling, but also opportunities. Both small and medium-scale companies report working with BIM immediately after conducting initial hand-sketches: *'I have a few years of experience in an architectural office that was working closely with a building services company, who also used ArchiCAD. It was easy for us to work on a bigger scale project. We had a system for teamwork [...] in time slots (each profession contributed to the shared model at different times).'*(P2) On the other hand, within the same company, there will be different levels of digital literacy, generally with an age-gap divide: *'Compatibility is one problem: when you have an older colleague who doesn't use the software, this complicates work.'* (P3)

Large companies, that are considered at the forefront of architectural design, have dedicated units for computational design and employ a series of extra steps in the conceptual design phase, before they start using BIM tools: *'Our common workflow in the design teams includes Rhino in the early phases, and later Revit to make BIM models. In my department, R&D, we use a lot of Grasshopper scripts, but we're also creating our own tools in C# or Python. Either integrated into Rhino as tools within the design software, or as web interfaces, or standalone interfaces. In this tool development, we're also using API's from other tools, such as Coco, or any other kinds of API's and libraries we need and [...] sometimes game engines for interactive/immersive experiences.'* (P5).

4.1.3. *On missing tools for automating architectural design work*

Additionally, participants mention places where they consider their workflows to be slow, inefficient, or tedious, as follows.

Visualisations remain time consuming, but technology makes a big difference in mediating communication: '*I gave as an input one rendering and it transformed it in a very kitschy way. [...] I hoped it would add some vegetation, make it look more realistic, change contrasts - it would analyse the rendering and figure out what was needed to it. But I could not find tools that do that.'* (P1)

Detailing is complex, difficult, and inefficient and AI-powered tools could help to automate part of this work. Of the architects we interviewed that are involved in architectural detailing, they note that: *'It would be great if you would just go in 3D, select a corner, and say: have this detail here. And all the material layers are added, the detail is adapted to the design. I spend so much time adapting constructive system details.'* or *'to have a facade system for a building. And then I could just decide on the construction system, from which company. This would be very useful.'* (P1). Similar ideas are also noted by P6: *'Detailing is the most complex part of architecture. ArchiCAD - gives me a base of detailing, it's good, that gives you that option to edit [...] but I hope that in future it will be easier to do.'* (P6)

4.2. MATTERS OF CONCERN

The article *Speculative Hybrids* (Pouliou et al. 2022), maps a series of concerns that architects express regarding technological tools as they shape architectural practice. The authors divide these concerns in two categories: some that have to do with design processes in general, and some that have to do with ethical and sustainability issues. Among the concerns that have to do with the design process in general, they find that software tools are considered too rigid, and might enforce a certain way of thinking. When it comes to sustainability and ethics-related challenges, the authors find that their participants report how computational design tools might force complex societal problems into numerical formats. The participants we interview here voice some of the same worries (although not all of the above), but also a set of others. The main categories we found under matters of concern have to do with: (1) ***limits on creative expression***, (2) a ***sense of technological overload or malaise***, a general (3) ***anxiety about keeping up to date*** and a generalised (4) ***lack of trust in AI*** and regulations related to it.

4.2.1. Limits on creative expression

Half of the participants mention they feel that software tools and technology in general limits their ability for creative expression, although those who mention this refer specifically to BIM tools: *'These software (Archicad and Nemetschek) were limiting in terms of design, capabilities, and exploration.* (P2) or [about Archicad] *'It still limits your imagination for new things.'* (P6) and [about technological tools] *'in the end, it might inhibit creativity'* (P8). This is similar to what P7 states: *'Depending on what each software can produce, you end up doing this much, there is a limit which I consider very bad.'*

4.2.2. Technological malaise: 'Technology steals something from us' (P2)

Moreover, some even feel that extensive use of technology is detrimental to individual thinking, and could hinder architects from using their own intuition: *'we start using our brain less and less [...] we want to make it easy, and become lazy. When you write and you want to express your own architectural idea, you're the only person that can express it. How can a machine can express it instead of you? I consider it [technology] only as a negative thing in these terms.'* (P3) or: *'We are spending a lot of time on technology and we are not so aware of our natural intelligence.'* (P2) or *'when the software doesn't give you anything, you have to think about every single detail'* and *'AutoCAD is a piece of paper [...] and it's very honest. If you draw it wrong, it's wrong [...] When you draw everything, you think about everything'* (P6).

All this represents a certain technological malaise, or overload, and to some extent even a sense of nostalgia for a time when architects had fewer tools to enhance their work processes.

4.2.3. The anxiety of keeping up to date

Many of the participants express a certain anxiety about having to keep up with emerging technologies and report difficulties in finding the time to invest in learning (yet) another piece of software or programming language/library while balancing this with an active career as an architectural practitioner: *'[about collaboration in BIM] I have not learned or used these tools in my work as my projects are smaller. I simply did not consider that it was worth it to invest the time in learning to use these tools'* (P1) or *'I feel that it keeps you in some chasing game that you need to learn more and more all the time, you have to keep up all the time.'* (P3)

Nevertheless, participants feel they should continue learning throughout their careers *'it is hard because everything grows so fast, that it's hard to keep up - but we should try.'* (P4) and *'I think it's necessary to adapt the domain'* (P2) or *'I think that architects need to keep ourselves updated to see how we can make our work easier.'* (P1)

