A BIM-based Framework for Assessing Architectural Competition Entries

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Architectural competitions have been traditionally used to select best design practices. The basis of assessment for competitions has typically involved non-technical concepts of quality, subjective and emotional appreciations of experiences, and inseparable accord of formal, functional, aesthetic and contextual values (Rönn, 2011), rather than clear-cut objective and precisely measured values as in the engineering domain (Nashed, 2005; Nelson, 2006). Criteria for judgment usually focus on design parti and clarity of concept, novelty of architectural approach, context compliance, spatial organization, functional adaptability, economical solutions, and design flexibility. The assessment process, although presumably comprehensive and involving multiple evaluation techniques and resources, may still overlook important technical issues that may be fundamentally significant to the exclusion or approval of a given entry. This paper introduces a framework for assessing architectural competition entries aided by concepts of building information modeling (BIM).

Keywords: *Building information modeling, architectural competitions, design evaluation, best practices, rule checking*

DO WE REALLY NEED BIM IN EVALUATING ARCHITECTURAL COMPETITION ENTRIES?

One of the essential questions that come to mind in this context is: why do we have to use BIM for assessment in the first place? Isn't assessment based on negotiation, interpretation, and tacit knowledge among professionals? How can BIM tools, with such a quantitative nature, inform the decision making process of a team of professionals? And would it be an automated process void of any potential for discussion and negotiation, or can it be framed in such a way that allows for intervention and agency?

Nature of Assessment in Architectural Competitions

It is important first of all to understand how the typical assessment process of architectural competitions works, in order to identify where BIM tools and methods can be of meaningful support. Typically, competent professionals (jury members) are assigned to select best design solutions among multiple entries, based on a competition program, requirements, best judgment and negotiation. Due to the richness of solution space and limited time availability, jury members establish a structure of dominance

(Montgomery et al., 1990) involving a lot of simplification, abstraction and overarching judgment to facilitate the process of qualifying superior candidates, relying on holistic judgment of overall quality, rather than exhaustively comparing advantages and disadvantages or thoroughly going through each and every single criterion outlined in the competition program.

Moreover, graphical representations in competition entries can be misleading and inevitably having an impact on the jury. As architects are trained to use their argumentation and persuasion skills, aspects that are critical to the success of a given project can be dismissed in this process, which implicitly involves as well oral rhetoric among jury members for persuasion purposes, and to come up with a winning entry. Although jury members can still consult with domain experts to calculate measurable technical aspects of an entry, they still have to assess aesthetics and quality, which relies heavily on interpretation, and their final judgment is based on an overall picture of the design that is not merely the sum of its technical and aesthetic components.

At the same time, competitions do not all fall into the same format or type (AIA, 1988). They vary for example according to the purpose of the competition (project competition versus idea competition), where project competitions are more well-structured and geared towards the construction of a winning entry, while idea competitions mostly involve innovative design explorations. They also vary according to entry eligibility (open competitions, limited competitions, invited competitions, and student competitions). Another yet important type involves phasing, where competitions can be either one-stage or two-stage competitions.

One of the fundamental issues in this regard is the fact that current assessment methods in competition juries are mostly identical regardless of the type of competition, although different types may entail different assessment approaches, techniques and perspectives. In some cases, such as in project competitions, jury criticism may need to be as explicit and clear as possible because it constitutes guidelines that are traceable throughout succeeding phases of the realization of the winning entry, and so it requires attention to detail in the basic principles being emphasized in each and every entry, aided by thorough comparisons and checks, rather than adopting elimination policies only without incorporating next steps or what-if scenarios for implementation. In idea competitions on the other hand, which do not involve subsequent stages or an explicit framework of realization, the jury assessment may be more related to conceptual innovation and uniqueness of design approach. The same mostly applies to the assessment of one-stage versus two-stage competitions. In addition, the way the jury attempts to evaluate an open competition is quite dissimilar from that related to a limited or invited competition, and definitely unlike that of a student competition, both in terms of complexity and level of detail.

The proposed framework in this paper attempts to incorporate concepts of BIM in the assessment of architectural competition entries with the aim of providing informed decision making for jury members, taking into consideration different types of competitions, and without compromising the nature of assessment in the process of selecting best design practices.

