RIBA AI Report
2024

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Contents

RIBA AI, generative design, and data

RIBA will continue to monitor developments and provide expert opinion and guidance about emerging and developing technology, and the profession.

An expert advisory group (EAG) has been set up to help steer this work.

The RIBA AI, generative design, and data EAG is Co-Chaired by Phil Allsopp and Nenpin Dimka, with a membership of Greta Jonsson, Maryam al Irhayim, and Des Fagan. RIBA staff support is provided by Alex Tait and Adrian Malleson.

This group is building on the findings of the RIBA AI survey, presented here, to look at the broader, ethical, professional practice, and competitive implications of the widespread integration of advancing digital technologies within architects' practice.

This EAG brings a wide range of expertise and experience in the fields of generative design systems, architectural practice, education and research, and public policy to examine both the opportunities and threats to the profession of architecture. The group will be using case studies to demonstrate the potential of these rapidly emerging technologies for equipping architects to play far more prominent and sought-after roles. These range from shaping climate adaptation policies for urban regions to the design, build and even manufacture of high-performance environments, where sustainable living and thriving commerce are the norm, not the exception for the few.

The EAG has a one-year time frame during which it will report to the RIBA Council each quarter, with its final report and presentations being made available by December 2024.

Philip D. Allsopp DArch., M.S.(Public Health), RIBA, CSBA

Front Cover: *Experiment with Midjourney, image courtesy of Jaina Valji, Copy and Space.*

Foreword

We are currently in an era marked by rapid technological advancement. Technology, for me, is a better way of doing things and that can involve tools or machines. Today, artificial intelligence (AI) emerges as the most disruptive tool of our time and its role in shaping the future of architecture cannot be overstated.

As we stand at the intersection of innovation and tradition, the decisions we make about the integration of AI into architectural practice will have profound implications for the trajectory of our profession and the built environment. As, in today's rapidly evolving landscape, technological innovation stands as a cornerstone of progress.

In this report, we embark on a comprehensive exploration of AI's impact on architecture, navigating the complex landscape of possibilities and challenges that lie ahead. Just as Yuval Noah Harari argues the direction of human history hinges on geopolitical events, the trajectory of architecture is significantly influenced by advancements in technology.

At the heart of our inquiry lies a fundamental question: how can we harness the power of AI to enhance the practice of architecture while safeguarding the values that define our profession? As architects, we are acutely aware of the transformative potential of technological advancement, yet we also recognise the imperative of responsible stewardship in the face of rapid change.

Within the architecture context, the choices we make about the use of AI will shape the character of our cities, the quality of our built environment and the well-being of future generations. In this context, the Royal Institute of British Architects (RIBA) plays a crucial role in guiding the discourse surrounding AI in architecture. By fostering interdisciplinary collaboration and promoting dialogue among architects, technologists, policymakers and the public, we present a pioneering exploration into the intersection of AI and architecture. Helping us to collectively chart a course through the complexities of AI integration while championing ethical principles and human-centred design.

Through a series of expert articles and case studies, we examine the ways in which AI is already reshaping architectural practice, from computational design and digital fabrication to urban planning and environmental sustainability. We also confront the ethical dilemmas inherent in the adoption of AI, exploring issues of equity, transparency and accountability in architectural decision-making.

As we confront these challenges, it is essential that we approach AI with a critical yet optimistic mindset, recognising its potential to unlock new possibilities for innovation and creativity in architecture. By fostering interdisciplinary collaboration and embracing a culture of responsible innovation, we can harness the power of AI to create more inclusive, resilient and sustainable built environments for all.

Join us on this journey as we navigate AI in architecture and chart a course towards a future that is technologically advanced, yet ethically grounded.

Muyiwa Oki

RIBA President 2023 - 2025

Digital twin technologies: a major opportunity

A digital twin of an urban region is an electronic model comprising several classes of analytic, simulation and visualisation technologies that use, and indeed generate, numeric, descriptive and 3D data to test-drive policies and design criteria. In the fields of urban policy and design, digital twins can be used to simulate how, optimally, to achieve a wide range of social, economic, mobility, energy, water-use and other climate-related environmental outcomes. The potential for transforming the guesswork involved in policymaking is significant.

Rapidly advancing computational power built around advanced reduced instruction set computing machines (ARM for short), pioneered 39 years ago in the UK, and emerging powerful AI systems, such as ChatGPT or Adobe Firefly, greatly expand our ability to imagine the future and account for the massive complexities that exist in any place on earth where human beings congregate and establish permanent settlements – the cities and urban regions we all know so well. The architecture profession is generally familiar with many of these technologies, such as building information modelling (BIM) systems, geographic information systems (GIS) and other modelling software, but emerging technologies, including advances in the field of system ***dynamics,***[1] 3D visualisation and animation systems and synthetic data from curated AI applications, offer the potential for architects to take on far broader and more impactful roles than ever before.[2]

These profound opportunities for the architecture profession arise from a confluence of economic, legislative, environmental and technological forces, which are making our urban regions ever more challenging for sustained livability to be the norm for everyone, especially given the catastrophic effects of climate change happening globally.

The Adam Smith problem

For over 250 years, commerce and industry have marched to the beat of Adam Smith's seminal work The Wealth of Nations, which viewed the earth's resources as infinite and held the marketplace, and those people whose interest in profits for personal gain superseded all other considerations, to be the drivers of competition and, according to his definition, innovation. By the end of the Second World War, Smith's model of human behaviour and commerce was dominant and, by 2020, had become supercharged to form a philosophy of planetary ownership by corporate entities who, to this day, exert enormous influence over national and global politics in their headlong extraction of profits by whatever means possible.

It now looks like our species and thousands of others will be paying a very heavy price for the folly of our belief that the Earth's resources were infinite, despite the finite size of the planet, and that economic 'externalities' created by commerce and industry would have no discernable impact on lives, the price of goods or the planet. There are few urban regions which have not been shaped by these pernicious forces. Despite monumental efforts by scientists, professionals and policymakers everywhere for better living conditions and better-performing built environments, the best-laid plans for greater livability and healthier environments, social equity and economic diversity continue to be based on the hope that private sector development will come up with the answers. For decades these 'answers' have been geared towards the extraction of profits to the exclusion of almost all other considerations. Hope faces powerful incentives to keep doing more of the things which we know are destroying our world. We have a choice to make, as a species and as a profession – continue the march to oblivion based on the concept of planetary ownership or shift everything about our society and what we do to the point where planetary stewardship guides our actions *(see Figure 1).*

[1] Jay Forrester, Urban Dynamics, MIT Press, Cambridge MA, 1969 and World Dynamics, Wright-Allen Press, Cambridge MA, 1971 (for more information on Forrester, see https://mitsloan.mit.edu/ideas-made-to-matter/professor-emeritus-jay-w-forrester-digital-computing-and-system-dynamics-pioneer-dies-98).

[2] We have already seen the stellar results achieved by architects engaged in developing (coding and programming) and applying early forms of these technologies from the 1970s to the present day (such as Applied Research of Cambridge and Skidmore, Owings and Merrill, among many others). One such example is David Rutten, an Austrian architect who devised and coded Grasshopper – one of the most powerful parametric and generative design environments available today.

Philip D. Allsopp

RIBA EAG: Data, Computational Design & AI, CEO of ORBIS Dynamics

ORBIS DYNAMICS

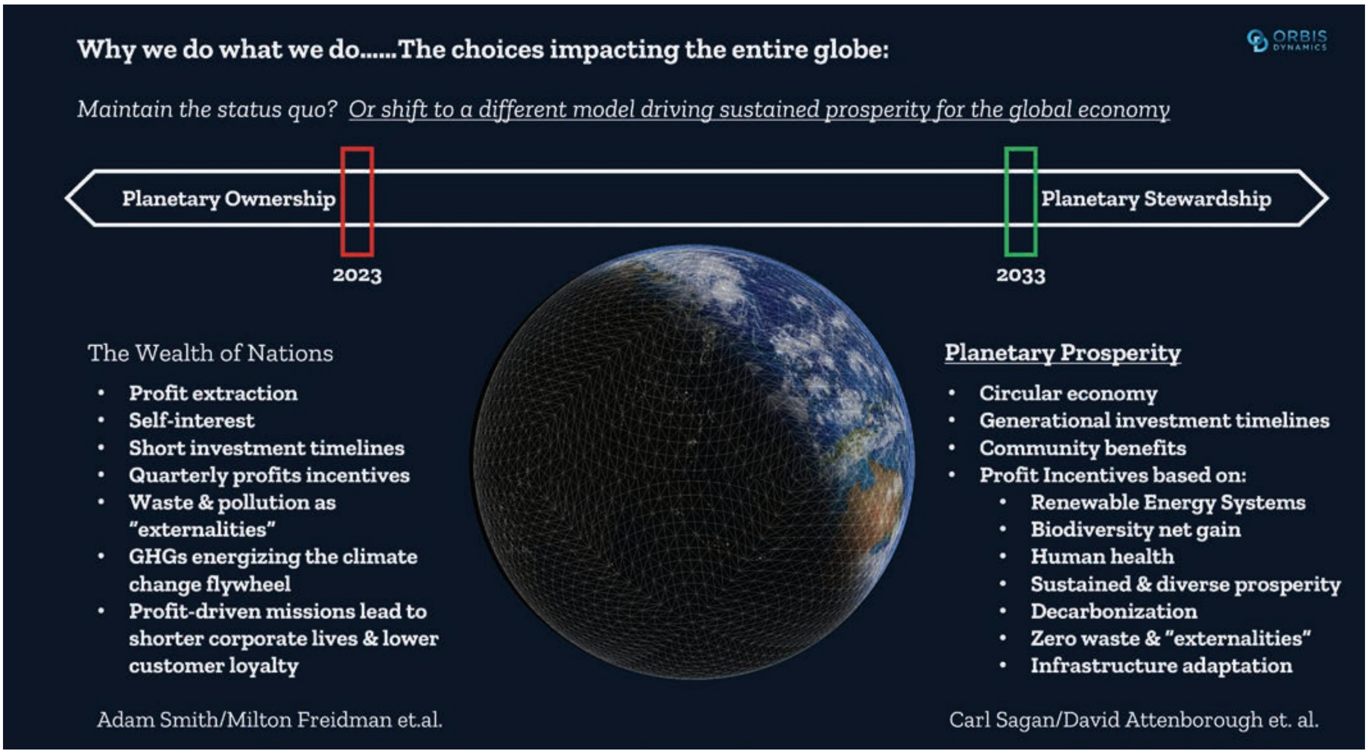


Figure 1: Planetary Ownership or Planetary Stewardship?

Given politicians' inaction over the past several decades, it might appear that all is lost and we will all be drawn into an extinction vortex from which escape is impossible. Although such an eventuality is possible, it is by no means inevitable if we apply our collective know-how and technologies to adapt to climate realities and, at the same time, slow the climate change flywheel which we have helped to spool up over the past couple of centuries of intensifying industrial development. It is in the urban regions, where hundreds of millions of people live, that we have the best chance of making a difference and changing the forces that currently pose such grave threats to life on Earth.

Today, the global construction sector lags behind all other sectors in innovation and productivity. Compared to most other industrial and service sectors, whose productivity and performance have increased by roughly 1,500% over the past 70 years, the construction sector barely breaks a ***1% improvement.***[3] This presents the architecture profession with a massive opportunity to leverage digital twin technologies to move from being drafting services for developers to premier league players operating at more strategic, policymaking levels, where profound decisions are regularly made which shape the performance and livability of every urban area on the planet.

Simulating the future by understanding urban DNA

If we were designing a jet engine for manufacture, we would build a digital twin comprising 100% of its parts. We would then simulate its performance against design goals, such as fuel efficiency, number of hours between maintenance, material degradation, integrity following bird strikes and so on. When the achievement of those criteria had been optimised according to the priorities given to each one, the resulting jet engine's digital twin would alter its form and shape to enable those complex sets of goals to be optimally achieved. From that optimised digital twin, the manufacturing process starts.

As soon as the engine is in service, its performance is monitored by on-board instruments and, whenever a problem arises, a product maintenance digital twin is also present to determine what improvements or repairs need to be made to keep the engine safely in service.

This does not happen in urban regions. As a society, we leave the design, location and performance of human habitats (the built environments which give form to and enable – or disable – a dizzying array of human endeavours) to the whims of real estate speculation, land-banking or to prescriptive 'urban planning' codes, many of which are devoid of any evidence basis and are often decades out of sync with present and future human needs. The results to date do not give much encouragement that doing more of the same will ensure better outcomes.

While some components of digital twin technologies are indeed used at the front end of the project design (including all construction documentation and engineering calculations), they tend to operate like a single bookend to a very full but open-ended shelf of books. What gets built is rarely, if ever, subjected to ongoing performance analytics to determine whether what was thought to be (and indeed simulated as) a good solution actually worked when it came into contact with people and the realities of their lives or the work they do. It is now very apparent that new financial incentives are needed to ensure that the story of an urban region is bookended from design to in-use evaluation and management. Many other fields already do this – medicine, consumer electronic products, aerospace, the automotive industry. Built environments remain by and large experimental prototypes that never go into production (paraphrasing Jony Ive, Apple's former chief design officer). AI, data, generative design systems, system dynamics models and curated AI all can play powerful roles in shifting the status quo to a better way of ensuring greater performance, better durability and better human outcomes from what is built.

[3] Reinventing Construction: A Route to Higher Productivity, McKinsey Global Institute, February 2017 (https://www.mckinsey.com/capabilities/operations/our-insights/reinventing-construction-through-a-productivity-revolution).

