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# A SURVEY ON THE VISUAL COMMUNICATION SKILLS OF BIM TOOLS

*Exploring a new story-telling methodology*

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**Abstract.** Building Information Modelling (BIM) applications are supported by various modelling tools, being expansive to deliver visualised geometry and databases simultaneously. But there is still a gap in visual communication amongst its professionals. Articulating the advantages of fully Web-based collaboration, this paper looks into how BIM tools make contribution to visual communication between different parties working collaboratively. A hybrid model of low-level and high-level interactions is tentatively conceptualised. Based on the hybridised model, a survey is conducted to elucidate a few experiential matters such as visual aesthetics, cognition and motivational impacts of visualisation in BIM tools. Following the survey, a discussion is oriented towards a new story-telling methodology with a novel term, namely *gamification*. Seeking motivating and efficient means of visual communication between human-human, human-tool and human-model interactions, the present study focuses on an enhanced legibility and appreciation of tools by those who are involved in BIM projects.

**Keywords.** Narrative visualisation; infinite computing; information aesthetics; gamification; hybrid model of interaction.

## 1. Introduction

BIM is claimed to be a paradigm shift in AEC as the complexity of information flow and exchange is at its highest level ever. Yet, BIM tools have not ascended in the advancement of visualising a narrative sequence to accomplish superior information flow chains. Rather, information loss and lack of communication are still at considerably high ranges. No wonder one of

the consequences is the failure in saving more time and budget, contrary to the main purpose of BIM. Generally speaking, this flaw happens due mainly to two following factors. The first is obviously the inability of the tools to store the whole information input and/or generated. Secondly, the information that is delivered by BIM tools with current visualisation means is not implemented within a cognitive narrative sequence.

Reserving huge amounts of information can be untangled pretty straightforward with technological advancements in storage capacities. But this paper contributes to these advancements with a hybrid model of control over BIM platforms where mass distributed users are allowed to synchronously communicate, share and work online throughout the process. This model relatively attempts to patch the gap where a sophisticated debate is being missed over a foundation upon which BIM tools can be based to fully exploit these advancements. A hybrid model is proposed with an aim to discuss possible improvements in visual communication skills in BIM.

Outlined with a hybrid model, the ensuing undertake of the present study addresses narration of information flow/exchange in/amongst BIM tools that generate a sequence of virtual scenarios. Improving these virtual scenarios is likely to enable BIM collaborators to get positive impacts on the cognitional aspects that are, in this study, relevant to visual aesthetics in BIM tools.

## 2. Knowledge visualisation and decision-making

In BIM projects, various kinds of information is visualised through a range of techniques. Amongst the research interests in knowledge visualisation, finding novel visualisation techniques is stated to be highly important because there are direct impacts of these techniques in decision support tools (Kunze et al, 2012). This paper focuses on the narration of the information flow in BIM with these techniques that are effective on decision-making.

In the Visualisation Summit 2007 where ten research goals were defined based on the assessment of nine workshops that were eventually combined in the last one as an outcome. Two similar topics, *Basic Narratives in Visualisation* and *Information Aesthetics* were rated amongst the top three in terms of their originality and importance. The latter workshop highlighted the value of creativity and emotional visualisation while the former was about emotional and cognitive involvement and better engagement for a deeper understanding by a broader audience, such as laypersons and interdisciplinary communicators (Burkhard et al, 2007).

These two workshops can also mean a very interesting background if one can realise why BIM is not still attractive enough for some. The visualisation performances of different BIM platforms have certain effects on cost esti-

mates and analysis. Based on the findings of these two workshops, this paper conveys a survey to display an analytical perspective for the experiential aspects of visual communication in BIM tools.

## 3. Exploring a new story-telling methodology for BIM

### 3.1. FLUID REPRESENTATION

The necessity to improve visualisation techniques leads to the realisation of discovering hidden depths of virtual space (Farrington and Studiotonne, 2002, 24). To put it other way around, research on shifting from stand-alone workflow to the Web is sooner or later going to be launched by the cooperating teams from *Autodesk, Otoy, Mozilla* and *Amazon* (Mozilla, 2013). Based on cloud services, this idea that is named as 'Infinite Computing' by *Autodesk* (2013) will make the PC ownership obsolete in coming years.

Likewise, this advancement will open up a new space to explore the potentials of virtual environments and cyberspace where visualisation can be more dynamic and interactive. As stated earlier by Bermudez (1997), highly hybrid and networked conditions will take place where the fruits of these advancements will lead AEC disciplines towards high levels of fluidity, exchanges, diversity and change. That is to say, hard-coding will less dominate the flexibility required to orientate interdisciplinary knowledge visualisation for networked collaborations. Rather will it be in a more fluid form of representation and information exchange, with more narrative information flow by means of BIM tools run on the Web.

