Towards computational dialogue types for BIM collaborative design: An initial Study

Alice Toniolo\textsuperscript{1}, Marianthi Leon\textsuperscript{2}

\textsuperscript{1}School of Computer Science, University of St Andrews
\textsuperscript{2}Scott Sutherland School of Architecture and the Built Environment, Robert Gordon University

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New Home Example
New Home Example

Team of Experts
- Construction Manager
- Quantity Surveyor
- Architects
- …
New Home Example
New Home Example
New Home Example
New Home Example
Construction Dispute Revenue

Average Dispute Values (US$ millions)

Average Length of Dispute (months)
Causes

- Failure to properly administer the contract
- Poorly drafted or incomplete and unsubstantiated claims
- Employer/Contractor/Subcontractor failing to understand and/or comply with its contractual obligation
- Errors and/or omissions in the contract document
- Incomplete design information or employer requirements (for Design-Build and Design & Construction)
How to manage? – Regulations

- BIM Mandate (Building Information Modelling) 2016/2017
- The Architecture Engineering and Construction (AEC) industry is shifting its focus in relation to projects delivery, from the chain of activities to managing an efficient collaboration and innovative ways of creating, sharing and collecting relevant information among AEC professionals – with BIM acting as a catalyst.
How to manage? – Collaboration

- Collaboration & communication central for successful construction and infrastructure projects
- But to avoid errors and improve outcome:
  - More efficient collaboration
  - Monitoring collaboration
  - Improve and streamline collaboration at the early stage of design
  - More transparency
Use of a facilitator to set goals and decision at the early stages significantly improve collaboration

M. Leon, R. Laing, J. Malins, and H. Salman. Development and testing of a design protocol for computer mediated multidisciplinary collaboration during the concept stages with application to the built environment, 2014
How can argumentation help?

Overarching Research Problem:

- How can we improve this phase of collaboration to help AEC professionals reduce errors?
  - Analysis of the reasoning process to identify sources of error
  - If any error was committed, analysis of the critical points that led to the error & log of why a decision was made in a certain way.
  - Forensic investigation of what was decided and why
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  - Forensic investigation of what was decided and why
  - Why not earlier?
Design Requirements

- Baroni, et al (2013)* structure requirements as arguments in advance but more complex argument analysis
- ...

- Black, et al (2013)† analysis of the design debates for a new protocol

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Design Requirements

- AEC design is a collaborative design process
- Graphical representation of design requirements may be helpful in clarity of requirements
- This can then be analysed formally
- But...
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- But...

  + Hamper Creativity
The pipeline

1. Annotate AEC debates
2. Extract argumentation structures
3. Analyse Argument Structures
4. Use argument-based reasoning to identify critical sources of error
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Dialogue extract Example

"We should elevate the building on stilts to control humidity"

1st Architect

"An elevated structure will cause problems with the access the building"

2nd Architect

"The building is on a slope and a ramp may lead to the entrance, which will not impede the access"

Construction Manager

Typical deliberation dialogue + practical reasoning
Deliberation models

How to enhance existing models of autonomous deliberation to capture the complexity of natural deliberation?

- New information (Walton, Toniolo, Norman, 2016)
- Regulated by norms (Walton, Toniolo, Norman, 2015)
- Revision of issues and new information

- Pncir: Only attacking arguments for negative consequence of adopting a new action
- Pcir: More flexible protocol, permits agent to take the initiative of sharing information about circumstances
First step - Aim

- Analysis of existing dialogue between AEC professional
- Extract arguments & Understand dialogue context
- Thematic analysis provided by the enforced AEC protocol analysis (qualitative data analysis)
- Hypothesis: Thematic analysis has similar characteristics of Walton & Krabbe’s dialogue types
- Question: would this contextual analysis be useful in providing context to the dialogue to help with argument extraction?
Study Context

**Analysis of:**
- Analysis of segments of dialogue from 2 studies among AEC professionals in the task of designing a small educational and research building
- 6 Participants: Architects, Project Manager, Quantity Surveyor, Building Surveyor, Construction Manager

**Qualitative/thematic analysis** considering conceptual phases of dialogue

**Argument-based analysis:**
- domain knowledge, design solutions, design criteria (regulations, style, costs, client requests) and design goals (brief).
- reasons for and against adopting a solution/criteria/goal
Studies Monitoring: examining a collaborative design process