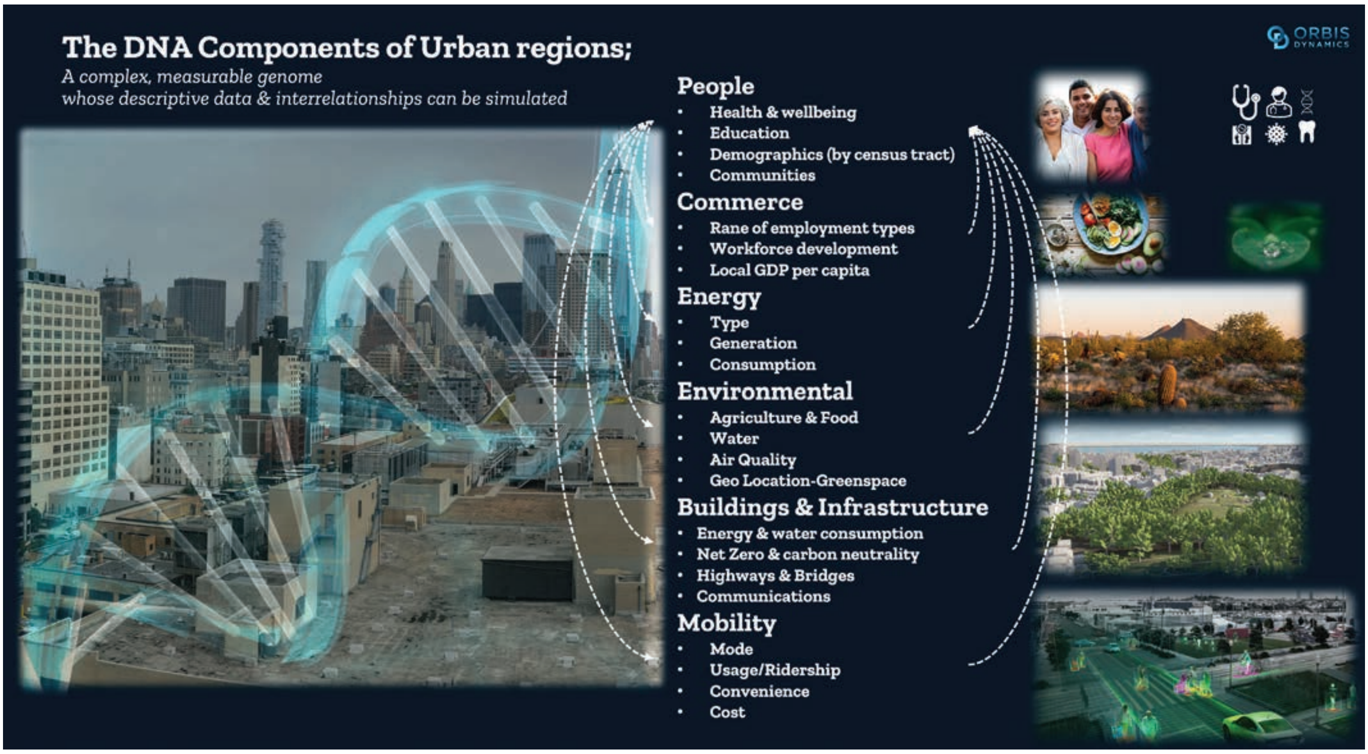


Figure 2: An illustrative example of an urban region's DNA components

Digital twin technologies enable architects to account for all the genomic complexities of an urban region's DNA that represent how and why an urban region works in the way that it does. This offers significant opportunities for architects to participate in shaping the structure and form of urban regions of any size and location, driven by urban genomic goals rather than hope, whimsy or artistic style-du-jour. There is no shortage of urgency for this endeavour. This reshaping of urban forms needs to be done on both a large scale and an individual building or urban site scale, including retrofitting what has already been built. The performance parameters for urban physical infrastructure are definable and we already know a great deal about them *(see Figure 2).*

What if the form of redeveloped urban regions was driven by these parameters rather than purely by profit extraction and code compliance, as so many 'developments' are today?[4] The technologies underpinning digital twins are capable of identifying a variety of performance-defined urban 'sand box' locations. Within these, developers, owners, architects and allied professionals can put their know-how and creativity to good use, knowing that what they built would have a higher probability of enabling performance goals, like walkability, high air quality, mobility choices and diverse local commerce, to be met rather than simply hoping that they'd turn out OK in the end.

The future before us

AI, generative design systems, data science and the field of system dynamics make it entirely possible for architects to take leadership roles in urban policy deliberations rather than being left out of the picture until a developer has been given permission to build something within prescribed zoning rules. Such leadership roles are attainable if architects engage in the creation of digital models of cities that go well beyond BIM systems and reach into the human, social, economic, mobility and environmental dynamics that drive sustainable livability, better health outcomes, economic opportunity and prosperity.

In the field of medicine, such diagnostic technologies, involving AI and digital twins of the human body and its complex systems, are used daily to detect diseases, conduct surgical procedures, apply gene therapies and benchmark progress towards recovered health. In the field of built environments, the application of similar digital twin technologies opens up a breathtaking spectrum of possibilities for improving the lives of billions of our fellow human beings and the planet we depend on for life.

[4] Judyta Cichocka, 'Generative design optimization in urban planning: Walkability-optimized city concept', Architectus, vol. 1, no. 41, 2015.

The current state, promise and near-term future of AI in architecture

When designing our homes, workplaces, schools and communities, the architecture industry is under constantly increasing pressures to help combat climate change, accommodate growing populations and meet stricter standards and requirements. To address these challenges, the industry is undergoing a technological shift – in addition to embracing 3D modelling, practices are adopting a more outcome-based way of working, one that is driven by AI, automation and data-supported software applications.

Over the past two decades, new tools have been transforming the way that architects work – from sketching concepts on a page to creating drawings in AutoCAD and, more recently, collaborating on building information models in the cloud. Architects have always been trailblazers in digital transformation, combining human creativity with tech innovation. Now, AI opens up a myriad of new opportunities for automating routine tasks, empowering architects to solve even more complex design challenges, such as delivering more sustainable building outcomes.

AI: empowering the new workforce of architects

At the turn of this century, architects embraced 3D parametric modelling through building information modelling (BIM), then connected BIM in the cloud to improve coordination and productivity – bringing in an era of greater creative and technical collaboration. Now, AI promises to disrupt the practice (for the better) once again.

Although BIM revolutionised the industry, the issue of silos remains – currently, BIM struggles to meet expectations to unify data and workflows across the entire plan, design, build and operate lifecycle. Integrating granular data, automaton and AI into existing workflows, while leveraging the design tools that architects use today, will create a more connected and outcome-based approach.

Insights derived from data throughout the design process can simplify everything from the exploration of design concepts, to evaluating environmental qualities surrounding a building site or how a building performs in the real world.

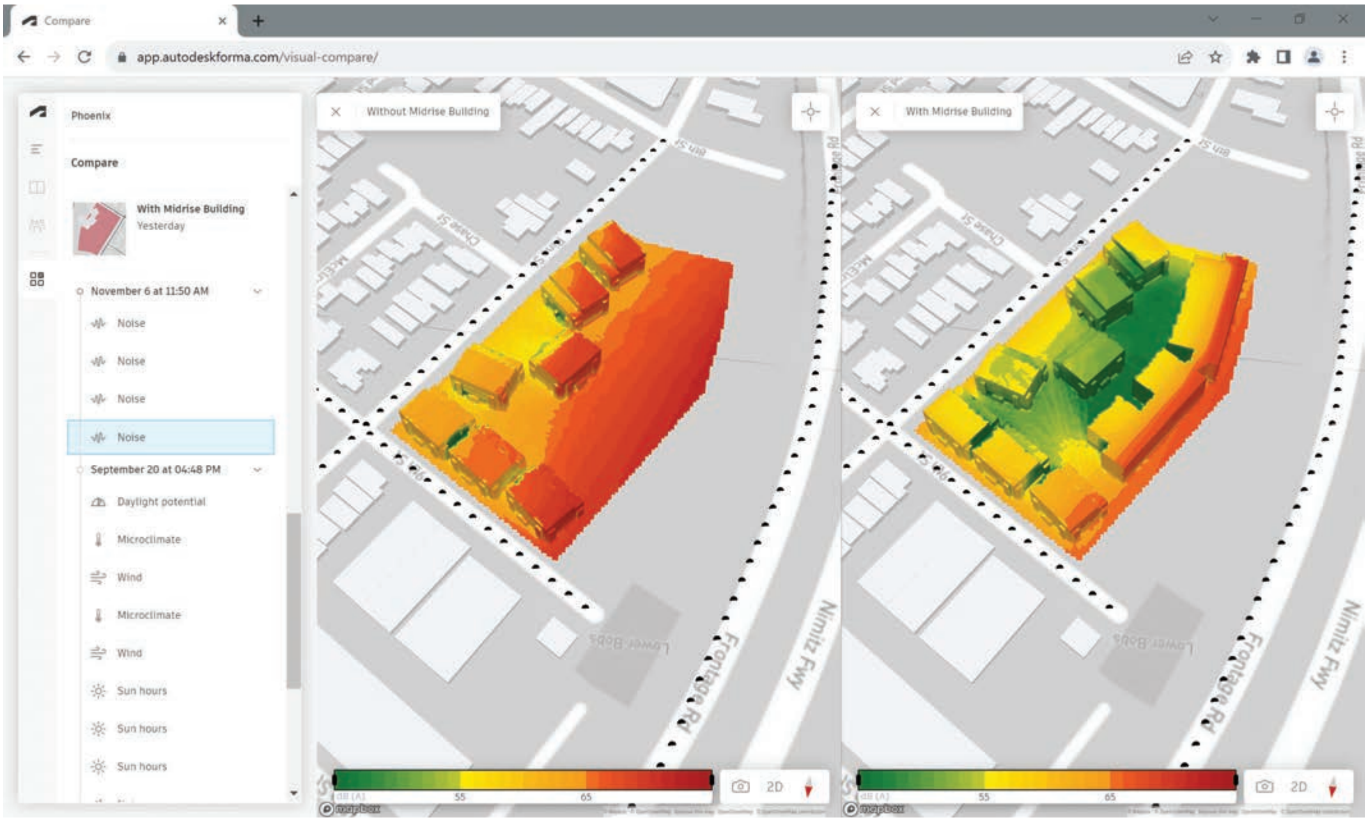
Leveraging the ability of AI to augment, automate and analyse gives architects their time back – not just by increasing productivity, but by giving them the space to be more ambitious and to focus on creative solutions. When used correctly, AI can help architects analyse a myriad of design variations in a very short time, offering them new perspectives on how to achieve important project outcomes. This expands the realm of design possibilities, bringing us closer to meeting increasing demands from building owners, developers, citizens and municipalities, all while creating something sustainable, something that can stand the test of time.

Project Phoenix in West Oakland, CA, showcases generative design, innovative materials like mycelium insulation, and carbon-neutrality. Image courtesy of Autodesk.

Amy Bunszel

Executive Vice President,
AEC Solutions at Autodesk

AUTODESK



The AI analysis capabilities of Autodesk Forma show the impact of different design concepts on livability and environmental performance in real-time. Image courtesy of Autodesk

Sustainability and climate change resilience: intelligent insights in early-stage design

Societal challenges, such as rapid urbanisation combined with population growth and climate change, are putting pressure on the architecture, engineering, construction and operations AECO industry. The complexity of urban areas has also increased massively, and climate change is fundamentally affecting the way people live and work.

At the same time, the economic demands on the AECO industry are also increasing. The creativity of architects is being tested by the need to maximise building density and use of space without negatively impacting people's quality of life or the environment. This is precisely where AI and outcome-based design come into play, empowering architects to solve problems and enhance their current ways of working. The shift towards outcome-based design, powered by AI, enables architects to arrive at solutions faster and more efficiently.

AI also makes it easy for architects to incorporate environmental and other contextual data into plans when optimising designs. AI not only provides real-time analytics, that fuel essential insights into operational energy, microclimate, sunlight, wind and noise, it also enables architects to test a wide variety of scenarios digitally, in a risk-free environment, to find optimal solutions within chosen parameters.

Take Project Phoenix, for example, a 316-unit modular housing development in West Oakland, California, on a site that is heavily impacted by congestion and noise pollution. In a collaborative effort between MBH Architects, Factory OS and Autodesk, a multidisciplinary team harnessed the power of technology to share data and workflows and tap into AI-powered insights across the project lifecycle to make housing that was faster to design and build and more sustainable.

In the early phases of the project, the team made data-informed trade-offs between goals for operational carbon, embodied carbon, cost and liveability. The team also leveraged their unit catalogue from past projects to reduce time and risk through reusable design intelligence.

Targeting carbon neutrality, the housing units feature innovative materials, including facade panels made from a core of mycelium, the rootlike structure of fungi. The panels themselves are carbon-negative, as the amount of carbon captured in the mycelium core exceeds the carbon emitted by the process of making the panels.

In the final stages of development, the team combined physical and digital automation to construct a set of buildings that is not only efficient, but is also loved by residents.

The Phoenix will be built at about half the cost, time, and carbon footprint of a typical multi-family building in the San Francisco Bay Area. Image courtesy of Autodesk.

AI assistants: human expertise remains irreplaceable

Despite the benefits that AI brings to the architectural profession today, it is understandable that many architects are still wary of the threat of job displacement. We envision AI serving as an assistant in the design process, with designers retaining their role as decision-makers, controlling the creative process and ultimately making the final call. It is the architect who has the real-world understanding of local specifics and needs – be they cultural and aesthetic concerns, regulatory issues, such as local and regional building codes, or the complex web of multi-layered relationships with stakeholders and customers. There is no doubt that machines can help with the heavy lifting, but it is humans who will be answering the all-important question of how to create better homes and buildings.

The integration of AI-enabled capabilities into the design process does not mean architects will no longer be required; instead, it empowers architects to focus on outcomes.

Combining human intuition and expertise with AI's computational capabilities allows architects to explore more possibilities for sustainable and innovative designs, leading to better informed and more creative solutions. The integration of AI-enabled capabilities into the design process does not mean architects will no longer be required; instead, it empowers architects to focus on outcomes.

So, what is next for the architect's toolbox? It is an exciting time: it is undeniable that AI is here to stay – both in our personal and professional lives. The practice of architecture is poised to leverage AI as an indispensable tool for transformation.