What can BIM offer?

Concepts of building information modeling (BIM) are potentially promising regarding the review and (rather automated) assessment of designs at different levels of detail in the form of 3D BIM models (Sanguinetti et al., 2012). The real question here then becomes: where should BIM be exactly integrated in the evaluation process? According to AIA (1988), there is a multitude of tasks that are conducted in a typical competition by professional advisers and jury members, some of which are technical and others are merely logistical. Based on the anticipated potential of BIM concepts in the assessment process, the framework proposed in this paper is primarily concerned with three of these tasks: (1) preparing and

testing the project program, (2) checking designs for compliance with program requirements, and (3) reporting to jury and competition sponsors.

The first task involves the development and testing of the competition program in a way that ensures the clarity and completeness of requirements and project information prior to sending out to competitors. The second task is more concerned with checking the compliance of competition entries with basic submission requirements, in addition to compliance with budgetary, energy performance and use, and other requirements, conducted by technical specialists to inform the jury assessment process. The third task involves the reporting process of relevant information to the jury and competition sponsors regarding budget, disqualifications, and compliance with program.

The three previous tasks are currently carried out in an ad hoc fashion that does not necessarily guarantee thorough evaluation of design alternatives, especially when it comes to compliance with detailed programmatic requirements, building codes and other technical requirements and guidelines. The value of conducting such a process in a more accurate manner is presumably significant in project competitions (as opposed to idea competitions) with focus on constructability and technical ramifications, as well as in limited and invited competitions where the competition scope is often more defined and structured.

The paper puts forward the assumption that by means of implementing BIM modeling, analysis and checking tools, technical aspects related to energy performance, cost analysis, spatial and functional rules, and simulations of projected conditions can be identified, checked and compared. One cannot argue that non-quantifiable aspects can be assessed using these tools, but the benefit of at least acquiring an informed decision making process that can contribute to the exclusion or approval of an entry can be achieved. The following represents three key areas where BIM tools and concepts are seen most applicable:

1. Preparing and testing the project program: It is evident that the initial exercise of formulating the competition brief or program is highly critical to the understanding and fulfillment of the competition intent, purpose and long-term objectives. This implies that all guidelines, standards and regulations upon which the competition is specifically based be transported into a machine readable medium prior to applying any compliance checking mechanism to the submitted entries, in addition to being communicated comprehensively and conclusively to both the designer and the jury (and its supporting automated assessment system).

2. Checking designs for compliance with program requirements: This is perhaps the core of the assessment process, where the validity of the competition entries is evaluated against clear cut criteria defined in the first task. The scope of this evaluation is dependent on the circumstances of each competition, but requires at least a checking mechanism and an interpretation mechanism. The checking mechanism conducts the necessary validation and compliance checks, while the interpretation mechanism translates the compliance check results into higher level and often natural language understanding.

3. Reporting to jury and competition sponsors: In this task, a reporting mechanism is developed to provide concluding remarks about all competition entries, a comparative assessment, and recommendations for the jury and competition sponsors, as supplementary material for an informed decision making process.

Based on these three key areas, the paper proposes a BIM-based framework for the assessment of architectural competition entries, by putting into effect BIM model deliverables with specific conventions and

guidelines using Industry Foundation Classes (IFC) data.

PROPOSED ASSESSMENT FRAMEWORK

The proposed BIM-based framework incorporates the designer submitting the competition entry, the jury members evaluating the entry, and the advisory team controlling and managing the competition procedures and regulations. Figure 1 illustrates the proposed process diagram for the framework.

First, the advisory team works on defining clear and explicit guidelines and rules for the designers and the jury. These include guidelines defined prior to the commencement of the competition and in concurrence with the call for entries, and others developed after the submissions in accord with the selected jury members. Prior to the commencement of the competition, the advisory team works on developing a clear outline of the competition terms of reference (TOR) document in a way that is unambiguous for both the designer and the jury members. They also include a document that sets fixed standards for BIM modeling standards for all designers entering the competition, such that modeling methods and conventions are defined unequivocally vis-à-vis all BIM-authoring tools. Defining these guidelines is imperative to the credibility and integrity of the resulting assessment data. Another significant task that is conducted by the advisory team is the extraction of data from building codes and design guidelines that is fundamental to the competition theme, building type, and best practices. These are translated to machine readable rules that are fed into the framework modules.

