Capturing and Utilising Information about Interactions During the Learning Process in 3D Virtual Worlds

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Abstract: The range of interactions in immersive 3D virtual worlds is increasing as new technologies are integrated with such environments. The increased complexity, however, does not necessarily deliver information on the interaction process specifically to the interacting and/or instructional parties. The challenge is how to extract and utilise information regarding the interaction process between team members in such environments enabling and supportive of the learning process. This paper reports on the application of a visual language in virtual worlds to provide information about the interaction process between team members in a learning context as it unfolds. The process of interaction over a number of weeks between team members, undergraduate design students, is demonstrated through chat logs. The resultant representations are described and commented upon as to their merit in provision of feedback on the interaction process. Reflection in action using shared knowledge products is a key component of the approach.

Introduction

The latest generation of immersive 3D virtual worlds and Web 2.0 technologies are enabling the incorporation of rich interactions in e-learning and mobile learning scenarios and provide the capability to capture promptly the data about such interactions and their content. These include interactions between the learner and people involved in different roles in the process, as well as interactions with various learning materials and the learning environment. (Billet, 2008). The range of interactions in immersive 3D virtual worlds is further enriched with real time physical sensory data. When the focus is upon developing these new input channels, for instance, brain-computer interfacing to virtual worlds,[1] and the access from mobile systems, little attention has been paid to presenting the information about the dynamics of the interaction process in such environments and how interactions through varied communication channels affect learning processes and subsequent outcomes.

This paper looks at the incorporation of the information about the way interactions unfold into the learning process in virtual worlds. This task requires finding ways to (i) represent and incorporate information about interactions as ***the interaction process unfolds*** in real time; (ii) enable such representations to ***'reflect'*** to the stakeholders this information in compact and efficient form; and (iii) take such information in account in the learning process. This follows elements of Donald Schoen's (1994) reflection in action approach where the "reflective practitioner' is embedded within and directly influences that which is being investigated, in this case the interaction space. Reflection using shared knowledge products (Laurillard, 2007) is central to presented approach. The approach is based on a methodology and respective technology for analysis of interaction dynamics, which incorporates the Kinetic InterActing (***KIA***) visual language and its interpretation techniques. The conceptual modeling that enables the method for designing representations of interactions is inspired by Lakoff and Johnson's

[1] See http://www.pinktentacle.com/2007/10/brain-computer-interface-for-second-life

(1980) approach to metaphors. It is the view of this work that it is important when designing for representations of interaction that meaning is accessible to wide audiences and is stable across different cultures. The main focus of the paper is on the application of the approach in the design education, in particular, in the context of collaborative designing by undergraduate design students in a virtual world.

Kinetic InterActing Language

The Kinetic InterActing (*KIA*) language was mapped from elements of human movement (Deray & Simoff, 2007). ***KIA*** operates with the concept of "elasticity" derived from human movement. "Elasticity" combines (i) the actions of rising and sinking (Fig1a) and (ii) the actions of contraction and extension (Figure1b), which in ***KIA*** correspond to ***R-S*** and ***C-E*** elasticity, respectively. These elasticities are described through the computational models of their qualities, which follow the behaviour shown in Figure1a and Figure1b. In its current development the ***R–S*** elasticity includes four qualities: ***flow*** (q_1^{R-S}), which characterises the obstruction (e.g. language/social/cultural, etc); ***transition*** (q_2^{R-S}), which characterises interaction in time; ***exertion*** (q_3^{R-S}), which correlates to the amount of effort required for an interaction to achieve some perceived position; and ***control*** (q_4^{R-S}), which indicates the amount of control applied in the interaction. The ***C–E*** elasticity currently includes a single quality – ***intensity*** (q_1^{C-E}), which indicates the strength of the interaction. The aggregation of these qualities into a production element is shown in Figure1c. Production element is the basic semantic unit in ***KIA***. Though each quality is estimated on a continuous scale [0; 1], for interpretation the range is divided into five intervals – minimum, intermediate-low, middle, intermediate-high and maximum, labelled as ***mn***, ***il***, ***md***, ***ih*** and ***mx***, respectively (Figure1c). Production elements are used to represent interaction dynamics in an interaction segment. A collection of production elements forms a production. Productions usually correspond to an interaction session, for example, a collaborative design session. Visual analysis is centred on the patterns extracted from such productions.

The interaction parameters that are used to compute these representations depend on the nature of the interactions. For example, modalities in face to face-to-face interactions differ from the modalities of interactions in virtual worlds. In face to face interactions parameters used to compute the models of the qualities are functions of time and frequency of individual actions in the interactions. For the interactions in virtual worlds that happen in the chat channel parameters used to compute the models of qualities are functions of the number of words and their average lengths (for the purpose of the analysis, avatar's gestures are converted to a finite set of symbols and then individual gestures are treated as words from this set, similar to emoticons).

