GROUP DESIGN VISUALIZATION

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Abstract

Architectural visualization refers not only to the bulk of documents produced in the externalization of design representations but also to a major component of design communication and decision-taking. The paper focuses on the use of visualization in group design processes, i.e. processes typically involving the issues of common authorship, multi-actor design and intensive interaction between different aspects. It proposes that effective group design visualization requires hybrid environments that combine digital and analogue media in unobtrusive and efficient support structures. Registration of design information in group visualization refers primarily to two complementary dimensions: the syntagmatic (the sequence of actions that produce an image) and the paradigmatic (the collection of graphic primitives in the image). Recording syntagmatic information (i.e. who drew what and when) is essential for disentangling the usually dense results of group visualization and for distinguishing between actors, aspects and alternatives.

1. Architectural visualization

Visualization in architecture covers a wide range of products and processes, including:

• Sketching: the production of free-hand representations (usually in early design stages) and annotations on earlier design documents (typical of middle and late design stages)

• Line drawings: measured representations in 2D or 3D projections (orthographic or perspective)

• Impressions: usually rendered perspective projections illustrating specific aspects and parts of a design, e.g. the atmosphere a user would experience visually in a space

• Animations: dynamic impressions, usually computer-made

• Models: physical, 3D representations of a design, normally at small scales for the overall form and larger ones for critical parts

• Diagrams: abstract representations of entities, relationships and qualities

Currently it is assumed that the computer forms a connecting tissue between such forms of visualization: 2D drawings combine unambiguously into (or derive from) 3D models; impressions, animations and models are automatically produced from 3D models; even sketches can be interpreted automatically into drawings or models. However, from a technical viewpoint converting one representation into another has yet to reach the level of efficiency and reliability required for geometric information – let alone the interpretation of meaning and intention. The practical side is equally unpromising. Most approaches to information integration and exchange presuppose that designers have the time, willingness and data required to record prescribed information on a rather large number of aspects, establish and maintain links between items, ensure continuity between stages. Even if such an extensive and intensive information system can be set up, its maintenance is beyond the scope of even large design and construction projects (Hovestadt and Hovestadt 1999).

One of the main conceptual limitations of existing approaches is the failure to acknowledge fully that architectural visualization refers not only to the bulk of documents produced in the externalization of design representations but also to a major component of design communication and decision-taking. Visual design representations of a wide variety are a prerequisite to many activities and procedures in the design process (both as direct input and as background information), as well as information carriers that register most discussions, explorations and decisions. This also means that visualization products and processes are frequently not individual or static but multi-actor and dynamic. Most
design documents combine contributions from several actors and continue to be developed, modified, adapted and re-interpreted for a length of time that depends on the significance of the information they convey. Therefore, it is advisable that studies of architectural visualization take into account the context of group processes.

2. Group design processes

The Group Design Room (GDR) is an environment developed for the analysis and support of group design processes, i.e., processes typically involving the issues of common authorship, multi-actor design and intensive interaction between different aspects (Fischer et al. 2002). In physical terms, the GDR consists of a number of workstations, servers, presentation and communication facilities. These can be configured in two different modes: interaction and brainstorm. In the interaction mode, each workstation is allocated to a particular aspect and a corresponding discipline, such as architectural design, cost analysis or HVAC. The participants to an interaction session are experts on these aspects. Each workstation is equipped with the software normally used by a particular discipline so as to provide a familiar working environment and full control over the programs and the information processed by the workstation. Connections between the workstations are at the level of input and output of the software used by each discipline. They comprise constraint propagation networks which transmit changes dynamically on an if-needed basis (Lees, Branki, and Aird 2001). In the brainstorm mode, information on each aspect of a design is enriched with automated processing facilities that constitute a virtual expert, capable of responding to relevant input on the basis of analyses and case-based rule systems. As in the interaction mode, each aspect and its virtual expert are accommodated in a separate workstation of the GDR. The participants to a brainstorm session are generally no domain experts but represent parties with a general interest in the project.

Information in the GDR is alphanumeric (brief, bills of quantity, cost estimates) or visual (mostly sketches and drawings, with impressions used mostly to represent simulation results). Diagrams also play an important role as process descriptions, as well as in connections between different representations, e.g., the brief and drawings (Steijns and Koutamanis 2004). The main research focus of the GDR is the complexity of group design processes and the corresponding complexity of design information. The presence of participants who may have no architectural training is an additional complicating factor, especially with respect to the registration and communication of visual information. In this framework, two kinds of questions emerge:

- Usability: evaluation of representations with respect to the purposes of multi-actor situations, from the communication of constraints to the registration of group decisions.
- Verification: identification of final decisions and their history in the visual documentation, including correlation and integration of related elements, disambiguation and noise reduction, attribution to participants or aspects.

The first kind relate to visual thinking and the role of visual representations in communication. The informal, abstract and cumulative character of visual imagery assists in the cyclic exploration of divergent approaches and solutions—especially in complex, multidimensional problems (Hooper Woolsey 1999; McKim 1979; Henderson 1999). In collaborative environments, drawings can also have a neutralizing effect: by focusing on a drawing we can ignore differences in personality or power between participants. Abstract representations such as diagrams facilitate the development of group graphics that mirror the discussions in a GDR session (Sibbet 1981, 1993). Moreover, visual documents can act as self-sufficient objects encapsulating decisions and constraints, independently from the processes from which they have emerged (Avouris, Dimitracopoulou, and Komis 2003).