Designers are usually asked to submit entries in several formats, including PDF and TIFF posters. For the purpose of this framework, they are asked to submit in addition the native BIM file format (both the file from the BIM-authoring tool, e.g. .rvt file, and the corresponding IFC file), in order to perform the necessary checks, evaluation methods and review procedures. After the submission of competition entries, the jury members are asked to develop a concise set of qualifying conditions and a set of assessment criteria specific to the competition at hand. These are translated by the advisory team into a group of machine readable rules that are used by the framework modules to check for compliance and assist with the decision making process regarding qualification or disqualification of competition entry on an informed basis.

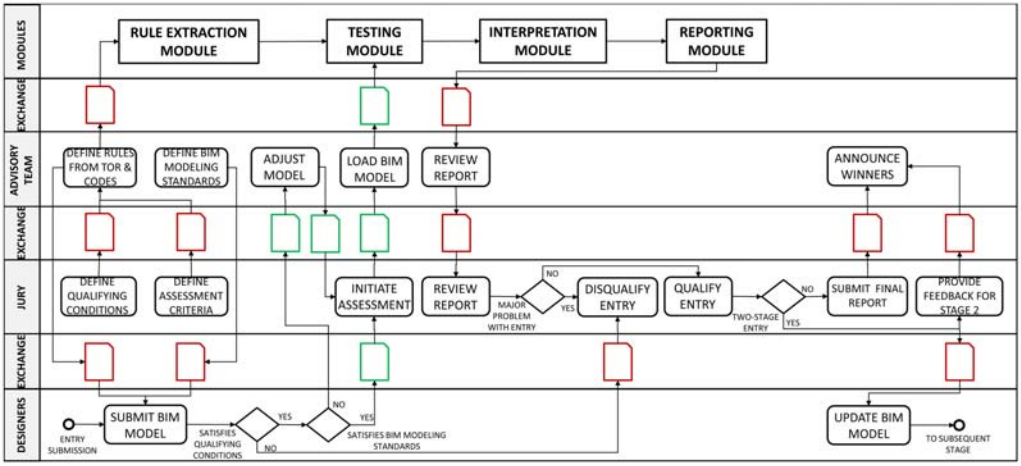

Figure 1
Process Diagram for the Proposed BIM-based Assessment Framework

Upon receiving competition entries, they are checked for compliance with the qualifying conditions set by the jury. These can include basic programmatic requirements and relations defined by the jury, or general conditions and rules that are seen as fundamental and could provide insight with regards to disqualifying entries, similar to the early elimination process conducted in conventional evaluation sessions but based on presumably accurate and explicit figures. If the entry does not pass this stage, a report is automatically generated and sent to the jury to approve or disapprove the disqualification process. Otherwise, the entry is checked for compliance with the BIM modeling standards and guidelines set initially by the advisory team in order to perform the detailed assessment procedures. If the entry does not fully satisfy these guidelines, in a way that affects the integrity of the assessment (to be defined by the advisory team), the team takes on itself the task of adjusting and updating the entry files, provided the integrity of basic design intent.

Once the BIM model is seen as satisfying the qualifying conditions set by the jury and the modeling standards set by the advisory team, it is prepared for the detailed assessment process. The jury initiates the assessment procedures for the entry, and the advisory team loads the entry BIM model (in IFC format) into the system. Four main modules are proposed to perform the assessment process: 1) the rule extraction module, 2) the testing module, 3) the interpretation module, and 4) the reporting module. Figure 2 shows the basic structure of these four modules.