As technology streamlines mundane processes and enhances workflows, architects will gain more time to design solutions to some of the world's most pressing problems. In the face of rapid change, one constant is the intuition and expertise of architects. Architects will remain irreplaceable – essential for balancing technological advancements with their understanding of human needs and cultural values – in shaping the cities of tomorrow. The humble pen and pencil will remain in the architect's toolbox – but now they are set up to work side-by-side with sophisticated AI-supported digital tools.

Architects and artificial intelligence

Architects have been applying AI for discrete aspects of their projects for some time, working parametrically and generatively using scripts and models, but in 2023 the topic went mainstream. Throughout that year, seemingly every article on technological innovation focused on AI, tumbling from the roll-out of, and to a certain extent the boardroom antics behind, ChatGPT.

This year, 2024, we are not likely to see any let-up in the conversation. From a practice perspective, many have already put in place measures and guidelines to ensure that their data is not compromised, and it will be important that ethics, cyber and data security and related topics continue to be addressed to bring clarity to how AI tools are used.

However, there is an imperative to take a step back. AI is moving from a narrow use in specific cases to an all-consuming application across every aspect of projects, yet the reality for most is that AI is an unknown entity and those implementing projects just want to know what it is and how they might use it. In this context, this article outlines the strategic implementation of AI and how it might be harnessed to create better outcomes for clients and a new generation of low-carbon, world-class buildings.

AI will benefit projects in various ways, making the day-to-day management of projects easier. Over recent years, communication has spiralled out of control, as old forms of correspondence, such as emails, reports and file-sharing, mesh with new ones, including instant messaging and online meetings. Digital has made the management of projects more difficult, not easier, but AI offers the perfect solution to this challenge.

However, to unlock the true value of AI we must go further. Transformation will not be achieved by optimising the traditional ways of doing things, or by powering up building information modelling (BIM), but by changing the essence of the design process itself. To achieve this, we need to rethink the concepts at the heart of the process. The timing is perfect. In the race to reduce carbon emissions, many new solutions and systems are being deployed and the lead designer can no longer rely on the inbuilt knowledge collected through years of learned experience. Throw into the mix the shift towards offsite manufacturing and it must be acknowledged that the design process has simply become too complex, and the knowledge required to create a new generation of buildings too vast.

With the pressing need to collate, learn from and disseminate this knowledge, and to deliver consistent and coherent solutions quickly, AI offers the opportunity to collect new knowledge rapidly and to disseminate it differently. It can place the most up-to-date learning and reliable and robust data at the fingertips of the project team, be that the embodied carbon of a product or the plant space required for a ground source heat pump installation.

In this shift away from heuristic ways of working, the fact remains that significant judgment calls will still need to be made. The human is not disappearing any time soon, although by augmenting current knowledge and skills with AI-facilitated knowledge, new value propositions will emerge. This new partnership will result in unknown and unintended consequences, and to deal with these the built environment industry must engage with a wide range of new professionals. Data scientists are an obvious start, but human factors experts can look at the crucial interfaces between expert systems and humans. Anthropologists can help shape the processes of the future. Decision-making will be transformed, allowing the project team to spend more time on the challenges of the future, such as creating materials that sequester carbon.

Of course, to get there requires carefully orchestrated steps, including the mundane task of properly classifying large amounts of metadata. Evidence-based design is not a new idea, but AI, and the onset of millions of data points, offers the opportunity to take this methodology to the next level. Finally, and most importantly of all, the future will not be an evolution of past processes, but a revolutionary way of doing things and such a paradigm shift is now inevitable. The key is preparing today for this disruptive new way of designing and making buildings.

Dale Sinclair

Head of Digital Innovation at WSP

Experiment 2 with Midjourney, image courtesy of Jaina Valji, Copy and Space

RIBA AI survey: findings

Introduction

As new tech tools became available over the past year to 18 months, there has been an increased intensity to the discussion about the future of artificial intelligence (AI) and what it means for society generally and for the architectural profession specifically. Too often, opinion seems irrevocably divided, between existential despair (the end of architects, the end of professions, the end of work) and a feeling of the untouchable primacy of human creativity (no machine could create as we create).

This discussion has not, however, been supported by evidence, as there has been very little information available about what is happening in practice. This is where the RIBA AI Survey aims to help, by gathering information about the current and near-term realities of AI in architecture. The findings suggest that, while a significant number of practices have started to use AI in at least some of their projects (41%), AI adoption in the profession is in its infancy, with many practices not using AI or using it only occasionally. However, adoption and use of AI are set to increase in the coming years.

AI promises a beneficial and rapid evolution of the architectural profession; routine tasks automated, the design process streamlined, carbon reduced, creativity accelerated and expanded, and client and societal outcomes improved. This survey looks at how far that promise might be realised now and within the next two years.

There are risks too, including further pressure on fees and job displacement, and these are also explored.

Adrian Malleson

Head of Economic Research and Analysis
Royal Institute of British Architects

Architecture and digital maturity

Digital innovation in architecture is ongoing and AI is its latest manifestation.

Architects have taken a leading role in the digitisation of the construction sector, exemplified by the professions' pioneering adoption and use of building information modelling (BIM). This makes sense. If the profession does not continue to adopt, adapt to and lead new technologies, it might not only fail to reap the benefits of innovation but also leave unguarded significant areas of current and future work and, therefore, revenue.

Digital maturity

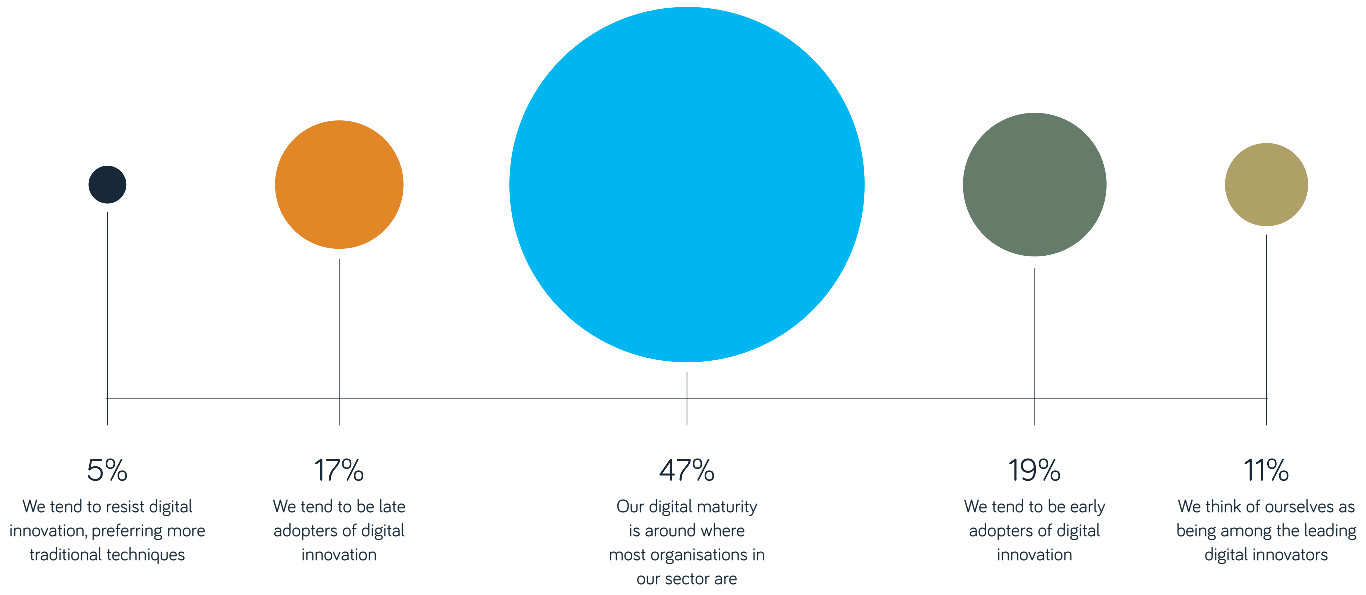
Respondents were asked to rate their organisation's digital maturity, and the responses suggest a well-distributed range.

A small but notable 11% consider themselves as leading digital innovators, with a further 19% identifying themselves as early adopters of digital innovation. This suggests around three in ten practices actively look to develop their practice offering through leading in digitisation.

A near-majority (47%) believe their digital maturity is around where most are, suggesting a willingness to adopt new digital tools that are already of proven value.

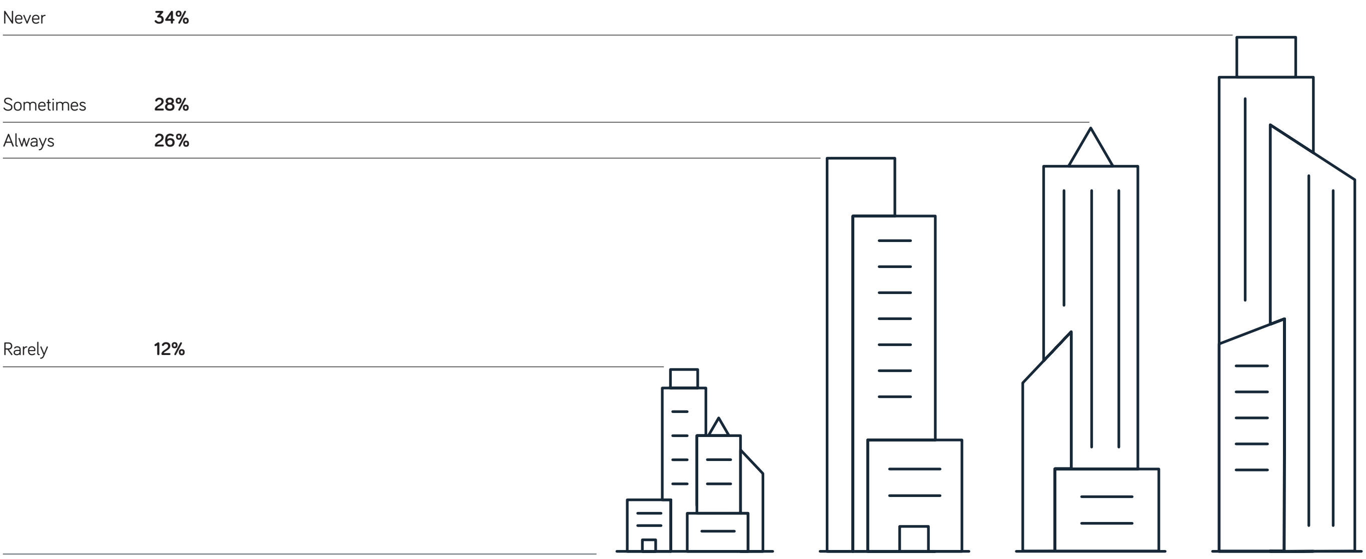
At the other end of the range, 17% are late adopters of digital innovation, and 5% resist digital innovation altogether, preferring traditional techniques. This resistance might be due to a lack of resources or in-house skills. Alternatively, it might be that for practices that take on particular types of work, digitisation has a more limited role.

Overall, how would you assess your organisation's digital maturity?



A near-majority (47%) believe their digital maturity is around where most are, suggesting a willingness to adopt new digital tools that are already of proven value.

During the work stages for which your practice is commissioned, do you create and maintain building models in accordance with ISO 19650?



Before AI: BIM

For most of this century, digital maturity has been associated with BIM. The architectural profession has successfully adopted BIM into its workflows and as a result is now well placed to implement AI.

The bedrock of BIM is well-structured data. AI cannot get off the ground without good training data – which BIM can provide. So, before examining AI, the survey looked to uncover the extent to which practices work with well-formed model data.

ISO 19650 [1] is a series of international standards that describes a collaborative and consistent approach to information management for built assets. It forms part of the UK BIM Framework. The series includes concepts and principles (ISO 19650-1), the asset delivery phase (ISO 19650-2), the asset operational phase (ISO 19650-3), information exchange (ISO 19650-4) and information security (ISO 19650-5).

Survey findings suggest there is a range in the extent to which practices create and maintain building models that comply with ISO 19650. A quarter of the respondents (26%) always create and maintain models that comply with ISO19650, a slightly higher proportion (28%) sometimes do, while 12% rarely do and just over a third (34%) never do.

Small practices are significantly less likely to create and maintain ISO 19650 compliant models, and large practices are significantly more likely to. Twelve per cent of small practices with between one and ten staff always create and maintain BIM models that comply with ISO 19650 and 62% never do. This 'always' figure rises to 43% for large (50 to 99 staff) practices, and 50% for those practices with 100 or more staff.

There is a resource of well-structured data in many but not all practices. This may prove to be a foundation for the future development of AI within the profession.

[1] *https://www.bsigroup.com/en-GB/capabilities/buildings-and-construction/iso-19650-building-information-modelling-bim/*

Knowledge and current use of AI

Knowledge of AI

AI adoption is in its infancy, with just 2% of practices using it on every project. But two-fifths use it on at least the occasional project.

Personal knowledge about AI is running ahead of its adoption by organisations.

Almost all architects have at least some knowledge of AI. The majority (51%) assess themselves as having a basic knowledge, and a third (32%) as having a practical knowledge of AI. A small percentage have advanced knowledge (6%) or are recognised authorities (2%). In contrast, fewer than one in ten (9%) architects have no knowledge of AI.

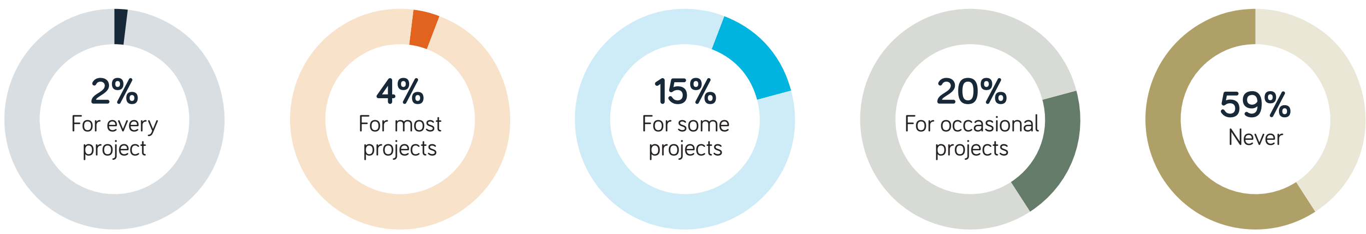
Overall, how would you rate your personal knowledge about AI, in general?

