

Close Future: Co-Design Assistant

How Proactive design paradigm can help

Antonio Fioravanti¹, Armando Trento²

^{1,2}Sapienza University of Rome

^{1,2}{antonio.fioravanti|armando.trento}@uniroma1.it

The present paper is focused on exploring a new paradigm in architectural design process that should raise the bar for a mutual collaboration between humans and digital assistants, able to face challenging problems of XXI century. Such a collaboration will aid design process freeing designer from middle level reasoning tasks, so they could focus on exploring - on the fly - design alternatives at a higher abstraction layer of knowledge. Such an assistant should explore and instantiate as much as possible knowledge structures and their inferences thanks to an extensive use of defaults, demons and agents, combined with its power and ubiquity so that they will be able to mimic behaviour of architectural design human experts. It aims other than to deal with data (1st layer) and simple reasoning tools (2nd layer) to automate design exploring consequences and side effects of design decisions and comparing goals (3rd layer). This assistant will speed up the evaluation of fresh design solutions, will suggest solutions by means of generative systems and will be able of a digital creativity.

Keywords: *Design process paradigm, Architectural design, Design assistant, Agents, Knowledge structures*

SCENARIO

In a changing world - in nature and humans needs - we need very clever tools to speed up the design (Bhatt 2013) - architectural design this case. Architecture as W. Morris [1] stated in "The Prospects of Architecture in Civilisation", a speech delivered at the London Institution on March 10th 1880: "A great subject truly, for it embraces the consideration of the whole external surroundings of the life of man; we cannot escape from it if we would so long as we are part of civilisation, for it means the moulding and altering to human needs of the very face of the earth itself,

except in the outermost desert.". More than a century ago W. Morris defined utopianly - but clearly - the vastness of architects' responsibility and now it is dramatically evident. As a matter of facts, humans colonised the Planet and now 7.5 billion people are able to destroy this world as it has been known till now.

It is clear that socio-techno-economical phenomena appear more and more complex and that technological innovation are cause-effect-remedy of subsequent problems. We know that humankind has a steady-acceleration considering it in the whole,

but if we considered single phenomenon it would follow the Kondratiev's evolutive curve [2] or modified Kondratiev's wave (Korotayev and Tsirel 2010). The evolution in average of humankind, GDP, technological and science philosophy has had a steady state acceleration. In any kind there was a spiral among problems-resources-side effects-problems and the overall balance has been manageable.

But now in the new era - the *Information Eve* - the curve has had a sharp edge and those concepts have climbed up. Consequences of that huge phenomena have arrived: most world population lives in cities, energy released in the atmosphere increases temperature, pollution is more dangerous than car accidents, and communications - any communication, among humans or things - run more than the capacity to understand context and information itself.

That gives huge responsibility to designers: they should understand in deep problems and boundary critical conditions as they can be able to modify event courses, Planet safety and drive projects toward success or failure (Meadows 1972, Diamonds 2011).

To manage these extreme problems and conflict-ing solutions means "designing". In our CAAD world, we should adhere to strategies nature did, particularly one of most successful example of adaptation: the human behaviour.

What humans do? Optimise. Optimizing thinking especially.

They are able to selectively explore solution domain. They are able to take into account any constraint and to skim off the wrong ones or not well-suited solutions.

In a design process, designers have to figure out predictions by means of simulation/learning tools that now are able to crunch a behemoth of numbers. But these examples are related to *brute force* + mental short-circuits as they are thought for "fewer dynamic domains with fixed rules in a limited period of time" compared with the Architecture-related knowledge domains.

Architecture, in a broad sense, is quite different from other discipline as their artefacts are unique or

and rooted. So, it must be considered at the same time: artistic aspects, building sciences, economical matters, social impacts. It has a peculiarity that it takes into account very long time period problems, but codes and regulations change very frequently as well as market rules, building components and new materials.