The Rule Extraction Module

This module extracts the necessary information to test the BIM model entry against specific guidelines and target values. It works independent of - and prior to - the BIM model entry submission, and specific to the competition theme, building type, and jury assessment criteria. Inputs to this module include any requirements as per the competition TOR, the jury assessment criteria and qualifying conditions, and any relevant standards, building and safety codes, design guidelines. The module core clearly identifies and transforms these inputs in narrative form from natural language to machine readable language, in order to perform the necessary testing procedures. Outputs from this module are in the form of extracted rulesets (in spreadsheet form) that are explicitly defined and categorized in groups according to the required domain of testing, such as functional and area requirements, circulation, zoning and spatial adja-

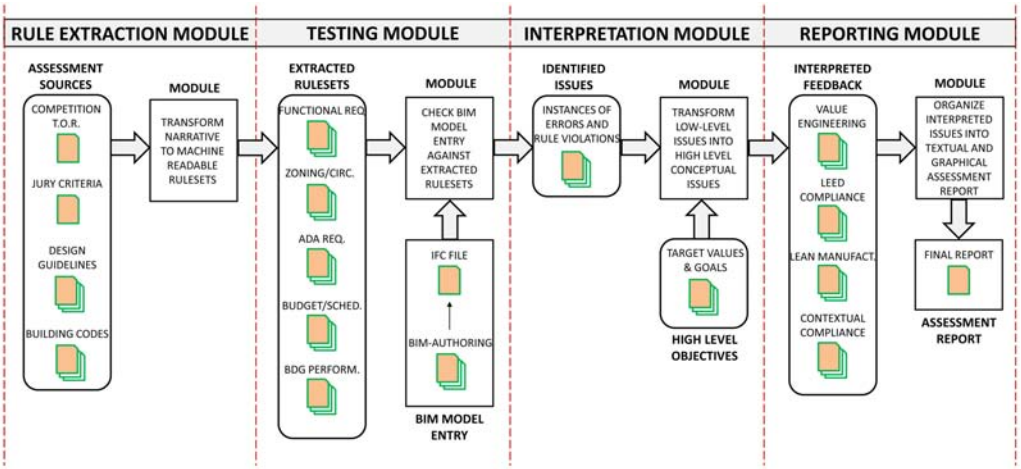

Figure 2
Structure of Assessment Framework Modules: 1) Rule Extraction Module, 2) Testing Module, 3) Interpretation Module, and 4) Reporting Module

cency relationships, ADA requirements, budgetary and scheduling requirements and constraints, and building performance requirements and target values. The extracted rulesets correspond to specific statements, guidelines and target values specified in codes, guides and relevant standards.

The Testing Module

This module performs the necessary operations to examine the validity and compliance of the competition BIM model entry against the rules extracted in the preceding stage. It works depending on the BIM model input of each competition entry. Inputs to this module include the BIM model (in IFC format) and the extracted rulesets. The module core checks the BIM model against each of the extracted rulesets for compliance. Outputs from this module are in the form of a group of reported instances of issues, errors and violations to the rules specified in the previous stage, in addition to comparisons of actual domain-specific values against their corresponding target values (e.g. R-value, project total cost, etc.). These comparisons do not necessarily disqualify entries, but provide supplementary data that can assist with informed decision making. This module consists of sub-modules for establishing modeling and labeling conventions for the model, others for mapping the model and the corresponding ruleset conventions, and others for preparing the model for the necessary testing process (simulation, conflict checking, etc.) based on the relevant category.

The Interpretation Module

This module works on developing a higher level understanding of the results from the testing module to provide the jury with an informed decision at the conceptual level rather than the low level errors or rule violations identified in the testing process. It works depending on the competition type and the required feedback to the jury and designers and its level of detail. Inputs to this module include the identified low level results containing instances of errors and violations, in addition to datasets of high level objectives that define conceptual goals and target values. The module core works on "making sense" of all the large numbers of rule violations and issues, and providing human readable information at a conceptual level, categorized into domain-specific datasets. Outputs from this module are in the form of conceptual categories resulting from the interpreted feedback, including high level understanding of issues such as value engineering, LEED compliance, contextual compliance, and lean manufacturing.

