INFORMATION STANDARDIZATION FROM A DESIGN PERSPECTIVE

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Abstract. One common assumption concerning the digitization of architectural processes and products is that it should be supported by extensive standardization of design and building information. This standardization should extend beyond pre-existing conventions of the analogue period in terms of scope, integration, continuity, flexibility and adaptability. From a design perspective standardization refers to three distinct information types with different origins: geometric, categorical and project-specific information. Such information is accommodated in standards and building models either top-down or bottom-up, resulting into different possibilities and limitations.

1. Introduction

Information standardization in architecture and building has a long and varied history. Early examples include the canonization of classical architecture (Alberti, 1988, Summerson, 1980) or, in pattern books such as, in China, the Ying Zao Fa Shi (Li, 1919). Standardization of classical elements was a means of imposing a formal style but it also allowed prefabrication of defining components (Warszawski, 1999). In the 20th century standardization was closely linked to post-World War II developments, such as transfer of war industries to peace-time applications and post-war reconstruction. In that framework standardization was a means for industrializing building and achieving benefits of economy and gradual refinement. For designing and design information this meant the development of standardization schemes for building elements such as CI/SfB (Construction Index ⁄ Samarbetskommitten for Byggnadsfragor) and techniques for using such schemes, e.g. modular coordination (Hawkes, 1975, Kroll and Blundell-Jones, 1987).

With the advent of computerization standardization has assumed an even more central role. The transfer of product modeling techniques from building industrialization to the computer underlay early computer-aided design successes (Eastman, 1999), while generative systems often relied on the standardization of elements in a formal system (Stiny and Mitchell, 1978, Li and Tsou, 1995). In recent years there has been renewed interest in information standardization with respect to interoperability. It is commonly assumed that computerization of architecture should be supported (and preferably preceded) by extensive standardization of design and building information.

Communication and interaction have top priority in this framework. Information standardization should allow for cooperation between all parties in a project regardless of geographic location or specialization. Moreover, it should cover not just the design stages and the production of conventional design documentation but also address the requirements of briefing and construction (i.e. before and after designing). Bridging the gap between design and construction in both directions is considered to be a primary function of information standardization. Finally, particular emphasis is on procedural matters that remain opaque in analogue standards even though they constitute the core subject matter of management activities.

Recent CAAD research has used information standards as implementation mechanisms for demanding tasks such as information management throughout a building’s lifecycle (Park and Krishnamurti, 2005) or the improvement of building specification, e.g. by enriching geometric specifications (Yang and Cui, 2003). Experiences tend to be positive but do not obscure conceptual difficulties and implementation limitations concerning early design and entities such as spaces and activities (Mourshed et al., 2001, Szewczyk, 2002) that may be beyond the scope of industrialization ideas from which current approaches derive. More worrying are the necessity to adapt information to the capabilities of a system and the burden of maintaining information (Plume and Mitchell, 2005, Arthaud and Lombardo, 2006).

The most striking conclusion of such research is that current information models and standards remain at the level of prototypes despite having an already lengthy history (Agger et al., 2002). The reasons of the prolonged prototyping are pragmatic and various, including a lack of cooperation in the building sector as well as in software development, limited investment in research and development for architecture and building, the fragmented nature of the construction industry, and the conservatism of building firms and organizations. The underlying assumption appears to be that standardization ideas are fundamentally sound and useful but not implemented or applied as widely and earnestly as they should.

In the present paper we adopt a different perspective. While we agree that implementation and application are being delayed for mostly pragmatic reasons, we do not assume that conceptual development has been hampered by similar reasons. The relevance and applicability of concepts underlying existing standardization approaches and systems to the processes and products of architectural design can consequently be examined at their current stage of development.

2. Design information requirements

A comparison between architecture and the design and production of aircraft, motor vehicles and even clothing reveals that architecture lags behind the others in terms of automation as well as underlying process and information organization. Such issues have been explored in experimental environments where digital means provide new possibilities for cooperation and interaction between actors and disciplines but also between users and information (Bouattour et al., 2005) and have been extended in a limited way to practice to support collaboration and digital fabrication (Burry, 2004, Kolarevic, 2003).

Interoperability is a key issue in such environments. Its aim is dual: information *integration* (of many aspects at a given moment in a process) and *continuity* (throughout a process). Continuity seems to have a lower priority in building design and construction as it does not have the financial nor legal imperatives for tracing decisions that exist in other industries. A possible reason is that in the digital era, the construction stage remains technically outdated and interposes an interruption in the lifecycle of the digital description. On the other hand, with the growing complexity of product specification and of the design process, integration has become a clear necessity. Communication and interaction between different aspects and the corresponding disciplines can only improve with the correlation of the information each aspect requires or produces. However, the emphasis on the needs of each aspect should not obscure that at the same time we are attempting to integrate and provide continuity to different information types.