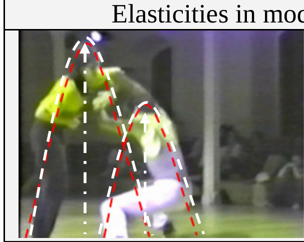
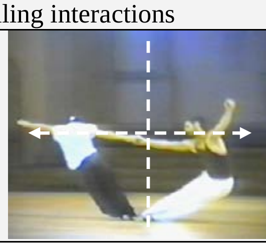
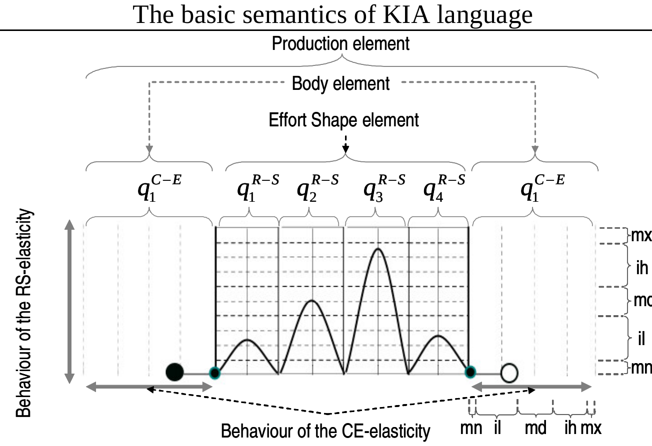
Elasticities in modelling interactions		The basic semantics of KIA language
		
The ***R-S*** elasticity is used to represent ***flow*** and ***effort*** of an interaction, modelling them as oscillations along the vertical axis of human movement.	The ***C-E*** elasticity is used to represent the level of ***attraction*** or ***repulsion*** in interaction, modelling it as oscillations along the horizontal axis	
a. rising/sinking	b. contraction/extension	c. visual elements and their aggregation

Figure 1. Aspects of elasticity of human movement and respective visual language for modeling interactions.

The Design Project: ‘Spatial’

The data in this study has been collected from the project ‘Spatial’ – a virtual world, constructed for teaching undergraduate design students at a university. The ontology of ‘Spatial’ includes three ‘rooms’, each of which poses some design activities and consequent design process to explore and solve a design problem. Design projects benefit by and require collaboration between various parties. The instructional strategy for the student project was based on constructivist principles, whereby the student through interacting with various learning contents constructs an internal representation of knowledge. Active Worlds was the selected platform, which, for reasons of security/privacy, was hosted on the faculty server. The class was divided into groups composed of two to three students. In this paper we consider only the communicative interaction in ***designing rooms*** 1 and 2. By communicative-interaction we mean the collection of utterances in communication channels of virtual worlds. We consider only the interaction in the chat channel to demonstrate the approach. Snapshots of student work in progress – the background and context of the interactions, are shown in Figure 2.

Figure 2. Student examples from *designing room* 2- research and conceptualization of chosen theme aging

Methodology

The aim of the study was to extract information about the dynamics of interactions between designers and to provide it to instructor so that the later can utilize it in her/his guidance of the project. If successful, the approach and technique discussed in (Deray and Simoff, 2007) can be utilized by the instructor both, (i) at the point of instructional decision making and (ii) subsequently as a research tool to implement and fine tune learning strategies and supporting resources in the educational deliveries in virtual worlds.

An action is the base unit of interactions. An action is equated to an utterance in the chat log of a session. For segmentation purposes, each utterance is defined as a sentence. Then the parameters of such action - the length of an action, the average length in a set of actions and its variance, the variety of actions of each party – are defined functions of the text statistics of the content of the utterance. For the purpose of this study, we base the estimate of the qualities on the number of words in an utterance and the frequency of utterances.

Understanding the total interaction set requires some kind of synthesis. Productions as formal representations of ‘scores’ provide synthesis of sets of interaction spaces.

The world ’Spatial’ was perceived as an investigational space; a spatial environment for design dialogue. Students were instructed to save their chat logs when working in the virtual world and to document their decision points in Goggle docs. A decision point was taken as an agreement between participants in a group on a design step in the process of designing their virtual space. It served as a form of reflection in action (Schoen, 1994). The accompanying chat logs provided insight into how this decision was made as an expression of the interaction process. The levels of analysis are comprised from a number of different modes and levels of granularity. Accordingly as space is limited and the work is in progress we take a chat log from only one group to demonstrate the method and application of KIA. Each team included two students. In the data set for each team the two participating students in a session are coded as ‘A’ and ‘B’ respectively. The chat log selected in this paper dealt with the selection of design theme, proposed design approach, and design language to be utilized to express the theme. The themes provided in the world 'Spatial' (in accordance with the meta theme of "Well Being") were, (i) obesity in children, (ii) aging, and (iii) depression in young adults. Each student group selected one of these three themes upon which to explore and construct an instructional design that through informative interaction provided opportunity for learning that could persuade, or assist, various identified groups with respective health issues.