In Architecture to manage such a bigger complexity (just for instance: ancient building restorations, urban zone renovations or high performative buildings) the process has been subdivided into phases and in specialists' works, so useful tools have been developed so far that follow the standard process of defining phase by phase solutions.

BACKGROUND

In recent decades relevant organizational efforts have been made in design process knowledge management by means of initiatives based on advanced information and communication technologies (ICT). However, organisations have experienced that leveraging knowledge through ICTs is often hard to achieve.

Walsham (2001) addressed the question of why this is the case, and what we can learn of value to the future practice of (design process) knowledge management. His analysis is based on a human-centred view of knowledge, emphasising the deep tacit knowledge which underpins human thought and action, and the complex sense-reading and sense-giving processes which human beings carry out in communicating each other and 'sharing' knowledge.

Looking specifically at the CAAD context, we concluded that computer-based systems can be of benefit in knowledge-based activities, but only if we are careful in using such systems to support the development and communication of human meaning and intentions (Trento et al. 2016, Novembri et al. 2017, Trento et al. 2018).

Architectural design process problems can be subdivided in two parts: the first one, it is the intrinsic nature of design process and how it can be faced by a new model; the second one, how such a model

can be defined by an applications ecosystem (a Digital Assistant) to be built upon it.

Regarding the first point, designers and researchers to deal with these tasks extensively explored the “Collaborative design” process paradigm as it can overcome the “Traditional design” process weaknesses where the activities were rigidly subdivided in boxes and each designer specialist operates inside his/her own box. Very often the latter process led to inconsistent solutions, organizations had partial overlapping competencies, so some part of problems are not dealt with by any specialist and the pyramidal hierarchy was so high that decision process was very slow.

Collaborative design paradigm studies (Kvan 2000, Achten and Beetz 2009, Fioravanti et al. 2011) turned out that to be effective the design process should have had been overcome among many problems: inconsistent data and incoherent semantic entities. The former has been faced by means of a “BIM (tool) layer”, the latter by means of an Ontology representation - OWL). So that it has been added a new layer over the BIM layer, the so called “upper Ontology layer” (Carrara et al. 2017).

Consequence of that it was needed a “bridge” of relationships between the “BIM layer” and the “upper Ontology layer”, this goal has been tackled by many approaches and solutions according to: J. Beetz, J. P. van Leeuwen and B. de Vries (2006); A. Fioravanti and G. Loffreda (2015); D. Simeone, S. Cursi and M. Acierno (2019); A. Fioravanti, G. Novembri and F. Rossini (2017).

The inconsistent database management problem has been treated by J. Gray - the Google Earth inventor - and now it is no more a taboo to deal with inconsistent entities, f.e. different interpretations of archaeological site entities (Cursi et al. 2015) or putting together ontologies and shape grammars (de Klerk and Beirao 2016).

We already explored in a previous study the possibility to realize a partial proactive design tool (Carrara et al. 2012), but with traditional ontologies it is possible to treat only entity property incoheren-

cies (2nd layer). As a matter of facts those ontologies are not able to treat difficult-to-classify entities, for instance different percentages of datings and interpretations of the same entity by an archaeologist (for example a capitol fragment embedded in a ruin), nor deep reasoning, which both take place at the 3rd layer.

CHALLENGES & NOVELTY

The goal to be pursued is a new design process paradigm that makes designers to face - in an easier way - complex problems as those cited before.

So, going back to thinking optimization and paraphrasing John Archa (1987), “what *great* architects do?”.

Apart the shortcomings of software programs and deficiencies in methodologies described in previous sections, from scratch they concurrently think at different abstraction layers and take into consideration different partial solutions of different design phases. They have in common that they sketch on a sheet of paper drafts that represent a building overall shape beside a vault detail, an interior perspective and the brick they prefer (Carrara et al. eCAADe 2004).

If they change an element, all their own reasoning networks in their brain will be activated - in real time - as far as it is possible.