Use of AI

AI adoption in practice stands at 41%. Significant numbers of practices are using AI for at least the occasional project. That said, the use of AI in architectural projects is not the norm, with 59% of practices never using AI, only 2% using it for every project, and just 4% using it for most projects.

Most commonly, practices that have adopted AI use it for some projects (15% of all) or the occasional project (20%). Should AI become the norm, we are at the start of the adoption curve.

For the projects you are currently working on, how often does your practice use AI in any way?



AI adoption in practice stands at 41%. Significant numbers of practices are using AI for at least the occasional project.

The profession's views on AI

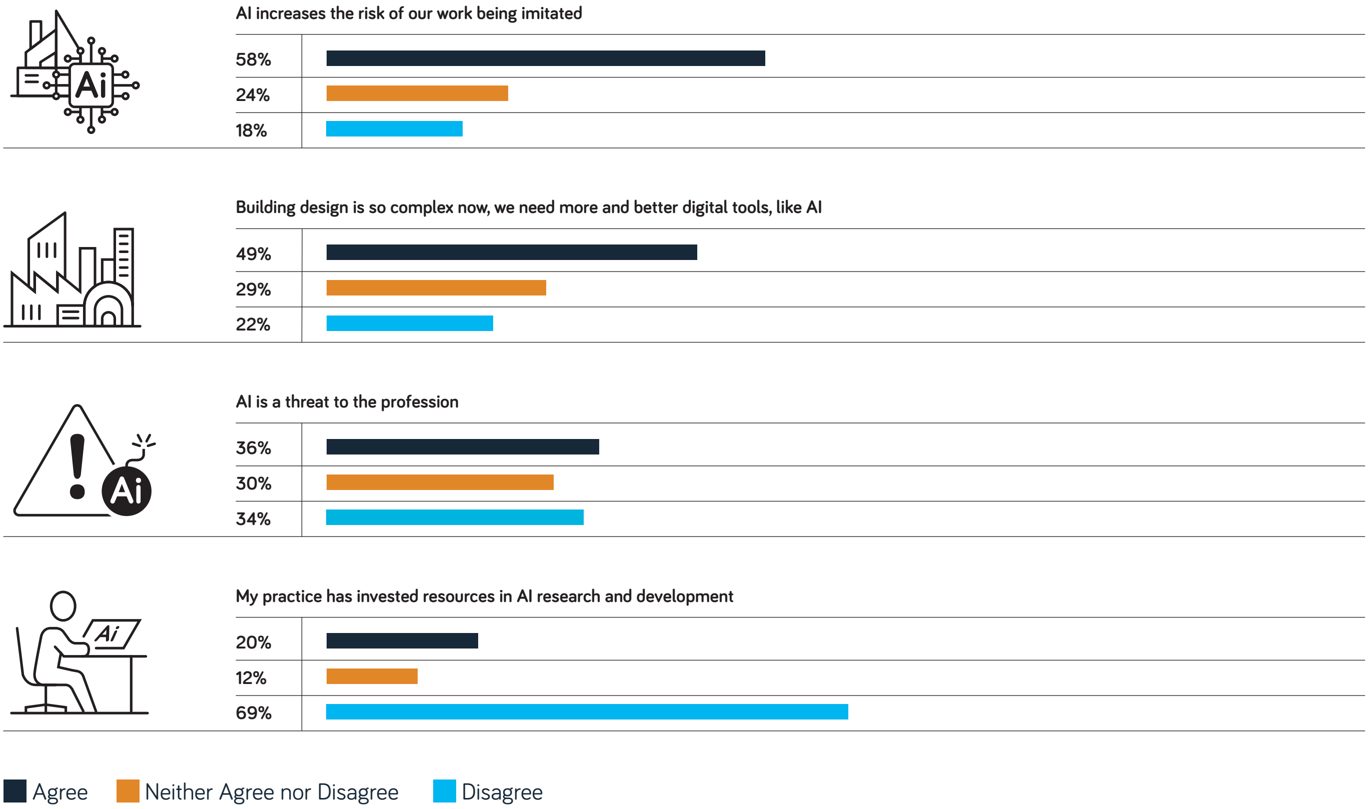
Architects' views about AI vary, and not all are positive. As well as seeing the potential benefits, the profession also sees significant risks. A common view is that AI is a threat to the profession; that it will destroy jobs by automating some or all of the roles architects fulfil. Architects are evenly split on this possible future, with 36% agreeing that AI is a threat to the architectural profession, 34% disagreeing and 30% neither agreeing nor disagreeing. A future without the profession is being seriously considered by some, suggesting architects need to engage with and shape the future of AI now.

Does AI present a risk of imitation? A majority of architects (58%) think it does. Architecture is a creative profession, with creativity expressed through building design. If AI can easily and cheaply output plausible design imitations that can be readily passed-off, the creative foundation of the profession may become vulnerable.

However, AI also has a transformative potential. Modern buildings are becoming increasingly complex in their design, construction and maintenance. A near majority (49%) of architects agree that this complexity means the profession needs more and better digital tools, including AI. Practices could gain a competitive edge here by being early AI adopters, but this potential is likely to need investment to realise. Just one in five (20%) practices have invested resources in AI research and development. The majority (69%) have not.

There is a balance that needs to be worked out, between making the most of (and investing in) the transformative potential AI offers, and safeguarding creativity and associated intellectual property. This is not just an issue for architects, but one for the wider creative industries.

Please state how strongly you agree or disagree with the following statements about AI now:



Views of current AI users

Forty-one per cent of respondents are using AI in their projects, but 59% are not. This section looks at the views of that 41%, those who are currently using AI in some way.

Current integration and benefits of AI

Of those using AI in some way, 43% agree that AI has improved efficiency in the architectural design processes, while 24% disagree. This is the one area where current users of AI, on balance, see a clear benefit.

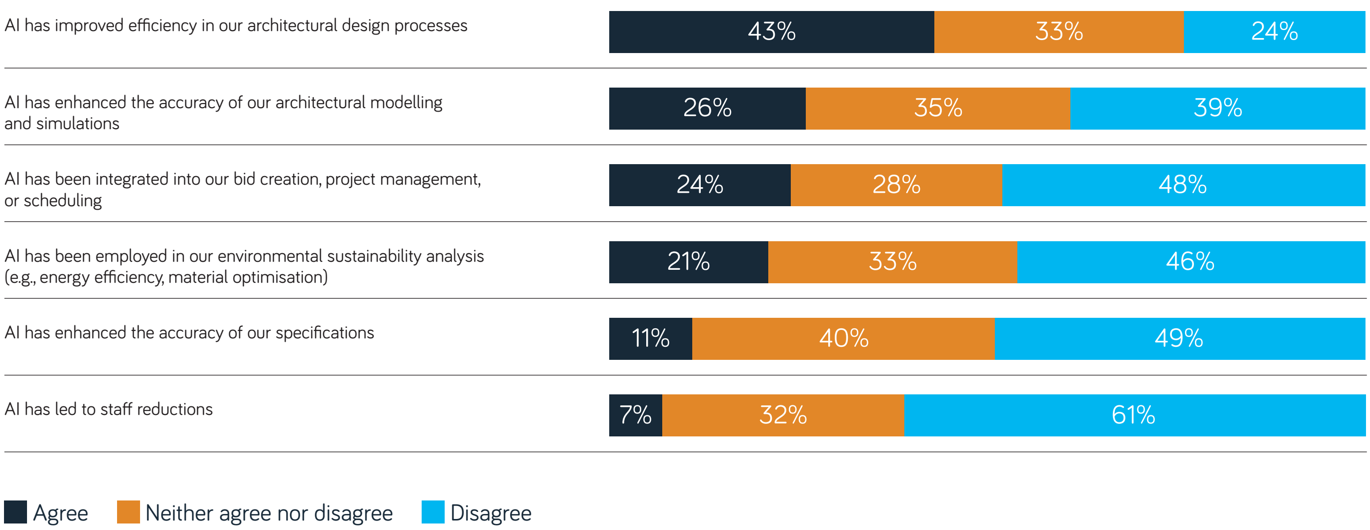
The benefits are less clear in the other areas asked about. More respondents disagree (39%) that AI currently enhances accuracy in modelling and simulations than agree (26%). Only 11% agree that AI enhances the accuracy of specifications, while a majority (49%) disagree.

This lack of perceived benefit might be because current AI tools are not yet sufficiently developed, or because most architects lack the training and guidance needed to make the most of them. Or perhaps this is typical in the early stages of the adoption of a new technology. The benefits to practice are expected to increase over the next two years.

Only 24% agree they have successfully integrated AI into bid creation, project management or scheduling, while a substantial 48% disagree. Twenty-one per cent agree that they have employed AI in environmental sustainability analysis, while 46% disagree. This level of integration is set to rise in the near term.

Just 7% agree that AI has led to staff reductions and 61% disagree, suggesting that AI adoption is not significantly affecting practice staff levels. While the most apocalyptic of AI writers describe the professions as next in line for employment decimation or obliteration, of the kind we saw for land workers during the agricultural revolution or for craft workers during the Industrial Revolution, there is little evidence of this currently being widespread. Views about the possible future are explored more later.

For those using AI - How strongly do you agree or disagree with the following statements about AI:



AI and the design process

Among respondents who are using AI in some way, the most common use is for early design stage visualisations, with 6% using it always, 22% often, 60% sometimes or rarely, and only 12% never using it for this purpose. This use of AI may, for example, help clients to see the possible resolutions of their brief more clearly, through detailed, even immersive, visualisations.

Twenty-one per cent use AI for generative design always or often, while 31% use it sometimes, 16% rarely and almost a third (32%) never. AI-based generative design has the potential to fundamentally change the design process, allowing architects to rapidly create new and innovative designs, which can be explored, analysed and then refined to meet the brief in new and better ways.

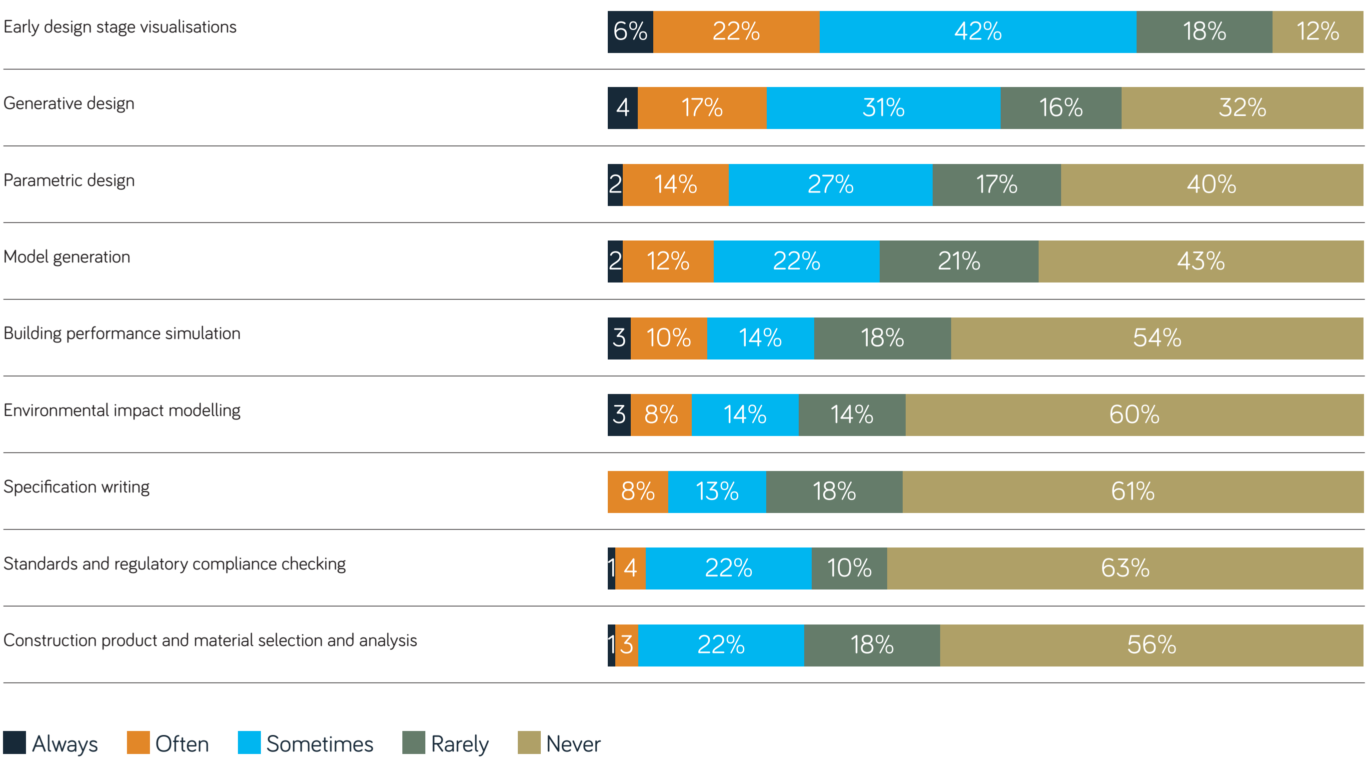
Parametric design has been a common feature of design tools since the early days of BIM and 3D design. AI has the potential to optimise and extend the use of parametric design, by drawing on wider and more complete datasets, allowing workable choices of building elements and systems to be algorithmically generated. Forty-three per cent of those using AI in some way always, often or sometimes use it for parametric design, while 17% rarely and 40% never use it for this purpose.