Since one of the goals of BIM is to integrate domain specific design models, narrative quality in-between them values the recognition for new models of visualisation (Fernando et al, 2011). Once the hurdle of creating an engaging information flow is resolved, BIM projects will be allowing more participatory decision-making in different stages.

Succar et al (2012) assesses BIM stages in three catogories. Despite the first one described as asynchronous, the other two is where the collaboration between domains starts and the integration ties become more complex. In order for a coherent development to supply data-enriched visualisation, the research kicked off by *Autodesk* gains significance promising to take the first stage into the networked environment where information is synchronously updated. This progression is to put an end to the inequality between small and big companies in organising advanced PC systems and software that are expensive in maintenance and update.

Although the advantages are apparent, the present study, with a survey, attempts to see how users actually foresee the future in this. Results show

that only 20% of BIM managers (19% in total) think that standalone tools used in BIM create inequality amongst the companies providing BIM services. Another outcome is that the participants are optimistic about the impacts of the *infinite computing* in BIM tools; 84% 'agree' or 'strongly agree' that the research on *infinite computing* can lead to the exploration of more dynamic and interactive visualisation. And only 6% 'disagree' or 'strongly disagree' that this exploration can improve visualisation in BIM tools. So it can be concluded that the users of BIM tools are aware of the potentials of moving to more interactive environments and that information exchange is not fluid enough with current tools, namely *Autodesk Revit* (51%), *Graphisoft ArchiCAD* (12%), *Bentley Systems* (9%), *Tekla Structures* (9%), *GT Digital Project* (5%), *Nemetschek Allplan* (3%) and other tools (12%).

### 3.2. MODELLING A NARRATIVE SEQUENCE

Before defining a new one for visualisation in BIM, one can look into different theoretical models. This paper draws a parallel between collaboration models for BIM domains and the interaction models for responsive architecture. The reason is because both paradigms juxtapose at a certain level in terms of three conjugate interactions that can be seen as two bodies interacting to reach a dynamic stability where both of them collaborate to succeed at a task (Sterk, 2006). With regards to BIM, this paper presents them as human-tool, human-human and human-model interactions. The experiential nature of the relations between these interactions is argued by the survey where it shows that both BIM managers and architects are less sure about the positive impacts of infinite computing on human-tool, human-human and human-model interactions; respectively, 40% and 50% of the responses are 'agree' or 'strongly agree' with that *infinite computing* **definitely** enhances these interactions.

The visualisation during the human-tool, human-human and human-model interactions can be accordingly divided into three steps. The first interaction enters into the collaborative environment within the confinement of technical information. But this confined information is delivered between different participants from the same discipline as well as others. This necessarily initiates the second level of visualisation based on delivering data identified for a specific goal where a cross-platform communication method is prompted. The last level of visualisation integrates the data of cross-platform communications from the previous level with virtual realisations through a set of combined techniques such as 2D drawings, 3D models and real-time clash detections. This level also becomes publicly available where a narrative sequence of these visualisation levels concludes with a common

understanding so that the norms for process, implementation and evaluation of an aimed-product are without bias and misinterpretation.

Highly complicated flows in BIM stages can be interpreted in three visualisation levels as described above. However, this paper bounds the discussion with a general model attempting to combine different approaches for all. The reason is that a mixture of models provides the vertebra to qualify a narrative sequence as well as flexibility to respond and meet varying demands.

Two important models are applied to responsive architecture where similar interactions of human-tool, human-human and human-model exist. The first is the feedback model put forward by Eastman in 1972 and participatory model by Friedman in the same year (Figure 1). In his feedback model, Eastman draws a sequence which is machine-led whereas participatory model is a more complex form of a user-led system that requires a centralised high-level device.

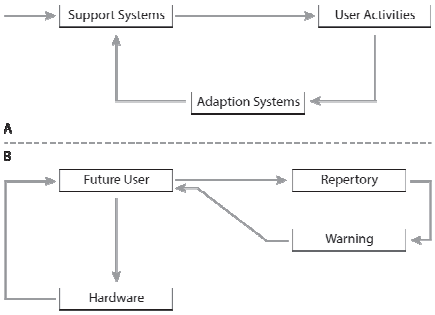


*Figure 1: (A)-The feedback model by Eastman and (B)-The participatory model by Friedman.*

Eastman's model can be designated as low-level operations running in parallel during the interactions. In contrast, Friedman's participatory model pertains to communication with centralised high-level operations (Sterk, 2006). The study takes these low-level operations of Eastman's model as a system that integrates domain specific information adopted from corporate knowledge. The responses of the *support systems* to meet the domain specifications are controlled automatically with individual preferences entered into the mechanism. More specifically, a parametric feedback cycle is run each time by this mechanism that is supported by a visualisation method where everything is fixed and automated either stand-alone or not.

