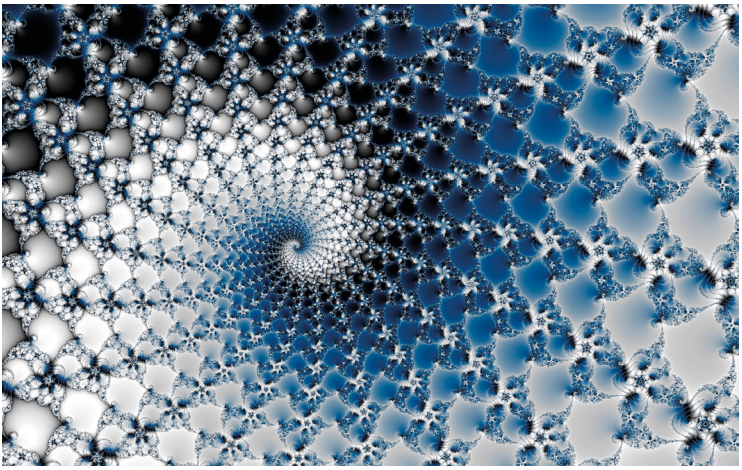
Convegni

Scienze e Tecnologie

Project Management

Driving Complexity
PMI® Italian Academic Workshop

edited by
Fabio Nonino, Alessandro Annarelli, Sergio Gerosa
Paola Mosca, Stefano Setti



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19. Improving the integration between BIMs and Agent-Based Simulations: the Swarm Building Modelling - SBM

Gabriele Novembri, Francesco Livio Rossini, Antonio Fioravanti

The construction sector is, currently, one of the most important sectors of the world economy, although it is managed by dated systems compared to innovation that pervades other sectors such as, for example, the automotive. Till now, in fact, it is estimated that about 30% (McKinsley, 2017) of resources globally used in these processes, is dissipated due to management inefficiencies, which can be found both in the design phase and in the executive as well.

This inefficiency is not a new problem, but a constant condition in the construction realm, faced by current developments in digital techniques according to different approaches to the extension of CAD capabilities: from the interactive verification of choices through the use of Augmented, Mediated and Virtual Reality (Park et al, 2013), to the integration between the BIM model and predictive statistical methods, till to the definition of methodologies oriented to the verification of the model through simulation approaches (Scherer et Schapke, 2011).

Despite the development of Collaborative Design methodologies, the analysis of results of different lines of research shows, however, the tendency to discretize the design problem in different 'specialist packages', risking losing of the sense of complexity of the building system, and the repercussions that design choices can have on the entire building organism.

The aim of the research is therefore to provide Actors of the building process appropriate methodologies to manage the complexity of building, and to evaluate the outcomes of these choices in a predictive way. Thus, the prototype under development "*Swarm Building*

Model - SBM" is based on the paradigm of *Agents Swarm*: each agent indeed is able to receive stimuli from the outside, reacting according to their behaviour and objectives, and then involve in any changes all the other agents involved in the system: the result is the adaptation adapting the model to a collectively satisfying behaviour as happens, in nature, with a flock of birds.

Design/methodology/approach

The adopted approach is inspired by the behaviour that some animal species are able to show by creating numerous and complex groups, able to make surprising flock-geometries based on extremely simple behavior of the individual components. Some species are in fact able to create groups of subjects that remain compact and coherent, despite the perturbations applied, thanks to the iterative application of very simple rules.

Despite the apparent simplicity, this approach represents a real revolution in the ways in which the behavior of artificial systems with high levels of interconnection can be simulated, in which the overall behavior is the result of the interaction of the individual elements that compose it.

Similarly to what happens in nature for a swarm, the proposed prototype SBM will be able to react to external stimuli, remaining intact and coherent in the case of addition or subtraction of elements, as is when happen changes in nature or in the behavior of some building components. More generally, changes consist in perturbations represented by new choices or modifications or, in general, variations in the context.

The objects of the building system will follow these changes with the same reaction rate of the flocks in nature: these, in fact, are essentially aimed at maintaining the compactness of the group, like the architect aims to maintain the coherence in the several parts of the building.