Forty-three per cent never use AI for model generation, while only 2% always do, with 12% using AI often here, 22% sometimes and 21% rarely.

An overwhelming 61% do not employ AI for specification writing. Creating the specification is possibly one of the least-loved parts of the design process and it might offer a significant opportunity for automation through AI, which could improve accuracy, material and product choice, and consistency with other sources of design information.

Only a minority of those who use AI use it for construction product and material selection and analysis, building performance simulation, standards and regulatory compliance checking or environmental impact modelling. There my be significant potential here. To take one example, an AI tool that can deliver accurate and speedy regulation and compliance checking could quicken planning application progress while helping to ensure that buildings are safe, accessible and sustainable.

Please indicate how far AI has been adopted within your organisation in the following areas of the design process:



AI and project management

The graph below shows the use of AI in project management. Generally, AI-using practices have been slower to adopt AI in project management than in the design process.

Within project management, AI is only used significantly in bid creation, where 10% have used AI sometimes or often, 19% sometimes and 25% rarely. That still leaves a significant 46% who have never used AI for this purpose.

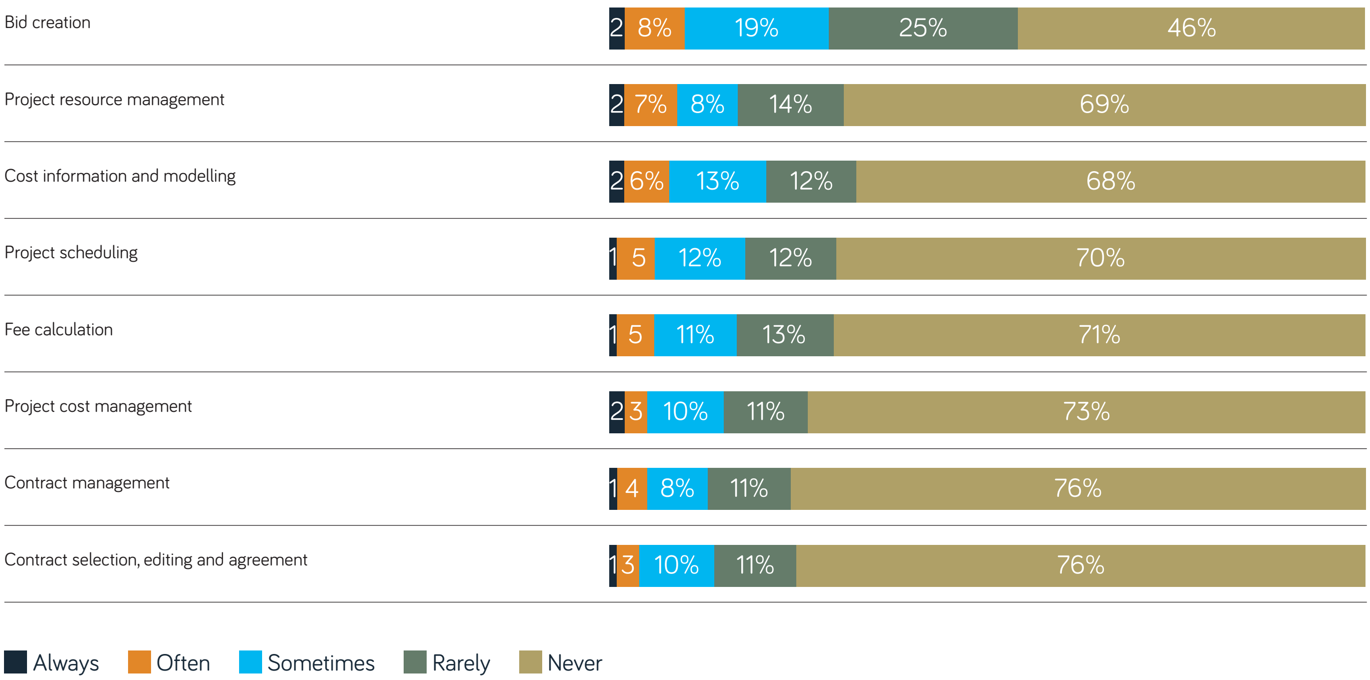
In all other areas of project management covered in the survey:

- project resource management
- cost information and modelling
- project scheduling
- fee calculation
- project cost management and
- contract management

a clear majority do not use AI, and only a small minority (10% or less) use it often or always.

With the business of architecture under significant pressure to remain profitable, there may be value in exploring the potential of AI to pick up project administration, leaving architects free to develop client relationships and create buildings.

Please indicate how far AI has been adopted within your organisation in the following areas of project management:



AI – the near-term future

The survey also explored the near-term outlook for AI adoption and use. This set of questions asked respondents to consider what might happen over the next two years. The questions were put to all respondents, not just those using AI. The findings suggest that AI will be widely adopted and integrated into practice and will deliver tangible benefits in the near term. But there are risks too.

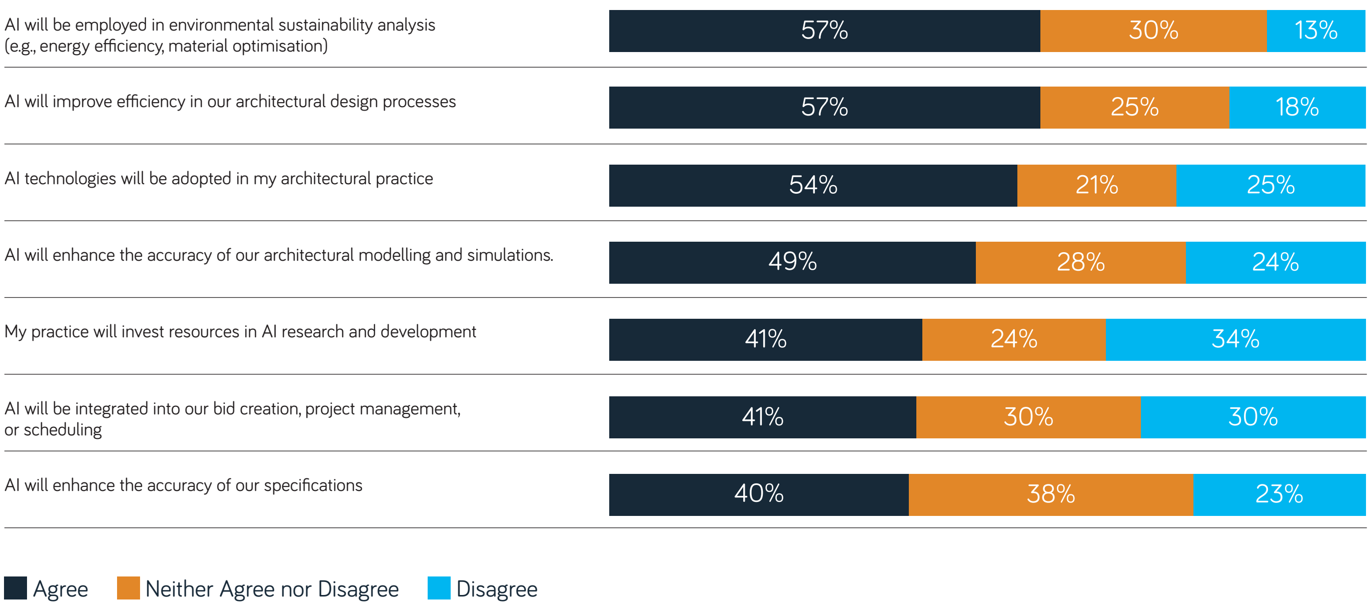
A majority of respondents (54%) agree that in two years' time AI will have been adopted in their practices, although a quarter (25%) disagree. The remainder (21%) are equivocal. This anticipated adoption is not quite matched by investment, with 41% anticipating that their practice will invest in AI research and development.

A majority also agree that AI will be used to carry out environmental sustainability analysis (57%) and that it will improve efficiency in architectural design (57%).

A near majority expect AI to enhance accuracy in modelling and simulations (49%). A significant minority expect AI will be integrated into bid creation and project management (41%) and will come to enhance the accuracy of their specifications (40%).

However, many of the comments received expressed the view that role of AI will always be limited. For example, that AI could never be well-suited to considering the cultural, historical and social factors of design, nor the intricate spatial, structural or regulatory complexities of the design process, nor to make the subjective judgments of aesthetics and client preference.

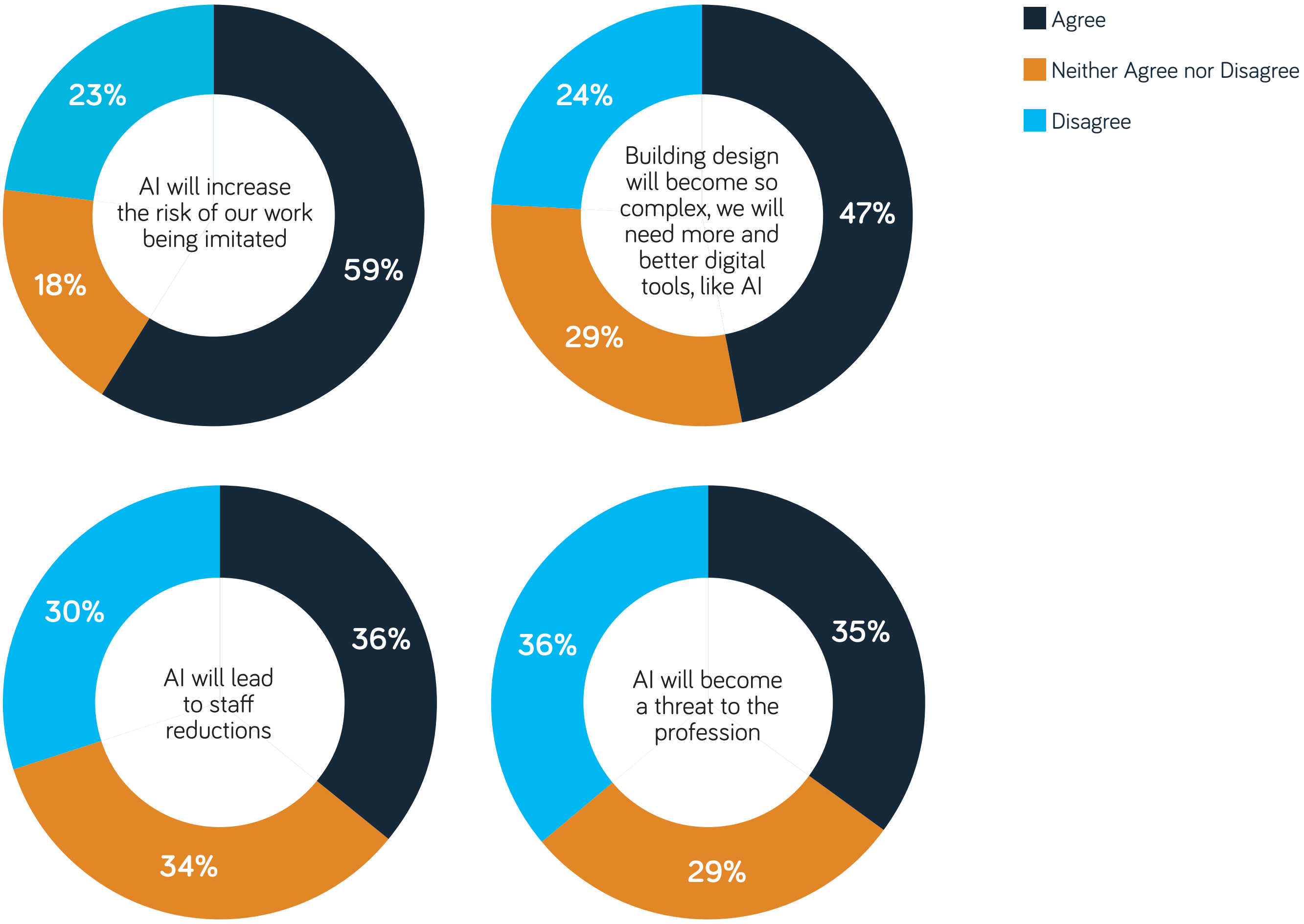
Agreement that in the next 2 years:



The findings suggest that AI will be widely adopted and integrated into practice and will deliver tangible benefits in the near term. But there are risks too.

The anticipated increase in AI adoption is not without risk to the profession. While 47% agree that more digital tools, such as AI, will be needed because of the increasing complexity of building design, a majority (59%) agree that AI brings with it a risk of work being imitated, perhaps as designs are appropriated by AI tools for use in AI training data, so becoming readily replicable in both spirit and detail.

A majority do not see the oft-postulated existential risks to the profession and employment coming in the next two years. But significant numbers do. Thirty-six per cent agree that AI will lead to staff reductions, while 30% disagree and 34% have no clear view. The view on the potential threat to the profession is finely balanced, with 35% agreeing that AI is a near-term threat to the profession, 36% disagreeing and 29% equivocal.



A majority (59%) agree that AI brings with it a risk of work being imitated, perhaps as designs are appropriated by AI tools for use in AI training data, so becoming readily replicable in both spirit and detail.

Evaluation of AI

The construction industry and the design team face several long-standing challenges. From ***Latham***[2] to ***Egan***[3] to ***Farrell***[4], the construction industry has been characterised as adversarial, siloed, insufficiently collaborative and failing to make the productivity gains seen in other sectors. BIM may have helped, as a part of a programme of wider ***digital transformation***[5] of the sector, but perhaps much of the early promise remains unrealised.