On the other hand, the high-level operations in the participatory model are related to communicative processes that allow direct manipulation of participants. Friedman's model interconnects *hardware* and *software* comprising of *repertory* and *warning* and both of them converge upon the *user* (Sterk, 2006). It is such that a feedback cycle adjusted by centralised devices

is optimised through immediate penetrations of participants. Within the context of visualisation this mechanism is correlated with the Web-based fluid representation of information that comes from different domains to collaborate directly over a BIM project.

These two models from responsive architecture succinctly convey useful hints for the collaboration methods in BIM projects where similar operations occur. Using this analogy the present study attempts to benefit from both models in a hybridised version which is outlined by Sterk (2006). The research about the online use of BIM tools is a tangible instance of a hybridised model of these two models where both of them can be observed simultaneously. That is to say, a powerful centralised device allocates different frames for individuals with cross-links at a sophisticated level so that the system can become available for high-level collaboration while the participation with simpler responses is still applicable.

Similar decision-making models are studied by others based on multi-agent systems (Maher et al, 2007). Although they still play a fundamental role in the proposed model in this paper, the present approach of the hybrid-model however goes a step further by using the advantage of direct interaction with the browser. This enhancement can also be taken as a required development for models supporting the adoption of more advanced computational technology as claimed for the *NetworkedDesign* by Coenders (2012). This paper offers a slightly different one than Chen and Hou (2011)'s BIM model using a *hybrid client-server and P2P network model* by discounting any participation at asynchronous level. Assuming that the fully Web-based workflows will be highly common in a couple of years, this study wonders the position of theorising a hybridised model for all stages of BIM. Encompassed by a hybridised model, the term of narrative sequence of visualisation for collaboration with *information aesthetics* is focused next.

### 3.3. THE HYBRIDISED MODEL OF VISUALISATION FOR BIM

The hybridised model of control prompts both lower-level operations where simple (automated) systems are incorporated with higher-level (deliberative) intelligent processes (Sterk, 2006). This model is applicable to BIM projects where automation of visual deliveries and user-led interactive communications are sought. By a hybrid model the logical, automated and narrative aspects of visualisation are combined with the ambiguity of aesthetic values which eventually facilitate better, quicker and less-expensive collaboration.

Interpreting Sterk's hybridised model diagram as a narrative sequence of visualisation, a new diagram is drawn (Figure 2). Fragmentally hybridised, the model triangulates the connections between the *User Input* (human), *Vir-*

*tual Space* (tool) and *BIM Models* (model). Here are represented the *User Input* with its internal interactions, the *Virtual Space* in which hidden depths are constantly explored and the *BIM Models* such as that of HVAC, lighting, geometry, structural design, parametric and so on. These high-level interactions are fed by the responses of low-level interactions within each of those (human, tool and model). The present study focuses on the visualisation of higher-level interactions, i.e. human-tool, human-human and human-model. It then continues by describing a narrative sequence of the triangle with *information aesthetics* based on *gamification*.

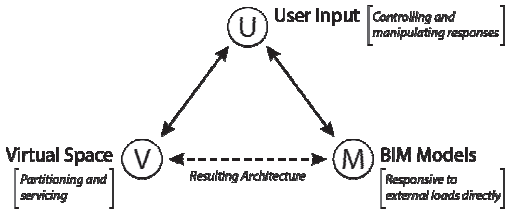


*Figure 2: 'MUV' hybridised model of the three types of interactions as a base for a narrative sequence of story-telling visualisation chain.*

As seen above, the *User Input* is where the whole information flow chains meet with each other. The *Virtual Space* serves for data visualisation which is a derivative of the information from geometrical models and non-model information. Composed of domain specific geometrical models, the *BIM Models* contain massive amount of information to deliver within the *Virtual Space*. These two together develop the general BIM model where an intelligent system is able to carry different types of visualisation techniques like hypermodelling tools (Bentley, 2013). The hybrid model makes use of automated and participatory models, enabling one to redefine it as well as the visualisation techniques that are used to deliver various information types for better communication.