So, in the proposed approach intelligent agents will be used to simulate the behavior of building objects for which, in this case, a general meaning is used. A building object can consist of a physical object, an idea or a concept (*design intent*) whose behaviour is relevant in describing the complex system.

The SBM, in this sense, is not only a tool to govern efficiently the building project, but an approach to support stakeholders along the whole building process: the modularity and scalability of the approach used, allow in fact to hypothesize a support system whose composition is not fixed, but varies according to the different phases of the building process, and to the subjects progressively involved.

Thus, to apply this approach, it is not necessary to proceed with the formalization of the whole system, but only the exact definition of the behavior of the individual components, that gradually harmonize the other elements and, as a result, give the correct project.

Findings

The approach adopted is also particularly efficient since the multi-agent are intrinsically based on *execution parallelism*, which makes them particularly suitable for exploiting the potential offered by the modern multi-core processors. The granularity and modularity of which it is equipped also allows the creation of distributed systems, allowing agents to interact simultaneously each other and with the context, regardless of their physical location. The application of the approach brings to the virtual construction of a real "ecosystem" able to give to every stakeholder a wide view on project evolution, a problem-solving approach and, finally, a more effective sharing of choices made by the different actors involved, thanks to a clearer sharing of the *design intent* that substantially in the base of the information itself.

Originality/value

This approach is in line with the research lines of the application of artificial intelligence techniques to the building process. These studies, so far, have always focused on solving specialist problems such as economic forecasts, or the management of complex construction sites, without considering the problem of complexity from a broader perspective.

This research, therefore, aims to provide technicians with a strategic support, able to synthesize the problems of the various sectors and to find solutions that meet the needs of the various players, through compromises and the clear identification of objectives.

Research limitations/implications

From the very beginning of the contemporary 'computational-era', the actors of the building process have found in the computer a valid ally, able to effectively manage important amounts of data and equip, in an ever more *democratic* way, the operators of the sector with instruments that are sufficiently complex, with respect to the insidious complexity of the design problem (Kuntz and Rittel, 1970).

These tools have therefore gradually evolved, depending on the computing power developed by the machines available on the market, allowing at first the possibility to manage geometries and data in separate environments and, from the last decades, modeling information in interconnected holistic environments, such as happens in the BIM approach.

The introduction of BIM systems has unequivocally represented a first important step towards new ways of designing, supporting and managing the executive and dialogue phases and the interaction between the different operators. Despite the obvious limitations (Miettinen et Paavola, 2014), the advantages obtained thanks to these systems now appear to be effective and measurable, even considering the slow and non-homogeneous adoption of this new type of tools.

Although there are several valid prototypes of interaction between designer / artificial intelligence (Cambeiro et al, 2014), the tendency is to focus on the development of these models in specialized field, without going into the *holistic vision* of the building process. Actually, it is to be implemented according to methodologies that prefer the collaborative approach in place of a mere sequential integration of specialisms. Beyond these research lines, the integration of BIM and Agents-based Simulation were developed, maintaining the global vision of the project, towards a synergic collaboration between man and machine (Fioravanti et al., 2017). Finally, among the limits found, the techniques of representation and transfer of *design intent* are ineffective, necessary both as a methodology of '*customization*' of the project, both as an iterative verification of changes and adaptations, occurring every time on the BIM model.

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Contemporary organizations are undertaking increasingly complex projects in globalized, uncertain and dynamic environments. Proliferation of international programs, growing and challenging sophistication of technologies and of projects' scope, and the increasing number of stakeholders are only some of the factors that increase or generate project complexity. Enhancing the understanding of what project complexity is and delineating the antecedents that increase or generate complexity can be fundamental steps towards the identification of drivers that cause complexity and consequences for project management performance.

The PMI® Italian Academic Workshop, organized in 20-21 September 2018 by Sapienza University of Rome and the three Italian Chapter of the Project Management Institute, has been an event aimed at supporting participants to develop their researches to a further stage through in-depth discussions on the topic of project complexity.

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