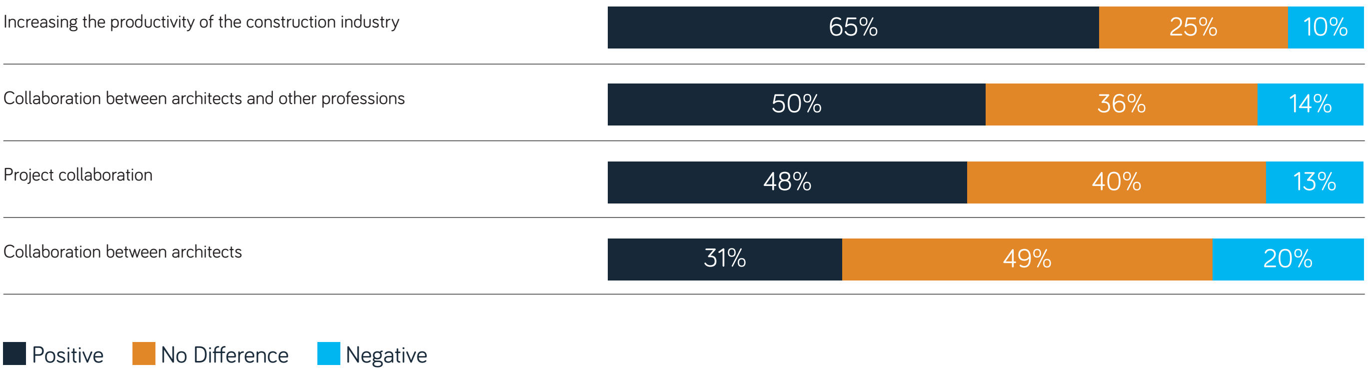
AI might help address these challenges. Respondents were asked whether AI would have a positive or negative effect in some important areas. On balance, the effect of AI is seen as positive.

Productivity and collaboration

Sixty-five per cent of respondents think that AI will have a positive effect on the productivity of the construction industry, and only 10% think it will have a negative effect. Half think that AI will have a positive effect on collaboration between architects and other professions, and only 14% think the effect will be negative. On balance, the effect of AI on project collaboration is anticipated to be positive, with 48% expecting AI to improve project collaboration and just 13% feeling the effect here will be negative.

Perhaps because architects collaborate well together already, 49% think AI will make no difference. But even here, the balance is for AI to have a positive effect, with 31% believing it will be positive for collaboration between architects, and 20% that it will be negative.

Overall, do you think the effects of AI will be positive or negative?



[2] https://constructingexcellence.org.uk/constructing-the-team-the-latham-report/
[3] https://constructingexcellence.org.uk/rethinking-construction-the-egan-report/
[4] https://farrellreview.co.uk
[5] https://www.mckinsey.com/capabilities/operations/our-insights/decoding-digital-transformation-in-construction

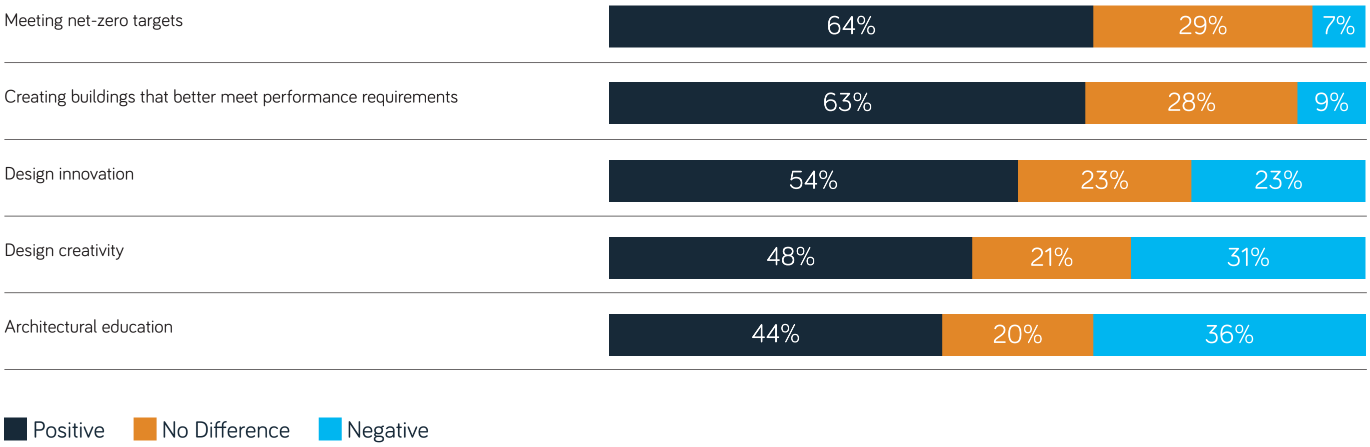
Carbon, innovation, creativity and education

With the built environment accounting for around 40% of greenhouse gas emissions, design professionals and the wider construction industry have a responsibility to decarbonise construction. AI won't solve the climate emergency (and is itself carbon intensive), but the survey suggests this is an area in which AI can have a positive effect. Sixty-four per cent of respondents believe AI, with its potential to optimise energy usage, will contribute positively to meeting net-zero targets. Aligned with this is the view that AI is well placed to help create buildings that better meet performance requirements, with 63% anticipating that AI will have a positive effect here.

On balance, respondents suggest that AI will have a positive effect on both design innovation (54% positive) and design creativity (48% positive). This positivity is not universal, however, with the effect seen as negative by 23% and 31% of respondents, respectively.

Forty-four per cent of respondents anticipate AI having a positive effect on architectural education, with AI having the potential to offer tailored on-demand learning and immediate feedback. The positive outlook is not universal, however, with 36% anticipating a negative effect. The experience of COVID-19 lockdowns reminds us of the ***dangers***[6] of digital-only education.

Overall, do you think the effects of AI will be positive or negative in?



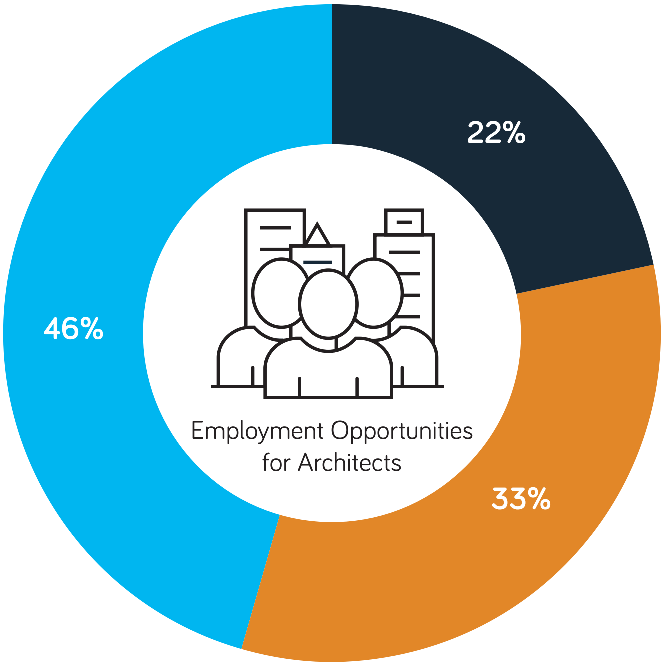
[6] https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/bulletins/coronavirusandthirdyearhighereducationstudentsengland/29novemberto20december2021

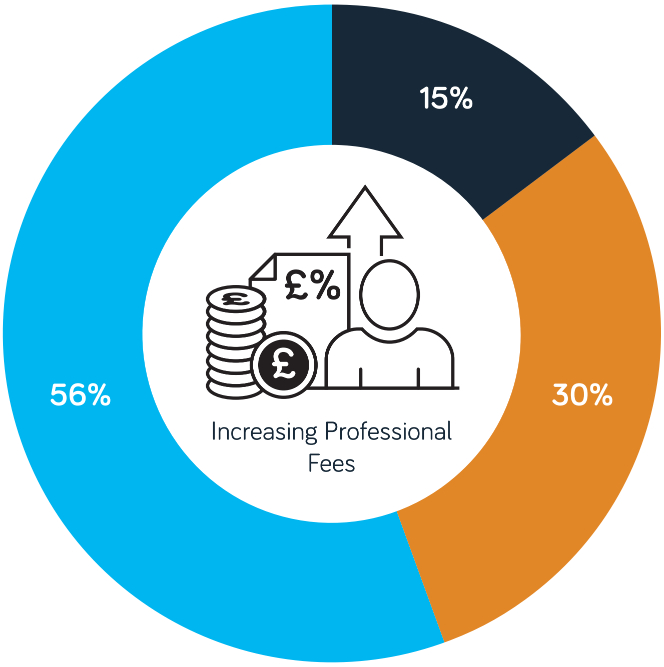
Risks remain

The most significant areas of concern are fees and employment. Without adequate fees, there will be fewer jobs in architecture, and ultimately no profession. Only 15% of respondents think that AI will have a positive effect on fee income, and a clear majority (56%) believe the effect will be negative. A significant minority (46%) anticipate negative effects on employment opportunities and only 22% see positive effects here.

These issues, the impact of AI on employment, fees and the future of the profession, are explored in more detail in the expert articles featured in this report. To preserve and enhance their roles and income, architects may need to reimagine what they do and how they charge for it. There are real opportunities, but these significant risks must not be ignored.

Overall, do you think the effects of AI will be positive or negative?





Positive No Difference Negative

The most significant areas of concern are fees and employment. Without adequate fees, there will be fewer jobs in architecture, and ultimately no profession.

Final word – ethical considerations

As a profession, architecture has a responsibility to practice within ethical boundaries. ***The RIBA Code of Professional Conduct***[7] makes explicit the ethical requirements of RIBA membership, and the ***RIBA Ethical Practice Guide***[8] and the ***Final Report***[9] of the RIBA Ethics and Sustainable Development Commission explore and outline the profession's ethical responsibilities in more detail.

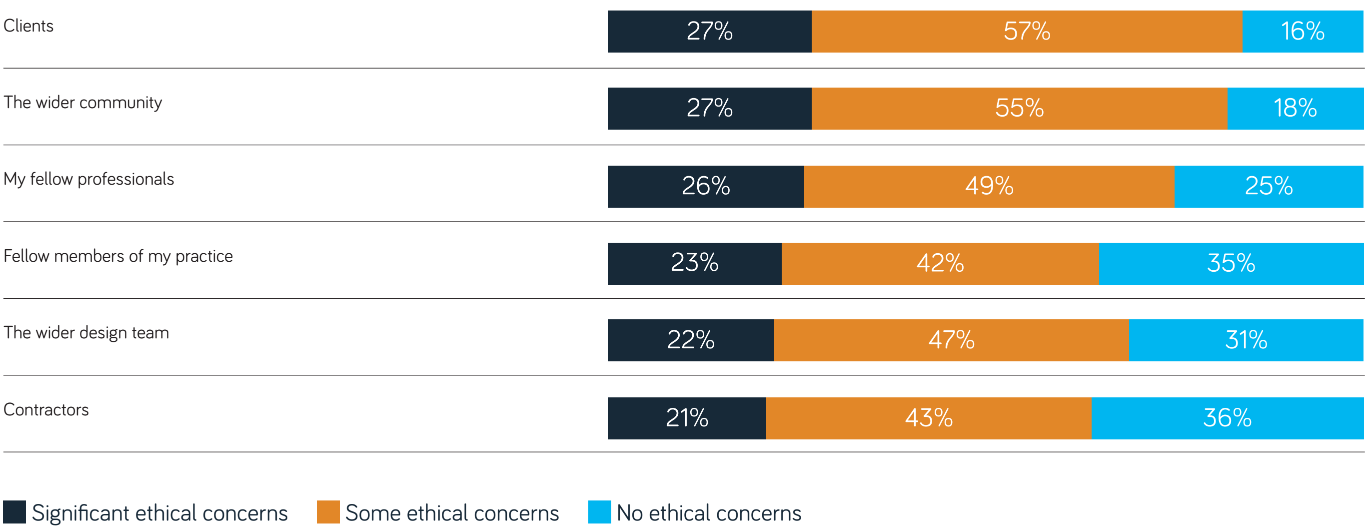
AI may bring with it ethical considerations, such as the risk of inadvertent plagiarism, how to attribute ownership of and charge a fair amount for work, and the changed relationship between the architect and others where machine-generated design and communication is interposed between them.

The survey results suggest architects tend to agree that AI brings with it ethical considerations. For each of the architect relationships given below, a clear majority of respondents suggest there are ethical concerns, and a noteworthy proportion (21–27%) rank the ethical concerns as 'significant'.

Ethical concerns around dealing with fellow members of the practice, fellow professionals, the wider design team and contractors were the least pronounced; concerns relating to dealing with clients and the wider community were the most pronounced.

Adopting AI is not just a technological challenge, but an ethical one too, particularly when considering those outside the design and construction sectors – the clients and communities the profession seeks to serve. The findings suggest there is a need for the profession to reflect upon and refine its responsibilities as the ethical implications of AI become clearer, to ensure continued trust and professional standing.

Do you foresee ethical concerns arising out of the adoption of AI, in professional responsibilities towards:



About the survey

The survey ran from October to November 2023, with RIBA members asked to share their views. Over 500 people responded to the survey; our sincere thanks to those who did. Not everyone responded to every question (in part because not every question was relevant to every respondent).

The respondents were self-selecting, so the results are best read as a very good indication of AI in the profession, but not as definitive.

RIBA would like to thank all those who took the time to complete the survey. It is greatly appreciated.

[7] *https://www.architecture.com/knowledge-and-resources/resources-landing-page/code-of-professional-conduct*
[8] *https://www.ribabooks.com/RIBA-Ethical-Practice-Guide_9781914124723*
[9] *https://www.architecture.com/knowledge-and-resources/resources-landing-page/ribas-ethics-and-sustainable-development-commission-final-report*

Adoption of AI and its use within the architecture industry

While the conversation surrounding AI is thriving within the architecture industry, is the actual adoption of AI by architects following the same path? The RIBA AI Survey sheds light on whether or not the industry is indeed turning to AI technologies to support design processes and project workflows.

AI technologies have the potential to transform traditional approaches to design and construction, offering architects powerful tools to enhance efficiency and creativity. However, there seems to be significant hesitation among architects about whether to fully adopt and embrace AI. This appears to stem from uncertainties about how AI will affect traditional roles within the industry, job displacement and both the reliability and the ethical implications of AI-driven decision-making. These concerns are reflected in the results of the RIBA AI Survey. For instance, a third of the architects surveyed agree that AI will become a threat to the profession, and a third that AI will lead to staff reductions. As a result of this uncertainty, many architects are hesitating to fully embrace AI technologies, leading to a relatively slow pace of adoption and integration within the field.