Study 1

Study 2
First step - Arguments

Data Analysis

Data extraction & transcription → Argument diagramming → Argument Evaluation
First step - Arguments

Text to Arguments:

A1: Comments about the materials, adds that they all agree about their preference to large glazing-covered areas and Nordic design inspiration
A2: Argues that too many windows might be a problem
PM: Adds that too much glazing can cost a lot and might cause problems to the construction
A1: Replies that you can shadow it, thus providing solutions
PM: Talks about problems with glare
A2: States that some rooms can have controlled shading while others can be more or less glazed depending on the heating loads and working needs.
QS: Agrees and further comments on it
First step - Arguments

Text to Arguments:

And evaluation
using a tool called CISpaces (cispaces.org) similar to OVA (arg-tech.org)
Second Step - Dialogue

Thematic analysis: Design thinking actions’ coding scheme

<table>
<thead>
<tr>
<th>Actions levels</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
<td>Cognitive synchronization: argumentation / negotiation</td>
</tr>
<tr>
<td></td>
<td>Workflow driver</td>
</tr>
<tr>
<td>Perception &amp; Concept</td>
<td>Perceptual Activities</td>
</tr>
<tr>
<td></td>
<td>Set up Goals</td>
</tr>
<tr>
<td>Physical Actions</td>
<td>Co-Evolution &amp; brainstorming</td>
</tr>
<tr>
<td></td>
<td>Sketching/ Drawing</td>
</tr>
</tbody>
</table>
Proposed connection between the dialogue context and the actions’ coding scheme:
Dialogue Examples

BS: What kind of storage do we need? What is going to be stored?
A1: Models
BS: Are these models small or large?
A1: I suppose sometimes they might be large models
BS: Storage space would need to be reasonably sizable.
A1: It depends how much you value the workshop, if the strategy of the client is to value the model making, workshops and storage should be big
BS: Yes, especially if it is for archive. How long do we have to keep documents for?
QS: Five years
BS: Hence we need a sizeable paper storage as well as space for models.
A1: And also, I suppose, this kind of facilities needs things like boards, or drawing tables

Relevant Clip Annotations:
Collaboration – Cognitive Synchronization: Shared Understanding and Representation
Collaboration – Workflow Driver: Decisions on New Features
Concept and Perception – Perceptual Activities: Problem finding
Concept and Perception – Co-Evolution: System Brainstorming
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Concept and Perception – Co-Evolution: System Brainstorming
BS: From building regulations, the minimum occupancy factor is 6, so each office space must be a minimum of 6 square meters.
A2: But we should go for the best quality of the space, so if we are designing an office for research and design, we should aim for bigger desks and room for devices.
BS: Yes, a building that is used to function, people need space to be creative. From a cost point of view we should design what we want.
QS: But a flexible budget is unrealistic, we should make it functional. We have to define priorities in terms of what we want and what we can actually afford.
BS: Otherwise we get a disparity between the budget and where ideally we want to be.
QS: At this stage, you made an assumption of a four storey building, let’s not make that assumption just yet because the higher we go the more expensive it is going to be. We need to design for a big number of people, now, it might have an influence on what type of structure we are going to use.
BS: It is going to be an issue anyway because of the slope of the site.
QS: If you are going for steel you are going to struggle to get it to the site.
BS: I was initially thinking that it would be concrete, if you post tension it, you get slimmer floor elements, with open plan spaces working.
QS: More expensive frame but you save in terms of height and materials.
BS: Yes, and you get more usable space as well.

Relevant Clip Annotations:
- Collaboration - Cognitive Synchronization: Shared Understanding and Representation
- Collaboration - Cognitive Synchronization: Negotiation
- Collaboration - Workflow Driver: Decisions on Existing Features
- Concept and Perception - Set-up Goals: Goals for Objectives and Functions
- Concept and Perception - Perceptual Activities: Focus on Features and Relations
Conclusion & Future work

- A preliminary work
- We presented an initial mapping between collaborative, conceptual and perceptual activities related to AEC design processes to information seeking, deliberation and negotiation.

Future work:

- Include automatic extraction using a combination of speech acts and conceptual annotation
- Develop sensitivity analysis and mitigation of risk of construction errors
Future work

The design process underpinning early building and construction design stages has potential for further future research:

- dialogue with focus on dialogue shifts and practical reasoning
- mixed-initiative argumentation-based dialogue between professionals and mediating agents to improve conflict detection and prevent errors
Thank you for your attention...

Any suggestion/questions?