## 3.4. THE GAMIFICATION OF BIM

BIM is described as not a thing or a type of software but a human activity that ultimately involves broad process changes in construction. (Eastman et al, 2011, 353). Seeking the experiential qualities of information visualisation for the collaboration of human activities, this study offers a new research area on the techniques of a novel approach which is called '*gamification*'. Being primarily about more cross-disciplinary tasks, *gamification* of BIM is related to the visualisation and *information aesthetics* in this paper as an initiation for further studies.

*Gamification* is to use game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems (Kapp, 2012). As a paradigm shift BIM can benefit from *gamification*. This includes integration of research on BIM tools and narration of visualisation tools that includes *information aesthetics* as a potentially independent research field (Lau and Moere, 2007).

The criteria of aesthetics that the present study looks into are also hard to judge including aspects such as emotion, affection, persuasion, impact, perception, criticism, style, culture, the body and user engagement (Burkhard et al, 2007). In the survey conducted to understand these experiential points, the place of *gamification* in BIM's future is sought. Only 20% of the participants amongst BIM managers responded with 'disagree' or 'strongly disagree' to that *gamification* is **totally unrelated** to the problems faced in collaborative BIM projects.

## 4. Survey and discussion

It is important to recognise that visualisation for BIM means more than 3D modelling, simulation or walkthrough options because they become insufficient to thoroughly represent a building (Boeykens and Neuckermans, 2008). According to Zamora (2011), the lack of visual organisation of parameters does not allow a clear understanding of the model parameter's structure. In the workshop called *Basic Narratives in Visualisation* in the Visualisation Summit in 2007, some aspects of the criteria of aesthetics are given (Burkhard et al, 2007). Based on these criteria to figure out how the visualisation of information is experienced and can be improved in BIM tools, twenty questions are asked to in three major points:

- Visualisation in BIM and *infinite computing.*
- Human-human, human-tool and human-model interactions in BIM.
- Information aesthetics and *gamification* of BIM.

Before implementing the survey, a pilot study was done with PhD students to understand what is missing in the way the questions are asked. The question types were in the form of selecting one of 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree'. At the end of the questionnaire, job-related questions were given to find out the participants' background (architects 29%, educators 26%, BIM managers 16%, engineers 19% and consultants 6%).

First of all, the questionnaire shows that the Web-based use of BIM tools is thought to be a nontrivial impact in the future of BIM, increasing the efficiency in collaboration. This optimism gives its place a little bit to wariness

in terms of its impacts on visualisation techniques in BIM tools. However, a large majority (80%) thinks that the human-tool, human-human and human-model interactions in BIM can be enriched by improving the quality of *information aesthetics*. Based on these findings, it can be concluded that more research can be done on the advantages of discovering hidden depths of virtual space with regards to visualisation techniques in BIM tools and their impacts on the interactions of the hybrid model.

It is also interesting to note that the responses of BIM managers vary according to what discipline their firm primarily practice in. For example, the ones working for architecture firms are relatively more content with their tools' motivational and cognitive impacts. In contrary, the large majority of architects in architecture firms are not satisfied with their tools' performance in these two points (72% and 83%, respectively). Apart from that, it is seen important to have high-quality of *information aesthetics* in BIM projects by 84% without no 'disagree' or 'strongly disagree' chosen.

With the majority (44%) of the responses being 'neutral', the participants were also cautious to claim that a new story-telling methodology is not **necessarily** required for organising the Model Progression Specifications (MPS), where the responsibilities of different professionals are scheduled. In fact, the present study with this survey refers *gamification* to as a stimulus for a new story-telling methodology. And the questionnaire's third part that is about *gamification* shows that most participants (37%) understand *gamification* primarily about better visualisation capabilities of BIM tools. With 34% of them staying 'neutral' in the same question, lack of clear knowledge about *gamification* can be deducted. This also means that *gamification* for better collaboration in BIM can be a new research field to unveil other advantages of borrowing engagement techniques from the gaming industry.

## 5. Conclusion

This study first draws a hybrid model for a narrative sequence of information flow between human-tool, human-human and human-model interactions. Based on the model, a survey is studied to explore a new story-telling methodology in BIM. Three new research areas are denoted as a result; improvements of visualisation in BIM tools with *infinite computing*, *information aesthetics* and *gamification*. The survey clearly indicates the gap in visualisation capabilities in BIM tools for better engagement of individuals and their collaboration. It is also remarked that *gamification* of BIM can be relevant to the research on *information aesthetics* which aims at promoting BIM tools with the techniques from gaming or "fun" environments for better engagement.

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