4.2.4. Trust and regulations

Apart from the concerns expressed above, architects also express issues related to trusting these systems. All eight participants report not trusting AI-powered tools. Most note that if it is not possible to understand why a tool gives certain results, then they do not see how it can be used to support decisions in architectural design: '*I want to follow these technologies and AI just with a critical mind, I wouldn't trust its results blindly.'* (P4). In addition, P8 states: '*I don't trust it [...]as the answers it gives me have a lot of errors. [...] I'm very reluctant to trust an evaluation from an AI, I would prefer a human doing it.'* and: *'I really feel that it's a black box: I don't know [where] anything is coming from, so I cannot believe or trust its valuation'*. Or, as P1 puts it: *'You can't take it seriously. It tells you some things, some fit, others not really'* and *'Even if you are using a software tool, you need to have some knowledge to see if what it does is correct [...] to be able*

to check what that tool is doing [...] In order to see if it's right or not. [...] that is also work'. Building on a similar line of thinking, P8 states that: *'If crosschecking means doing the whole evaluation manually, then we can just do it without the use of the AI. [...] putting a lot of limitations and restricting the AI might give you good results [...] but I'm far from trusting such a process.'*

The experiences of P5 in this case are very interesting, *'it's important for the process to be transparent. [...] If we know how the scientific methodology behind an algorithm works, then it makes sense to make decisions based on that.' [...].'* She then gives the following example: *'We're using Forma (Autodesk), where the fast version of the noise simulation is with AI. But we cannot back it up with scientific methodology, so we cannot use it. That's another aspect of AI generated environmental analysis, you cannot fact check it, you cannot just reverse engineer it and understand why you have this result'.*

Moreover, both the participants working in large companies and those working in universities mention that large corporations (in Europe) do not allow the use of these tools yet because it is not clear how to engage with them given copyright issues: *'we cannot use these platforms because of regulations from the company'* (P4) or '*We are a very traditional education, we do not accept it yet and we don't have the tools to use it. We don't know how to incorporate it because of the plagiarism issues that surround it.'* (P2). Additionally, P5 mentions: *'We cannot use tools of which we are not 100% sure. We cannot go to the client with a number and not explain this number. We are not on the level of a Netflix recommendation that says that it's an 80% match on your profile.'*

Perhaps most importantly, participants note that they feel they would like to be educated about how AI works, and that having a better understanding of the ways in which these tools make decisions, would allow them to trust them more. In this way, critical computational thinking is suggested as a subject to be taught both as part of architectural education, but also as courses for life-long learning for professionals: *'If I think about softwares using AI for architecture - I think: ok, but how much input can you give them? How do they generate the final product? How does that correlate to what you put in the software: how does it work?'* (P1) or *'I'm very curious about exploring - to know how to implement it. Our generation didn't have the chance to experiment with it while studying. So I would love to have a seminar.'* (P8), or: *'What could be done is to educate people better in this matter.'* (P7)

4.3. MATTERS OF TIME

Some of the participants (P1, P2, P3, P6) feel that the profession is becoming increasingly technical, and that the more artistic aspects of architecture are being neglected. This pressure comes both from the technologies that enforce certain ways of thinking, but also from clients who demand more technical (quantitative) knowledge about the project from the beginning (i.e. wanting to know the carbon footprint, how the building would perform from an energy point of view, or how much it will cost in a very precise way): *'Architecture is becoming extremely*

complex, with every year that passes, and more technical than it was 15 years ago, which is very demanding, and leaves less time for the creative part.' (P6)

Overall, P6 believes that AI tools could be useful in two stages of a project *'In the beginning and in the end. At the beginning you need to collect information, rules, considerations that you might be forgetting. [...] In the end, when we get to a very technical part of the project, it can be a great assistance.'* Both P6 and P7 hope that AI-powered frameworks would assist in the more tedious activities but not interfere with the creative exploration: *'these tools could be very good if they can give assistance in the technical parts of projects, I would prefer that to don't interfere on the creative part.'* (P6) and: [on how AI-frameworks could be useful in current workflows] *'To give the AI a model that I build myself, and tell the system: I want views, sections and changes on the design. In other words, do all the hard tasks I don't want to do.'* (P7).

When asked to reflect on the future of the profession, P1 states that *'We need to think in a more sophisticated way than to claim that AI will make us lose our jobs. I don't think it can do something that is of high enough quality.'* further stating that *'I don't think these tools are there yet. Maybe they will be someday, but who knows how much they will cost, and who will use them, it will all matter.'* P3 adds on this but also discusses who would make most use of such tools: *'You could put information such as size of your plot, what kind of house you want to have, and your style (pictures from Pinterest), and then it produces drawings for you: renders and mood boards. I'm not sure if this is going to be implemented from the architect side, or from the investor side [...] Because, it's cheaper for them.'* (P3)

5. Conclusion

In this paper we present a qualitative analysis of eight interviews with practising architects, and their attitudes towards technology in general and AI-powered frameworks in particular. The architects we interviewed used AI for a range of tasks: from help with programming, scientific writing, ideating on a company name, image generation, environmental analysis, and 'just to see how these tools work'. Participants are open to and curious about introducing AI in their current workflows, and mention many places where digitalization has transformed architecture for the better. Some participants suggest that AI would be useful in automating parts of architectural design workflows that are technical (such as detailing, or collecting regulations for a site), but that the creative aspects should be 'left to us humans'. Nevertheless, they also identify challenges related to AI, and its use for architectural design, with the main one relating to trust and lack of transparency on how AIs make decisions. To mitigate this, many suggest that AI should be included both in educational curricula and in further education programs as this would help them keep up-to-date with a rapidly shifting technological landscape, and gain a better critical and practical understanding of how these tools can be useful in architectural design work.

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