The Reporting Module

This module allows for an automated reporting mechanism such that testing results for all competition entries are displayed comparatively. The goal of the final report is not to select winning entries per se, but to outline results in a way that allows for informed decision making. Inputs to this module include both the results from the testing module and the interpreted feedback from the interpretation module for all competition entries. The module core manages the results and feedback in order to provide comparative reporting in both textual and graphical format to inform the jury decision making process. Outputs from this module are in the form of an automatically generated assessment report in PDF format. As different levels of detail are incorporated in the four modules, the reporting mechanism is flexible enough to allow for different versions of the report for varying purposes. The advisory team may choose to provide a fully detailed report in two-stage competitions for example to allow for thorough study of the issues for further development and refinement. A shorter version can be generated for one-stage competitions and idea competitions.

As soon as the report is automatically generated, it is reviewed by the advisory team and handed over to the jury for their examination. The report is typically provided as a guide for the jury and is by no means compulsory, but the jury may decide to qualify or disqualify the remaining entries based on the provided results. If the entry is found by the jury to have serious flaws based on the generated report, they can disqualify the entry after a discussion with

the advisory team for double checks to ensure the credibility of the information. Otherwise, the entry is qualified. In this stage, the jury consults to select the winning entries.

The final jury report and feedback to designers depends on the competition type. In one-stage competitions, the jury submit their short version final report and announce the winning entries, justifying their decision based on their consultation, and aided by results from the system automated report. In project competitions, the jury provide more elaborate feedback to the winning entry in preparation for the next stage of design development and construction. Based on the feedback from the automatically generated report - which includes data from all entries - the jury may decide upon consultation to incorporate successful ideas and merits from other entries in the entry chosen to proceed. These ideas are integrated into their final report. In idea competitions, comments and notes are less elaborate and are at a more conceptual level. If the competition is a two-stage competition, the jury are asked by the advisory team to provide detailed and tailored feedback for the continuing entries. The jury announces the winning entries and calls for an updated BIM model. This is used to initiate the assessment process for the subsequent stage.

DISCUSSION

Based on the proposed framework, there is potential for some aspects and issues open for discussion and debate concerning the validity of implementation. Benefits include the thorough investigation of design model entries, and learning from each and every proposal, as the detailed comparison and checking can help tailor or refine a best entry by making use of qualities in different entries. By running the necessary checks and simulations, jury members can read more into the proposals and examine their long term impacts, and simulate different scenarios in the project context and environment using building information modelling tools and possibly geospatial information systems. This process is also extensible, where a variety of plug-ins and interfaces can be incorporated on demand to inform the jury decision making process. At the same time, the intervention of this type of assessment opens the door for openness to public access and integrating the opinion of the public, thus enhancing collective debate, where the subjective or tacit component of the assessment can be shared among experts together with the community.

Below are two significant topics for discussion following the suggested framework, that are viewed as essential to understand its value as well as its advantages and disadvantages. The first deals with the competition and assessment culture and the new dynamics of the jury process, while the second involves the topic of architectural quality versus blind elimination of competition entries.

Changing Dynamics of Competition Culture

One of the fundamental issues that follow the development of the aforementioned proposal is taking a step back to evaluate how such a framework would affect the nature of assessment, jury structure, roles of advisory teams, jury and sponsors, and competition culture at large. Usually, a jury process involves certain characteristics such as identifying assessment criteria, weighing the criteria, grading every alternative in respect of every criterion, and making the ultimate decision (Bazerman, 2006). According to Svensson (2013), there are some unique characteristics and features however pertaining to the process of assessment and the structure of the jury for an architectural competition, which can be summarized in this context into two main features: 1) diversity of jury representation and jury consensus, and 2) representation-based assessment.

Regarding the first feature, a competition jury typically consists of different representatives from multiple professions and domains, including members with professional competence similar to that of the designer participants, but also representatives from sponsoring institutions, advisory boards and others. This implies that there are usually varying

interests, perspectives and duties among jury members towards the competition entries. In addition, the final decision of the jury must be made in concurrence, where a carefully laid systematic process is conducted to evaluate all entries and then discuss and negotiate till arriving at one common and final decision.

The extensibility of the proposed framework in both its preliminary stages (the ability to provide input requirements and qualifying conditions for each jury member) and terminal stages (the ability to define clear and explicit assessment criteria, and conduct prediction models for the potential of certain projects and study their future impact through simulations of on-demand conditions and factors) suggest new dynamics to the jury assessment process and the interaction among its members to address different viewpoints.