2.1. GEOMETRIC INFORMATION

Geometric information is not necessarily the starting point of all design activities and may even be outclassed in terms of volume by other types of information (e.g. calculations) but it remains the main focus in the registration and communication of design decisions. Drawings and models are the main repository of geometric information, with alphanumeric documents complementing the drawings (e.g. by annotating non-geometric, non-visual properties) or making explicit aspects of a design’s geometry (e.g. floor area calculations, fire safety analyses).

The importance of geometric information appears to have increased with computer use, arguably due to the promises of digital flexibility, adaptability and completeness (e.g. through 3D modeling). Digital modeling has also added to the complexity of design representation: geometric information is by definition unstructured. Its fundamental interpretation (as a scene consisting of discernible components) is based on general visual cognitive mechanisms (Biederman, 1987, Koutamanis, 2006) but beyond this basic level we rely on domain conventions in order to identify a configuration of components as a building element or an architectural arrangement, e.g. a Doric column or a sequence of offices. In effect we apply labels to common configurations and categorize the resulting symbols usually in variable, overlapping hierarchies. By augmenting the modeling repertories of architects with a large number of digital means, which moreover stimulate explorations of new possibilities in the form and construction of buildings, we increase the complexity of the basic configuration and the variability of building elements and symbols.

Geometric and symbolic variability are among the main effects of digital design environments. In the past there has been a tendency to assume that architectural entities had a rather fixed form. This is increasingly challenged by current design approaches, which are either motivated or facilitated by computer-based modeling. Technical and morphological innovation conspire to undermine more than ever existing definitions. As a result, the form of an architectural element cannot always be derived from its category. Geometric standardization (e.g. in "blocks") which had been the customary solution to such problems nowadays runs contrary to current tendencies and expectations because it reduces the formal repertory of the designers and negates emerging technological possibilities in e.g. fabrication. The decoupling of geometry and symbol / categorization seems a logical conclusion, however we should be wary of the role of geometry as one of the prime classification criteria: at what angle does an element stop being a wall and becomes a roof?

2.2. CATEGORICAL INFORMATION

The complexity of geometric information is greatly reduced by its interpretation as a collection of normally discrete yet sometimes fuzzy elements with a known function and familiar structure and appearance. The mnemonic advantages of such symbols are further augmented by categorization into homogeneous classes. The resulting (poly)hierarchies permit identification of elements under even elliptical or redundant conditions and facilitate communication at a more abstract level by means of common semantics. Moreover, they may add information that is absent or implicit in the geometric representation, e.g. construction details.

Categorical information may be sufficient for a task especially if the geometric interpretation is unambiguous (e.g. a Doric column according to a particular authority or a door handle of a specific manufacturer). This appears to be the main justification for the traditional focus of standardization on the categorization of building elements and components. While one cannot argue against the utility of categorical information, it is becoming increasingly difficulty to rely on it in designing and communication. The reasons include the aforementioned geometric complexity and variability, and the plasticity of categorical information itself: the collection of building elements, components and architectural concepts and entities in general is not fixed but constantly subject to revision and enrichment – as it should be in a design profession.

In terms of continuity this poses interesting questions concerning the concepts and elements designers use in different stages of the design process and especially in the transitions between stages. Such transitions mean not only that the appearance of elements changes but also that elements and relationships may emerge abruptly as a result of changes in abstraction and specificity. The current expectation to use the same digital models throughout a design process (or at least have seamless transitions between models) stresses the significance such transformations – in contrast to the more fixed abstraction levels of analogue representations.

2.3. PROJECT-SPECIFIC INFORMATION

A third type of information is incidental to each design project. It consists of an apparently motley collection of issues from various sources: the brief, the physical and other contexts, legal or professional rules and regulations etc. Upon closer examination this information turns to be mostly constraints but not necessarily of the kind familiar from current parametric models, i.e. constraints on a particular property or relationship of an element. Quite a few project-specific constraints refer to multilateral relationships between elements which become explicit only in analyses of the behavior or performance of a design. For example, fire safety refers not only to the material and geometric properties of critical elements such as doors and corridors but also to egress time, i.e. a complex relationship between users, building, time of the day, fire source and location, weather conditions etc.

The close relationship between specific constraints and elements has led to the integration of constraints in design representations and building models, mostly ad hoc and incompletely, as the focus remained on the elements. Information standards increasingly offer facilities for the orderly integration of constraints but this should not obscure the need for a separate, well-formed corpus of project-specific information. A programmatic requirement may lead to a constraint on the size of a space but this constraint should be expressed as a relationship between the geometric information and the brief, the latter being accommodated in e.g. a database of activities and requirements. This allows for transparent and comprehensive treatment of both the brief and its relationships with a design. Moreover, such a database has a distinct structure and purpose than geometric representations (Steijns and Koutamanis, 2005).

3. Information standards and product models

Current approaches to information standardization and product modeling in architecture and building fall under two distinct categories, either bottom up or top down, both with similar goals but different departures and genealogies. Both offer opportunities in implementation but also introduce constraints and limitations.