The design process for students was constructed as a number of tasks that together make up an activity. Each task was decomposed into actions. For this analysis each utterance by a participant in the chat log was taken to be an action. Interfacing actions, such as, "umm", "hmm" or irrelevant remarks were cleaned from the data prior to transcripts being analyzed. For coding purposes each utterance was placed on a separate line and numbered. The methodology to extract both number of actions contributed by each participant and subsequent length of actions is demonstrated in Table 1. The length of the actions is a function used to compute the values of the elasticities and qualities in KIA. In Table 1 a fragment from the chat log is segmented into actions, that is, utterance**s.** Once the text had been coded as utterances the length of each utterance is equated to the number of words in it. In the text-based channel in virtual worlds this is a more appropriate estimate of the length of communicative action rather than time, as is in time stamped data that is available in face-to-face interaction, as it is not biased by the typing skills of participants as well as possible time delays due to varying internet traffic.

Raw transcript	Segmentation of data as utterances	Coding of actions as utterances	Length (word count)	Subtask
That would make sense, make it easier to work with. I was just thinking about the education system would be a good place to research see what they have in place to assist children.	That would make sense, make it easier to work with.	A1	10	Interpreting information through analogy of a story-board
	I was just thinking about the education system would be a good place to research see what they have in place to assist children	A2	24	

Table 1. A fragment of the action transcript from the chat log, segment 2, demonstrating segmentation and coding of actions and derivation of length by word count

Once the number of actions per turn taking had been determined and interactions constructed KIA elements are generated via the KIA engine to express the interaction process for different groups through the activities.

The segmentation of the data follows the decision points derived by the students in their Google docs. Each decision point is called a decision fork (DF) with accompanying number to determine sequencing in the text, (DF1, DF2, DF3 and so on). DF ROOT stands for the base fork or node from which the other subsequent DF's follow in each segment. In Table 2 fragment of the action sequence for the interaction session (as per student interpretation in Google docs) is provided. Each interaction is taken to be one turn taking. For instance, "A4-A5:B4-B5" corresponds to Party A contributing actions A4 and A5, while Party B contributed actions B4 and B5 (":" is used to indicate turn). The length of each action and the numbers of actions by A and B, respectively in different segments are the arguments in the functions that compute the values of the different qualities in the representation of the interactions.

Segment	Action sequence	Subtasks	Decision Forks
1	A1-A2:B1-B4	Choice of theme	B4-DF ROOT
2	A1-A3:B1-B3: A4-A5:B4-B5: A6-A7:B6-B7: A8-A9:B8-B10: A10-A11:B11: A12:B12:B13: A13:B14-B15	Application of educational focus	A2-DF ROOT B5-DF1 A10-DF2

Table 2. Action sequences for two selected segments

Reflective Action for Learning Through Delivery of KIA

The visual expressions of the information about the interaction process can be delivered on various computing platforms, providing communication of knowledge about the unfolding of the interaction processes to the parties involved in the learning process. Such parties may not necessarily be directly involved in the interaction but through their role may be embedded in the interaction context.

The idea of the methodology for incorporating the interaction patterns into the learning process is explained in Figure 5. The order of production elements, in a production with respect to time is as agreed within the study. By default, the time axis increases from top to bottom. Figure 3 demonstrates the expression of the interaction process through representation of KIA. Each production element corresponds to a segment in the chat log. In Figure 3 five production elements are represented corresponding to the segments as described. They form the production (the 'score') of the session, showing how interaction has unfolded in the chat log between the parties. Based on the values, an indicative interpretation about the interaction in terms of the elasticities can be provided. Instantly noticeable is the behavior of the ***C-E*** elasticity. Segment 1 has the weakest intensity while segment 5 has the strongest. The expression of anchor points indicates that both parties took different roles in the interaction process, oscillating between dynamic and static; (an anchor point represents a party involved in the interaction with static (○) or dynamic (●) behaviour). At present features of anchor points are only calculated on the number of actions contributed by participants in a segment. This is problematic in such instances as segment 5, where the differences in the action count from each participant is very small, only one action. Thus, it is only perceived as a fairly coarse level indicator of role. In the production the variation of the shape the ***R-S*** elasticity is represented in the four qualities of the Effort Shape element. Flow (q_1 in Figure 5), a measure of obstruction, indicates above average communication between the parties; transition (q_2), which characterises interaction in time, indicates that interaction between parties occurred with average to slightly long responses with actions of medium to longish length; exertion (q_3), which correlates to the amount of effort required for an interaction to achieve some perceived position, indicates complex level of interaction in segments 2 and 3 as it shows greater effort, especially in segment 3, than in segment 1 which shows least effort; control (q_4), which indicates the amount of control applied in the interaction, shows flexibility over most of the session with segment one having the smallest number of decision points resulting in the lowest complexity of the session. This corresponds to segment 1 being the shortest in the interaction session.