Most of the specific requirements, perspectives and objectives of the different parties involved can be met by embedding and defining specific rulesets in the system that becomes a basis for testing. Typically, not all the issues in this context are explicitly quantifiable, but the fact that tailored requirements can be embedded on a case by case basis can add to the discussion and negotiation component of the jury deliberation process. At the same time, the interpretation module can generate different feedback at the conceptual level for each different category of the jury members according to their needs and inquiries.

As for the second feature, it has typically been the case that the assessment of any jury is based on representations of architecture rather than architecture itself (Svensson, 2013), where graphical and textual representations, plans, facades, sections, illustrative diagrams and 3D perspective drawings traditionally constitute the "product" before the jury and are the basis for its assessment. This becomes a fundamentally important and an influencing factor in the jury process, where communicational interaction through visuals and persuasion through the maximum available methods of argumentation and visual rhetoric - as viewed by Tostrup (2007) - can often precede matters of substantial value and higher significance.

In the context of the proposed framework, the added value lies in the nature of the deliverable, which is the information model, which represents much more than graphics and visuals, but rather much of the semantics upon which the assessment is based. By exposing the native model together with graphics or image captures, the assessment process becomes presumably less prone to the often illusory effect of architectural catchy representations, and more focused on issues of performance which set a clear and explicit assessment metrics. Access to the geometric and semantic data of each entry allows not only for more accurate information visualization and comparative analysis, but also for running what-if scenarios and arriving at optimized and integrated solutions.

The exercise of submitting a BIM model however has its drawbacks. It puts some pressure on the designer due to the number of requirements, the high learning curve, and the effort exerted in creating a correct and complete BIM model that satisfies preset modelling standards and qualifying conditions. This is questionable especially with architects, where the process of delivering BIM models and adhering to strict conventions and modelling standards can be viewed as restraining and limiting in terms of creativity. This also constitutes a burden on the advisory team whose role is clearly quite different than in a conventional competition assessment process, extending beyond just a managerial role to a higher level of expertise in using BIM-authoring and analysis tools and running simulation and optimization tools to assist the jury with their final decisions.

As described above, the nature of the whole culture of architectural competitions can be dramatically affected by using the proposed framework. Not only is the assessment process different, but also the nature of the competition program, its description and its requirements. The level of detail and explicitness of information provided to and required by de-

signers becomes of higher significance. The development of platforms for rule extraction, testing, interpretation and reporting becomes inevitable, with more and more required intelligence based on competition type and theme. The dynamics of assessment and generating a well justified decision for winning entries (and therefore a much more elaborate and rich decision making process) is one of the main anticipated benefits, where it is less likely to rely on subjective decisions or verdicts based on mere aesthetic values.

Whether or not competition deliverables should be more or less detailed or sophisticated remains an open ended question. Different competition types can also feature different assessment formats and therefore different types of deliverables. Although the flexibility and extensibility of the system allows for these variations and on-demand iterations, the reciprocal relation between the efforts done by both designers and advisory teams remains key in determining the required load, level of detail and phasing. The lower the level of detail and sophistication of BIM model data required by the designer, the more the burden on the advisory team to adjust the data in order to meet the assessment criteria and the more the process is error prone and open to ambiguity. If the designer for example misses the name of a space, the definition of a wall composition, an opening or a massing element, the team can intervene relatively easily, although questions of design intent are legitimate. But if the required alterations exceeded the level of model completeness to model correctness, this would require much more and could jeopardize the assessment process. In a typical scenario - other than a competition setting - designers would be asked to adjust their models accordingly, but the single submission process in a competition puts naturally more load on the advisory team in terms of inference and data manipulation.

It is unfair to assume that a BIM-based methodology will produce better architectural products or solutions, but more importantly it is anticipated that implementing such a framework will help raise the bar and provide for a stronger and enhanced competition culture.