3.1. BOTTOM-UP

Bottom-up approaches start with a pragmatic inventory and classification of existing architectural entities, either at the level of commercially available components and materials or at the slightly more abstract level of elements such as windows of different functional types and construction. Most bottom-up approaches derive from building industrialization and are primarily meant for later design stages and the transition to construction.

An example of bottom-up approaches is the Dutch STABU-Lexicon (http://www.stabu-lexicon.com/), the main national project in building information standardization. STABU-Lexicon is part of PAIS, a wider national standardization platform (http://www.paisbouw.nl), which was also formed in a bottom-up fashion by clustering together similarly motivated projects. The idea behind STABU-Lexicon was to provide a placeholder structure for producers of construction components to fill in and maintain. In recent years there has been a change of focus and purpose with the realization that the project itself had to provide not only the placeholders but also a substantial proportion of the content, as well as through comparisons and contacts with international standardization projects (notably IAI).

The main strength of bottom-up approaches is also their primary weakness: by focusing on the final product of designing and the specification of construction they offer workable solutions for a number of problems (including many forms of integration). At the same time they tend to neglect earlier design stages, continuity and procedural matters. Bottom-up standardization tends to prefer geometrically fixed elements and ignore project-specific information. On the positive side, categorical information is pragmatic and usable, especially in later design stages.

3.2. TOP-DOWN

Top-down approaches sometimes form a conscious reaction to the limitations of bottom-up systems in that they attempt to cover the whole lifecycle of a building and both products and processes. Their departure is usually a conceptual framework for the description of elements, components, constraints, actors, procedures, actions and transactions. Such comprehensive representations of a building's lifecycle focus on issues like consistency, reliability and completeness. The best known example of top-down is the IFC (Industry Foundation Classes) of the IAI (International Association for Interoperability – http://www.iai-international.org/). The framework of the IFC is developed centrally and refined or applied regionally through the various chapters of the IAI. This promises wider international compatibility and not merely standardization within a national context but without suppressing regional socio-technical characteristics.

The difficulty with top-down approaches is that much of the initial work and evaluation is done at the abstract level of conceptual systems and definitions or in experimental applications within arbitrary microworlds. Concrete applications and tools tend to develop quite late, after many have formed a definite opinion on the approach and, given the scope of top-down approaches, require disproportionately extensive development. In terms of categorical information they may offer more flexibility and adaptability than bottom-up approaches, as well as explicit descriptions of relationships and processes. Project-specific information is available as distributed constraints, while the geometry of elements is less fixed – especially if many-to-many relationships are permitted between geometric information and categories.

The top-down approaches propose a framework of modelling useful for the interoperability of applications, but the precise definition of the objects offered in these models remains unsuited for the management of the fuzzy, the inaccuracy, and the unknown which exists in design process.

Judging from other areas such as lexicography, the main problem with top-down is that it is rarely sufficient to provide a conceptual structure for representation and classification. Providing the content is equally important both for the usability of a system and for its development and testing. A comparison between architectural information standards and architectural controlled vocabularies, e.g. IFC and the Art & Architecture Thesaurus (http://www.getty.edu/research/conducting_research/vocabularies/aat/), shows clearly the advantages of the reciprocal relationship between structure and content in classification and representation.

4. Discussion

From a design perspective any information standardization is both obstacle and enrichment because it presupposes conformity beyond basic conventions like line thickness and section height in a projection, while its interpretation of categorical information adds abstraction and direct relationships to external information. In terms of usability current standards (both top-down and bottom-up) have an uncertain attitude towards geometric information. In a number of experiments with IFC-based translators we were less surprised by the frequent resort to generic categories than by the unstable translation of geometric structures (e.g. a circle as four ungrouped arcs).

The integration of external constraints and procedural matters in architectural product models is welcome but offers insufficient scope for the comprehensive and consistent representation of programmatic and other requirements. However, we are confident that the application of the same approaches and techniques to such requirements could produce usable concepts and structures for the description of, for example, a brief in terms other than the entities that comprise an architectural design. This approach links these concepts to those of parametric design where performance of resultant properties is as important to record as are the geometries of the objects themselves.

The success of information standards and resulting building models cannot be measured only relatively to other standards at the abstract conceptual levels that appear to form the focus of most relevant debates. Wide acceptance in architectural and building practice should become the main criterion and guiding principle of further development, re-directing effort towards issues of utility and usability. If designers are expected to bear the burden of generating, disseminating and maintaining such extensive and demanding information structures, the benefits should be direct and obvious. Existing ideas and structures have this potential but future research and development should be directed more towards practical goals (the solution of real problems in a knowledgeable way) that demonstrate clearly the added value of the proposed methods and tools. This inevitably involves pragmatic fusions of the top-down and bottom-up approaches that pay more attention to ease of use and performance than to conceptual models. Such pragmatism should also extend to the integration of geometric and project-specific information issues in standards and their applications.

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