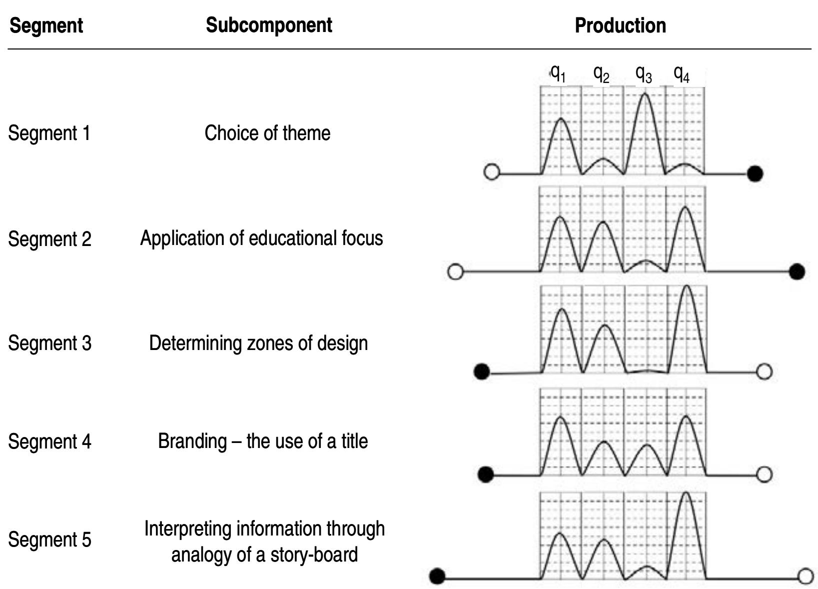


Figure 3. The Production for the interaction between participants A and B

Ideally a record of the interactions should be included in the virtual environment for participants to access. Such a ’tool’ would assist in evaluating the interaction process and facilitate self–reflection by participants. Additionally the visualisation of the interaction process through KIA, over different groups, provides valuable information to the instructor in the learning context as to the progress of students in set tasks. Timely feedback from instructor to students at point of decision-making would be of assistance in the learning process.

Conclusion

The research demonstrates the capabilities offered by the approach of representing interactions in virtual worlds through the patterns derived from the formalism. The approach aims to link learning outcomes with the way people interact by formulating a methodology that provides for a way of getting information about the learning environment, as visual patterns that provide source analysis, and feeding it back into that environment. By such analysis capabilities a reflective system is constructed that forms information ‘loop’ from virtual to physical and back to the virtual. Bogdanovych (2007, p149) notes that a “reflective systems are a particular case in which the representation of the system is part of the system itself.” By so doing the approach in this research presents rich opportunities for the extension of knowledge about how interactions unfold as a process in virtual worlds and how such processes can be structured to assist with learning. As proposed formalism is a way to capture and transfer knowledge about interactions, the expected outcome is that it can be developed further into a knowledge capturing and transferring machinery that can become an embedded technology in domains that require and will benefit from such capturing and utilising such knowledge. It is expected that the research can be applied to other virtual environments in future work.

In terms of pedagogical output some benefits of representing interactions as they unfold over the project demonstrated in this paper include:

- the instructor can monitor and steer (intervene to facilitate) interaction if necessary. In this project the chat log of student groups was extended in each teaching week of the project providing opportunities for such feedback to occur.
- building interaction profiles of teams that can be used in other subjects with team assignments, that can assist lecturers in handling teams.
- creativity/innovation and the ability to display empathy are important attributes in the designing process. It is difficult to determine how to model, stimulate, or evaluate creativity in the design process. The ability to monitor such process through representations of KIA in virtual worlds with an appropriate project is of interest.

Finally, the proposed formalism reflects continuous nature of interactions that is advantageous in learning environments such as virtual worlds. The representation of interaction process supports real time feedback from both student participants and instructor in learning context. It provides the ability to identify issues/problems in learning capacity of students at an early stage and can be utilized as a research tool. As current limitations we would like to mention (i) the semi-automatic segmentation of the interaction data and (ii) that some anomalies in the interactions may not be well exposed by the formalism and the interpolating visual patterns.

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