AI in architecture and how is it used within the industry

Let us begin by looking at what we mean by AI within the architecture industry and how it is currently being used. AI within architecture refers to the application of computational techniques, algorithms and technologies to assist architects and designers at various stages of the architectural process. It is already being utilised in various ways, often without even being labelled as AI. Some of the more common areas of its current application are given below.

Generative Design: AI algorithms generate and optimise design solutions based on criteria such as space requirements and aesthetic preferences. This approach allows architects to explore innovative options efficiently.

Project management and scheduling: AI is being used in Customer Relationship Management (CRM) and cloud-based project management software/systems to make predictions, optimise schedules, carry out risk assessments, and more.

Building information modelling (BIM): AI is prevalent in existing BIM practices. For example, AI algorithms can analyse BIM models and provide valuable insights. It is also responsible for detecting clashes between architectural, structural and mechanical systems, thereby reducing errors and conflicts during construction.

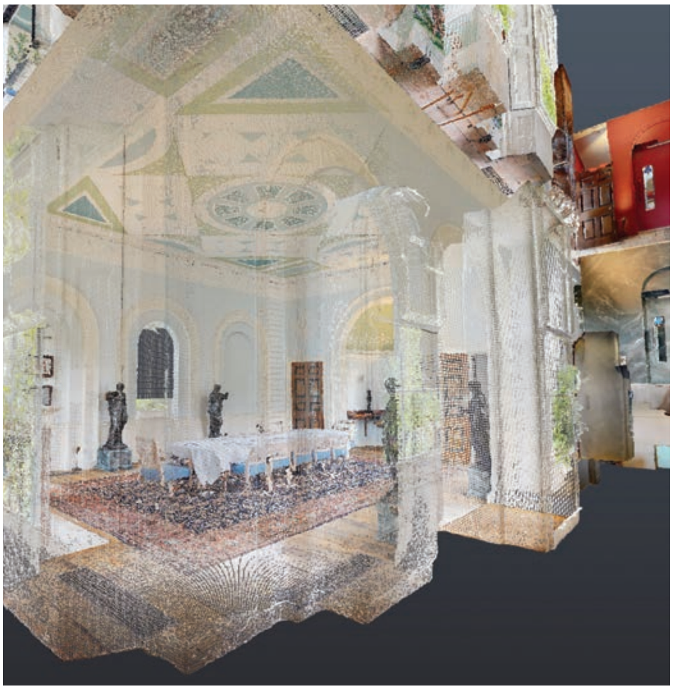
Digital twins: Digital twins enable architects to simulate an existing building at maximum accuracy. This can be achieved through point cloud models of existing spaces, which can be used to create BIM models, or by providing a collaborative platform for architects, clients and stakeholders, where they can view and interact with a virtual model.

Energy efficiency and sustainability: AI algorithms can optimise building performance and predict energy use, daylighting, thermal properties, and more.

Technology interactions: AI can help architects and engineers to conduct structural analysis, analyse loads and optimise designs for maximum strength and safety. There may be a happy time when AI will produce building control drawings and specifications!

Jaina Valji
Architect and Founder of Copy and Space

COPY + SPACE



Screenshot of a point cloud scan of Pitzanger Manor, image courtesy of Jaina Valji, Copy and Space.

Jaina Valji conducting a point cloud scan of Pitzanger Manor, image courtesy of Jaina Valji, Copy and Space.

AI and its implementation through BIM

All of the applications outlined above can be implemented through the use of BIM, which has a crucial role to play in the integration of AI within the architecture industry. BIM is a digital representation of the physical and functional characteristics of a building, providing a collaborative platform where architects, engineers, contractors and other stakeholders can design, visualise, simulate and manage buildings throughout their life cycle.

When combined with AI technologies, BIM becomes even more powerful, enabling enhanced automation and analysis and optimising decision-making capabilities. By applying machine learning algorithms to BIM data, AI can identify patterns, optimise design parameters and predict project outcomes more accurately. The integration of AI with BIM empowers architects to leverage the full potential of their digital models. I believe that the use of BIM offers the greatest opportunity for integrating AI within the architectural workflow – having a single collaborative model that allows repositories of information to be accessed using AI.

The integration of AI with BIM empowers architects to leverage the full potential of their digital models.

Challenges and risks of AI in the architecture industry

With the great potential of AI comes inherent risks and challenges. Some of the key challenges that AI may pose within the architecture industry are examined below.

Overreliance on certain aspects of AI: Insufficient human oversight could lead to unchecked biases or errors in AI-generated designs, or to designs that unintentionally imitate copyrighted material. To mitigate this risk, architects should remain critical of everything that AI produces, leveraging AI as a tool to enhance, rather than replace, human expertise and creativity.

Legal and insurance considerations: Given the advancements of generative design iterations and technology interactions, it is important for architects to remember that AI is not an entity that can be held liable. Architects hold PI insurance and assume liability for all information produced as a result of the use of AI.

Accuracy of the data used to train AI: The integration of AI in architecture has several attendant risks relating to the data used to train AI. For instance, biased, inaccurate or incomplete training data can lead to designs that introduce societal biases, result in inaccuracies in predictions and give rise to privacy concerns relating to sensitive data. To mitigate these risks, a diverse and transparent process of data selection should be applied with rigorous validation processes.

Even as an advocate of AI, I admit that achieving the balance is undoubtedly tricky. On the one hand we, as architects, are asked to embrace AI while, on the other hand, we are asked to be cautious of it and double-check everything it produces. Despite AI's capabilities, there remains a need for human oversight and validation to ensure the accuracy, reliability and ethical integrity of the outcomes it produces. This dual responsibility requires architects to embrace AI as a valuable tool while also maintaining an observant stance, double-checking and verifying its outputs to mitigate potential errors or biases. If we take this approach, we can ensure responsible AI adoption while driving innovation in architecture.

Experiment 3 with Midjourney, image courtesy of Jaina Valji, Copy and Space

Is AI going to steal our jobs?

This is possibly one of the greatest perceived threats related to AI generally, including within the architecture industry, as shown by the results of the RIBA AI Survey. I do not believe that AI will replace the role of the architect but it will certainly reshape the nature of the profession. While AI technologies are increasingly capable of automating certain tasks within architectural practice, such as drafting, modelling and analysis, they are not capable of replacing the creative and critical thinking abilities of human architects.

Instead, AI is positioned to complement the capabilities of architects, offering powerful tools for design exploration and optimisation. AI allows architects to tackle complex challenges in design and construction more efficiently and effectively. It facilitates faster iteration, exploration of design alternatives and evaluation of performance criteria, leading to better-informed design decisions and more innovative solutions.

Ultimately, I believe that the role of architects in the era of AI is likely to evolve. Part of our role will be to learn how to successfully create and implement parameters so we can leverage AI as a tool to enhance our creativity and expertise, thinking beyond the limits of the human mind and without time constraints. For example, if we wanted AI to produce design options for 30m2 apartment arrangements that were compliant with building regulations and London housing design standards while also maximising the use of daylight, we would need to know how to ask AI to go about this task. Therefore, our roles will adapt to include learning how best to extract this information from the platform we are using in the same way that ChatGPT produces the most useful information when you ask it a precise, specific question.

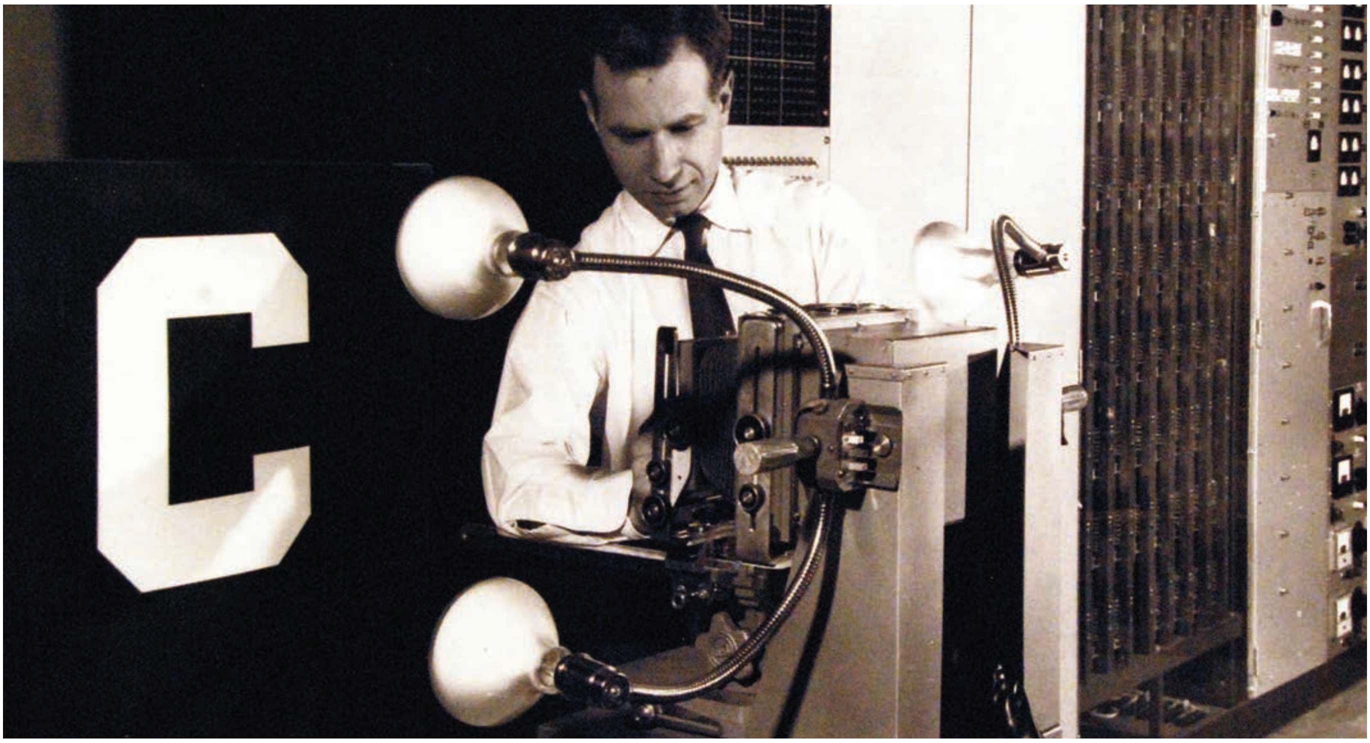
Conclusion

Fostering transparent communication between industry experts, AI developers and architectural professionals will help to clarify the misconceptions surrounding AI and build trust in AI technologies. Facilitating collaboration between architects, AI developers and other stakeholders encourages a shared understanding of AI's potential and its limitations. By working together on pilot projects and research initiatives, architects can gain hands-on experience of AI technologies and build confidence in their application within the industry.

Establishing clear ethical guidelines and regulatory frameworks at a higher regulatory level to govern the use of AI in architecture would help to alleviate concerns about potential misuse or unintended consequences. Architects need assurance that AI-driven decision-making processes both adhere to ethical standards and prioritise societal well-being.

Finally, integrating AI into architecture schools would not only prepare students for the future of the profession but also teach them to leverage AI technologies responsibly and ethically to address contemporary architectural challenges. Teaching students how to properly benefit from and safely use AI does not need to detract from learning the fundamental skills of being an architect.

Addressing challenges and fears within the industry through education and transparent communication about AI's capabilities and limitations is critical to paving the way for more widespread adoption of AI in architecture.



The Perceptron, invented by Frank Rosenblatt in 1958: The origins of deep-learning from machine perception. Image courtesy of National Museum of the US Navy

The computable and the incomputable

In the RIBA Journal of February 1967, Roger Walters described design with computers as a series of choices or decisions involving complex data: 'At one end of the data spectrum were complete quantifiable factors, at the other end the factors which could never be quantified, which derived from an architect's creativity and turned buildings into architecture.' The debate then, as now, considered how computers might transform design and which tasks they could and should be allowed to undertake.

In the 50 years since Walters wrote this, computing has not just delivered new drawing tools, but also fuelled a wider systemisation of the workplace. The role of the architect is increasingly described through discrete tasks and operations. The design process is divided into stages and packages of information through drawings, models or simulations. The modern digital landscape, through the adoption of computer-aided design (CAD) and building information modelling (BIM), has integrated the quantifiable whenever possible. Being an architect now certainly appears much more systematic and computational, but does that make architects suitable for replacement by AI?