Another problem to be tackled if we modelled the architectural design process with OOP entities, would be the “combinatorial explosion” of entity attributes (i.e. other entities) we have to define (Tessier et al. 2001); it is not just a quantitative problem related to the huge attribute number but the ability to address information in a synthetic way that means an upper knowledge abstraction layer. That it is not tractable with usual ontology systems as f.e. Protégé Ontology Editor (Musen 2015).

So, we need an “application ecosystem” - an *Assistant* - able to take into account heterogeneous entities of different knowledge abstraction layers (each of these ones with several levels of detail) in domains full of default entities, that in real time explores entity

networks and puts in evidence consequences and side effects.

Summing up all these characteristics we can define a model of abstraction layer that can act as a *proactive design assistant*.

METHODOLOGY

We already studied the first two layers: data layer and simple reasoning layer (Predicate Logic) together with a new 'bridge' between them (Fioravanti et al. 2017). Now it is time to think about the 3rd layer, the one of strategic thinking.

Design "entity" history in short from computer science point of view:

- First - digital OO entities - they belonged from an ontology universe made by objects; these objects had inheritance and automatic propagation of consequences; only one world = geometry and included knowledge.
- Then - digital entities are "pluri-objects" - they belonged from many ontology universes thanks to ontological representations; a dual representation world = geometry and knowledge for each specialist actor.
- Next - digital proactive entities - they belonged from many ontology universes and are represented by agents, agencies and actors; all the worlds are made by them (Mei, 2015).

The third layer can be done by means of a network of mixed knots of agents, ontologies and fuzzy ontologies and should be explored a possible cooperation between stochastic and deterministic searches.

What we want to highlight is the need to do not limit the present research on CAAD systems "only" to the development of 'intelligent' routine that can help designers to design faster, memorize and manage big data or produce increasingly realistic simulations. Proactive design assistants should rather explore and enhance the responsiveness based on the cognizance of complex relationships that exist between professional knowledge, to activate them, exchange them and increase them in the life cycle of

the "*aedificium*".

To support proactively designers, third generation of CAAD systems should be able to perform the following complex tasks:

- To define, by means of a satisficing approach, the designers' objective;
- To enhance awareness about the design product/process, in relation to the designer objective;
- To compare goals and explore consequences and side effects of design choices (3rd layer);
- To reach the designer at the right moment with the right contents: evaluation and prediction.

In a proactive design process the assistant will automate a fast evaluation of fresh design solutions, will suggest solutions by means of generative systems and will be able to perform a digital creativity (Colton and Wiggins 2012).

CONCLUSIONS

From the clients to the designers, from the builders to the end users, the state of the art related to the tools for the management of technical knowledge and to handle architectural design process has been studied in depth and a new paradigm has been delineated in order to capitalize on the enormous amount of knowledge of which they are protagonists (producers-consumers).

If the various actors, especially in the initial stages of planning and engineering, will be aided by proactive design assistant, the quality of the buildings and of the lives of those who live there can only benefit from them.

We argue that CAAD systems need to support the use of information for action, but that this is often compromised by poor quality and reliability of data. In addition, good data and related design-oriented ICTs are inadequate by themselves since effective action also needs knowledgeable people and supportive institutions.

What we want to underline is that new ap-

proaches must be discussed on CAAD software philosophy, educating people and changing institutions. We need an effort to conceive an all new paradigm as theory and practice in design have never been so intertwined as in the last years.

This is a theoretical effort to treat design process problems as a whole, related to Architecture complexity that after almost fifty years from Architectural Machine (Llach 2011) seems possible to be faced.

ACKNOWLEDGEMENTS

The research project has been partially financed by PRIN 2018 National Interest Research Program titled: "A Distributed Digital Collaboration Framework for Small and Medium-Sized Engineering and Construction Enterprises" of MIUR (Italian Ministry of Education, University and Research).

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