Group support systems have been paying more attention to these roles of visualization. In environments that provide extensive support to multi-actor actions, transactions and information integration, visual means facilitate information visibility, change awareness, group interaction and effective group coordination (De...
Vreede, Guerrero, and Marin Raventós 2004; De Vreede, Niederman, and Paarlberg 2002). CAAD research contains a wider domain exploration of product and process visualization, including relational and agent-based models that link aspects, goals, actors, documents and decisions in flexible, adaptable configurations rather than central models or databases (Hanser, Halin, and Bignon 2001; Rosenman and Wang 2001; Rosenman et al. 2005). The GDR has adopted a similarly flexible strategy based on document integrity, correlation and visibility coupled to decentral information management: information production, control and management takes place primarily within each aspect, while dynamic links between documents (including blackboard and agent-based facilities) facilitate communication, interaction and the production of common and compound documents. This strategy does not so much answers usability questions as defer them, primarily to the structure of representations used in the GDR.

The same structure is also fundamental to questions of the second kind. These involve the parsing of documents with respect to two major dimensions (Van Sommers 1984):

- Paradigmatic: the symbols and graphic elements used to denote architectural entities in a visual representation
- Syntagmatic: the sequence by which these symbols and elements are entered in a representation

In the synchronous, multi-actor context of a GDR session, the syntagmatic dimension is an obvious priority: the ability to distinguish between different contributions and their history is essential for disentangling the multi-layered, intricate and frequently confusing products of complex, generally unstructured procedures. The resolution of inconsistencies, incompatibilities and interpretation errors (including cases of accidental emergence) often relies on backtracking in the histories of individual input. However, the main prerequisite for syntagmatic analysis is a reliable symbol set, i.e. the results of paradigmatic analysis.

Of the representations used in the GDR, diagrams are mostly graph-based, which makes the identification of symbol sets trivial. The same applies to impressions, which refer to the models and drawings used for their production. For these drawings and models there are more than enough options, ranging from basic, generic categorization (Koutamanis 1995) to extensive, detailed libraries and classifications such the Industry Foundation Classes (IFC). In all cases, symbols in drawings and models describe (with variable accuracy, consistency and reliability) the building elements and spaces (solids and voids) of a design. Sketches are parsed in two alternative ways, depending upon their character. Generative sketches that describe a design from scratch are analysed on the basis of an experimental collection of symbols and implementation primitives (Koutamanis 2001). Annotation sketches made on top of existing documents are recognized by reference to the original design entities (as variations, alternatives, elaborations etc.).

3. Implementation issues

It is a sad fact that the computerization of architectural representations in practice still aims primarily at the production of analog drawings and similar conventional documents. On the other hand, most approaches to exclusively digital design environments fail to avoid prescriptive or proscriptive connotations: they attempt to enforce digital modes and procedures with frequently little concern for wider aspects, from cognitive ergonomics to practical problems in information production and maintenance. The GDR follows a more realistic approach because of the background of the participants to a session, but also because we are interested in a seamless integration of analog and digital information. Of paramount importance for this integration is feedback from analog to digital documents, e.g. the transfer of annotations made on a print of a CAD drawing back to the CAD system.

In order to achieve that we require hybrid environments that combine digital and analogue media in unobtrusive and efficient support structures. Virtual reality and related augmented reality approaches which are frequently used in collaborative design do not qualify as such. Mobile
technologies seem more promising, also with respect to flexibility and adaptability. For sketching in the GDR we have experimented with the Anoto digital pen and paper (Cheng 2004a, 2004b; Cheng and Lane-Cumming 2003; Cheng and McKelvey 2005). Anoto pens can write on any kind of paper form, provided the form is covered with a proprietary dot pattern. The digital pen is equipped with a tiny infrared LED camera that takes 50-100 digital snapshots of strokes made by the pen. The snapshots can be transferred (synchronized) to a computer or smartphone using Bluetooth or a USB connection. The digital image produced by synchronization is a precise and exact copy of the analogue drawings made with the pen. In transferring the images the pen also reports on which piece of paper the drawing has been made. This automatic document management allows users to switch between different documents. The digital images are not static but can play back the sequence of strokes as they were made on paper. This provides a representation of syntagmatic aspects that is adequate for the identification and analysis of drawing actions (Koutamanis 2005). By contrast, recognition of paradigmatic information is largely restricted to low-level geometric primitives such as straight line segments, arcs and shapes composed of these. This means that extensive post-processing is required in order to recognize automatically meaningful symbols in a sketch (Koutamanis 2001).

4. Conclusion

The exploration of group design visualization in the GDR has stressed the significance of the paradigmatic and syntagmatic dimensions not only for the analysis and recognition of visual representations but also for automatically linking different documents. Sketching with digital pen and paper makes clear that a sound lexical, grammatical and syntactic basis is an essential prerequisite. A solution that has been sufficiently tested in CAAD is the use of predefined symbols. However, such symbols may restrict expressive freedom and generally involve training. Similarly mixed are the capabilities of existing standards and building information models (e.g. IFC). These provide a cohesive framework for many aspects but are still restricted to a few design stages and aspects (Rosenman et al. 2005). Moreover, they normally involve extensive manual (and hence intrusive) classification or the use of predefined symbols. Consequently, we propose that computer support to group design visualization in the short term has two primary application areas: diagramming (including early design sketching), where information tends to be abstract and compact, and the processing of existing design documentation, i.e. analysis and modification of existing design decisions and specifications.

References


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