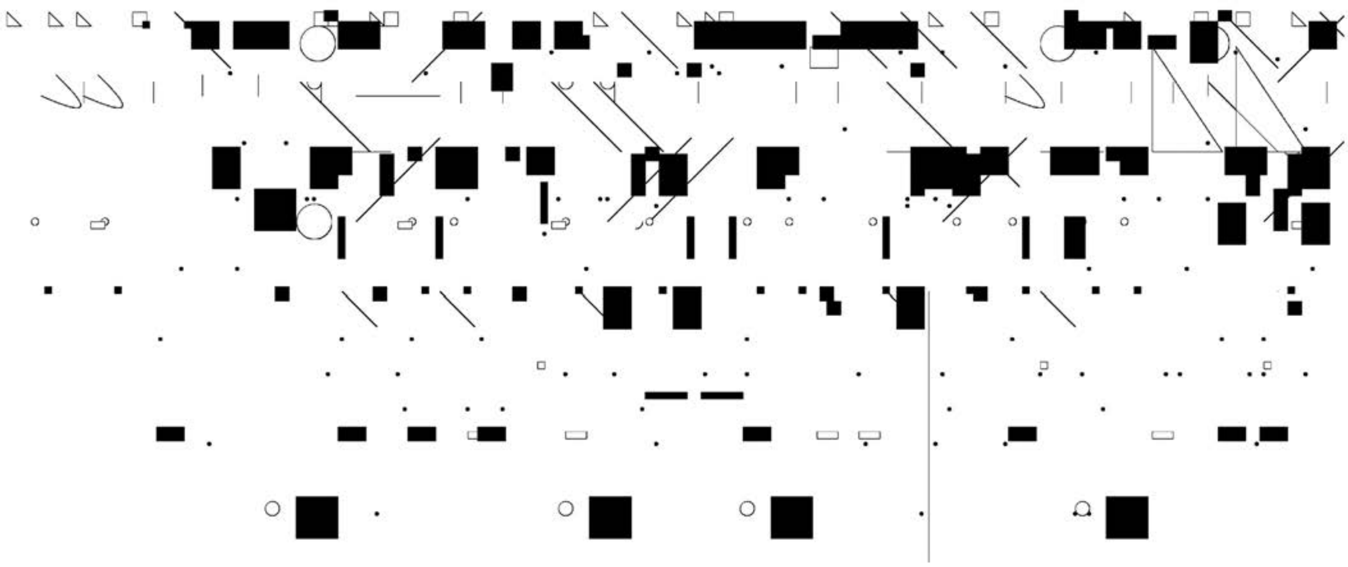
The quantified

If we keep to the historical narrative, AI is the latest form of automation that aims to turbocharge the efficiency of a well-defined task. Provided with a dataset, machine-learning will create a model – capable of doing something, but learned through examples and comparison rather than based on rules. It can replace certain machinic functions and absorb the quantifiable thinking. Generative machine learning can create a letter, a sketch or an image faster. Pre-qualification questionnaires or reports can be effortlessly improvised by ChatGPT with some simple prompting. The results may be relatively generic, and might sometimes contain inaccurate hallucinations, but through a little supervision we can be fairly clear on whether the machine's output is aligned with our own. These applications are inevitably creeping into the routine of practices, replacing straightforward activities. They offer many benefits, providing we remain circumspect about their limitations. They can be easily sold to an overstretched profession as a way to spend 'more time on what they enjoy', as was promised last century with the introduction of CAD.[1]

[1] *'Towards computer-aided building design', RIBA Journal, 1968.*

Tom Holberton

AI Researcher and Lecturer,
Bartlett School of Architecture, UCL



Parole Composte, by Natalia Michalowksa, UG21 Bartlett School of Architecture: Co-authoring designs with AI Large Language Models. Image courtesy of Natalia Michalowksa.

Extending generative AI to design-specific tasks is more challenging. New AI software manufacturers are keen to present intelligent tools that correspond with a systemised definition of architecture, stage by stage, output by output. It might be suggested that these tools can replace pieces of design thinking. The best arrangement of volumes on a site can be treated as a parametric problem to 'solve', where multiple factors of efficiency, daylight and cost can all be combined. Yet the datasets used to build this intelligence are permutations generated by algorithm. This approach can render options upon options, combining and blending multiple simulations into a chain of quantified factors. Extending this into plan generation can be used to draw and multiply highly standardised layouts automatically, but with little explanation.

In design, the optimisation of one factor over another, or where a solution must strike a balance, still requires an architect to understand each factor's relationship to the overall design. In the current world of computation, we can depend on the clarity of simulations and mathematical functions to explain both how and why changes occur with parametric precision. Machine learning may reveal more solutions, but the danger of this new kind of combinatorial intelligence is that it obscures how a solution has been generated. As a design develops and becomes subject to inevitable changes from other quantified and unquantified factors, an architect and the design team are then detached from how these changes impact previous assumptions.

If AI is to automate larger portions of the design process, then a model will need to be trained on a large dataset of drawn problems to construction outcomes. Integrating methods of detailed design to built solutions could offer great benefits in performance, considering efficiency of fabrication, waste management and sustainability with a real evidence base. While there may be companies that can assemble the necessary dataset of training examples, the model's methods would largely remain a black box, unavailable for scrutiny. An AI model will simply present a fully formed but unexplained solution. Any company would need to absorb all of the risk of performance and failure, with plenty of confidence in the probability that it works, and insurance in case it does not. Without a huge liberalisation of standards, the current network of competencies, responsibility and checks would have to be applied retrospectively to a solution, with humans checking the machine's work without access to any underlying strategy.

As we try to replace larger and larger chunks of the design process with machine-learning we encounter difficulties with its blackboxed nature. We have become accustomed to digital technologies bringing greater legibility to process. Software should bring reliable functions with clear inputs and outputs. More crucially, when a building must reconcile both quantified and unquantified factors, the designer needs to be able to interrogate how different calculations are manifesting in an outcome. Architects cannot locate a building design entirely within one simulation or system and ignore everything else.

Yet AI and deep learning is a paradigm shift in how we relate to computation. It offers none of the algorithmic feedback we have become accustomed to. It is not written in code as operations or processes, but merely learns an emergent behaviour from examples. We have to take on trust that its function will be the same next week as it was last week and that it has not been altered by a new context. There is no hard-coded function that explains its behaviour, just probability.

The expectations that AI is here to automate, to literally self-act, might suggest this technology can fit neatly into the computational world we have built over the past 50 years. Design has been transformed by and for software, with many discrete and quantifiable tasks that might be replaced. And yet, deep learning is a different kind of automation, acting in the world but without any function, without a parametric legibility. It does not easily replace or extend the established computational tools without undermining our ability to make complementary good creative judgments.

The unquantified

The unquantifiable has helped architecture to learn the limitations of generative processes. In education and practice, we frequently interrogate where a designer's agency is located alongside the computer. This debate is integral to the profession. We are ahead of many other subjects in how to assess processes that combine the human and the generative. This difference has been stark in the past year, when many of the arts and humanities have first been confronted by ChatGPT, raising profound philosophical questions around automatic writing and integrity.

Much of the work of architects that is most cherished lies in these gaps between discrete pieces of information. It sits within eternally difficult terms and the particularity of design. It depends on complex feedback and foresight: how might a sketch be resolved to a built detail or absorb other requirements? There are intuitive pieces of experience and judgment that allow the design to progress and emerge – crucially through anticipation but not determination of an outcome. It remains unquantified and indeterminate, trading in probabilities.

So, if this was unsuited to previous modes of computation, is it now beyond AI? While generative models, such as text-to-image generators, still use data, they explore what might have been considered previously unquantifiable qualities. Through assessing the probability of different combinations of image content and captions they build subjective but powerful readings. The training method measures the patterns of human deployment of meaning out in the world to build an understanding of syntax and, possibly, semantics, behaving more like a form of perception than cognition. Learning is created directly through recognising how examples reinforce or diverge from one another.

Methods such as these are crossmodal; they learn the correspondence between different kinds of data and contexts. In this they can capture the patterns and structures of relationships as are tested and applied in real life. They mimic the crossmodality of architecture itself, which depends on multiple sources of representation to develop and refine one idea: through drawings, models, plans and sections. The architect deploys and develops many parallel methods of representation to interrogate and refine a single design.

The crossmodal text-to-image generators such as Midjourney, Stable Diffusion and DALL.E provide new large-scale methods of rendering and visualising ideas, questionably web-scraped from all kinds of creative labour. However, these fantastical images, detached from any underlying 3D model, have limited usefulness for spatial development. The more unexpected impact of this technology is the prominence it gives to language as a means to access and manipulate imagery through entering prompts. The image caption becomes as important as the image itself. Language becomes a new, direct way not just to describe but to directly instruct image construction.

The technology companies who create the text-to-image models see creativity as a 'zero-shot' or one-click process open to all. It brings a quality of synthetic representation to anyone; one which was only possible previously with extensive visualisation software and skills. This deskilling might inevitably bring architectural representation back into the routine of practices, where the combinations of 3D models, description and reference images can quickly communicate architectural ideas. New AI plugins to 3D-modelling software are already heading in this direction.

If we see generative AI as an opportunity of perception rather than cognition, we can train tools that augment creativity by relating different data types or moving between exploratory forms of representation. These can be formal: sketches, diagrams and gestures to 3D volumes. They might equally be far more speculative and connect other sensory inputs, such as music or language. They can be focused on the specifics of a site, or a typology, or a process. AI models can act as creative tools for individual projects that work iteratively rather than offering a single-click outcome.

To harness this will require more direct engagement in the collection of datasets and training of models by architects themselves. We now operate in a data-rich environment and have the means to curate and generate our own data to direct bespoke machine-learning models. These can be part of a design process and are already being enthusiastically tested and scrutinised by new generations of students engaging with AI at a code level.

AI can learn a 'centralising tendency', converging to the average in any dataset, ignoring the outliers and any exceptional data. This is inevitably a concern with large-scale commercial tools, where their mass utility is at odds with the specialist and applied knowledge of a profession. Writing the right kind of technical email to a contractor or positioning material junctions correctly in an image might be impossible for a user to prompt out of a general purpose model. Identifying and safeguarding specialist data might become a key objective of professional bodies. Bespoke AI models for case law or medicine are already being pursued and, with methods such as transfer learning, more generally intelligent models can be focused towards a specific domain of knowledge.

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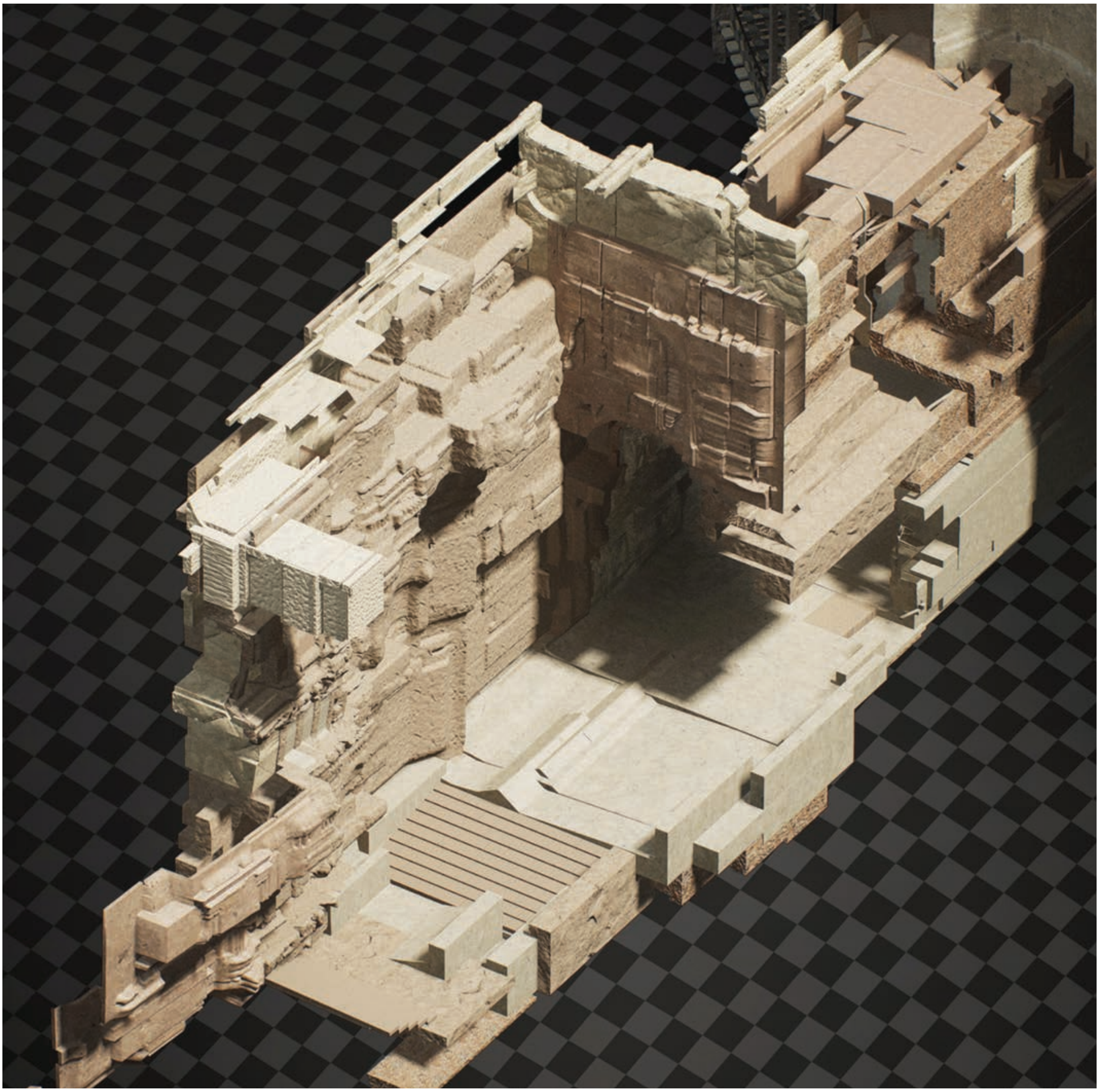
A new relationship

From a mixture of quantifiable and unquantifiable factors, design has become a mixture of the computable and incomputable. There are dangers in assuming this relationship with computation remains the same with AI. If machine learning is adopted only as a technology of the quantified, it risks a further systemisation of architecture by those who operate within conventional metrics. It will not, however, extend transparency or legibility, but risks extending power to software with inscrutable logic. It will make it harder to reconcile the complex mixture of factors that combine in a building, frustrating judgment and creativity.

If architecture can engage with this technology as a form of machine-perception, one that perceives a site, a design and a process in novel and unexpected ways, architecture will have a new tool for the unquantifiable. It can extend and recalibrate the relationships and associations that are already out in cities and everyday life and serve as a constant source of reference for new buildings. It can combine different patterns of participation and representation, extending the crossmodality of practice to the community. Architects must engage with AI, not only as a means to solve universal problems, but also to localise problems with bespoke models and data. This should ultimately place architecture at the centre of the debate about how to use the technology, rather than just being another automated application.



Cross-modal compositions, by Rolandas Markevicius, PG21 Bartlett School of Architecture: Designing architecture and music simultaneously with AI. Image courtesy of Rolandas Markevicius.

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