Architectural Quality vs. Blind Elimination

The notion of architectural quality is continually imperative to the assessment process in any type of competition, and is probably the core of decision making in this process. Any assessment of a competition entry typically falls at the end into one of two categories: 1) evaluating the quantifiable functional and technical qualities, and 2) assessing the qualitative aesthetic aspects of design (Lundequist, 1992), with varying degrees and levels of significance given to each on a case by case basis.

A typical scenario for the former involves either eyeballing or measuring by the jury to compare between different entries, or consulting domain experts for the purpose of checking certain performance issues such as energy efficiency and consumption, budget, and other spatial and physical qualities. A typical scenario in the latter mostly relies on the individual readings and constructs of different jury members of the submitted solution in terms of appearance and other qualitative and aesthetic values. This is where the visual rhetoric and catchy presentations plays a significant role as mentioned earlier.

Moreover, the final jury decision is typically based on the overall impression and image taken as a whole, rather than mere aggregate collection of points in a checklist. The jury - each member with a specific agenda in mind - search during the assessment process for answers to preset domain-specific and global questions that have to do with the embedded meanings in the design, the character of the building design, the value of the entry in its micro and macro scale, how it is communicated, and how well it serves the community or larger context. The jury deliberation usually discusses these overarching issues and questions more than delving into the minutiae of the former technical quantifiable aspects of the entries.

The proposed framework attempts to address both categories in a slightly different fashion. With

regards to the technical category, domain-specific expertise and performance-based evaluation techniques are embedded in the system, where various functional, spatial, and technical qualities are assessed based on a multitude of codes, design guides and assessment criteria - incorporating different perspectives and requirements of different involved parties - combined in one all-encompassing and extensible framework. In addition, at any point in the assessment process, the jury can choose to conduct tests and run what-if scenarios, and furthermore incorporate ideas from different entries and validate their appropriateness within the competition setting.

With respect to the qualitative category, it is quite acknowledged that this area will mostly remain subjective and left to the discretion and interests of different jury members, and it is not the purpose of this framework to replace human judgment with automated results and figures devoid of any holistic view that evaluates the integrity or value of a given architectural design. However, the framework provides a supporting tool for decision making on an informed basis through its interpretation module. This module provides indicators to the jury regarding concepts that can be used to infer some qualitative features.

For example, in master plan and urban-scale project competitions, input parameters of urban fabric, setbacks, building heights, street widths, materials, textures, solid-void percentages, proportion, rhythm, and so forth can be used to develop a contextual compliance indicator, using target values from codes and guidelines and actual values from the BIM model entries. In the same manner, in other competition types with specific attention to environmental and thermal comfort standards, parameters that are related to water consumption and efficiency, solar radiation, thermal mass, materials, U-values, building mass ratio, and so forth can be used to develop a LEED compliance indicator. These indicators can be reviewed comparatively by the jury in a way that allows for a more informed process of evaluation, where the final say remains in the hands of the overall opinion and perspective of all jury members.

This framework thus does not rely solely on a process of blind elimination procedures, as may be falsely perceived from its process diagram. The aim is to target a process of enhancing quality and producing best fit solutions rather than just reducing error or pointing out areas of easy disqualification of entries. It is rather an evaluation decision support system targeted at architectural quality in essence, that is not simply reduced to pieces of software such as conventional conflict checking tools that generate thousands of errors which may be meaningless to its users. It is the interpretation of instances of errors or issues and translating those into meaningful chunks of conceptual categories to the jury that produces articulate feedback and assessment with minor subjective domination. Further work may delve into the value of how such a framework can benefit from exploring other subjective concepts such as wholeness, coherence, suitability, and meaning, embedded in a given architectural competition entry, in order to identify how much the limits can be pushed between conventional and BIM-based assessment.

CONCLUSION

This paper introduced a BIM-based framework for assessing architectural competition entries that aims at supporting the evaluation decision making process without compromising architectural quality. Using IFC data from BIM model entries, the framework incorporates designers, jury members and competition advisory team in a process that tests BIM model entries against extensible rulesets extracted from building codes, design guidelines, competition terms of reference and any specified assessment criteria and qualifying conditions. Feedback is then provided to jury members in the form of tailored reports of interpreted conceptual categories that address both quantitative and qualitative aspects of designs to inform the assessment process.

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