Speaking (and touching) to learn: a method for mining the digital footprints of face-to-face collaboration†

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ABSTRACT

The research space on educational data mining exploiting data captured from the collaborative learning interactions of students, particularly in face-to-face environments, is vast but still basically unexplored. Students who build a solution in a group have to externalise and make their understandings about the topic explicit to establish common ground with their peers. This offers an enormous opportunity to capture the digital footprints of the process followed by students, these can be used to uncover patterns linked with successful collaboration and learning skills. The full spectrum of emerging technologies to support classroom and small-group work are opening up the possibility to investigate aspects of collocated collaboration. These technologies include interactive tabletops, digital whiteboards and multi-display settings. We present a method to capture, exploit and mine the digital footprints of students working face-to-face to build a concept map at an interactive tabletop. This includes a system that has a mechanism for recording the history of the collaborative process including the partial versions of the solution, applications logs, individual contributions and verbal participation of each student. This paper describes the learning environment, the system to capture a dataset and the data mining techniques that will be used for the study.

Keywords

Multi-touch tabletop, group modelling, collaborative learning, collocated collaboration, sequence pattern mining

1. INTRODUCTION

Students working in small-group activities, in order to collaborate effectively, ought to interact with other participants, who thus need to keep some degree of mutual understanding about the topic under discussion [2]. In collaborative work students have to externalise their points of view and make explicit statements to explain their understanding to others or to regulate the social dynamics. These externalisations include not only verbal explanations but also physical representations according to the tools provided.

Emerging pervasive technologies that support classroom and small-group activities are opening up the possibility to provide novel ways to capture and analyse these externalisations in order to help students collaboration and teachers to orchestrate the classroom [6]. These technologies include shared devices for supporting face-to-face collaboration (interactive tabletops, digital whiteboards, multi-display settings); personal devices that can provide a private workspace and personalised content; and sensors that can monitor aspects of students' participation.

This paper presents a method to capture and exploit the digital footprints of students working face-to-face to build a concept map at an interactive tabletop drawing on research from two main areas: computer-supported collaborative learning and educational data mining. We present a system that has a mechanism for recording a dataset that includes the history of the collaborative interactions that students perform to build the shared solution, partial versions of their final product, applications logs that include the individual contributions and the verbal participation of each student. The data capture is performed in a pervasive manner; thus students can focus all their attention on the activity. This paper describes the learning environment, the apparatus to capture a dataset and the data mining techniques that will be used for the study.

2. DESCRIPTION OF THE LEARNING ENVIRONMENT

The system used to sense and capture the learners' face-to-face interactions consists of an augmented interactive tabletop that permits students to discuss and work on the task of building a solution in the form of a concept map at a shared space [3] (Figure 1). The tabletop hardware can detect multiple simultaneous touches. To distinguish between users' touches an overhead depth sensor tracks the position of each user around the table, so recognising which users provided an input. Each single touch performed on the interactive surface is paired with the user. Thus, the system records and logs activity, similarly to any e-learning application. In order to capture the verbal communication of group members, a microphone array that

Figure. 1. Interactive tabletop learning environment being used to build a joint solution

† http://chai.it.usyd.edu.au/Projects/DataMiningForTabletop

recognises when a learner is speaking is situated above or at one side of the tabletop.

The learning application used to collect the dataset of group interactions uses the well known technique of Concept Mapping [7]. The tabletop application Cmate [4] permits learners to represent their collective understanding about a topic while they discuss and agree on the arrangement and content of the propositions of a group concept map. The learning environment can capture the evolution of the final solution and the individual contributions of each learner to the final product in both, verbal and physical dimensions.

2.1 Method

A total of 75 students enrolled mostly in engineering and science courses participated in the study to gather a complete dataset. An initial focus question was posed to the students. The goal for students was to learn, and create a concept map as representation of the Australian Dietary Guidelines 2011 form of concept maps. Participants were grouped in 25 triads. They were initially requested to read an article based on these Guidelines and draw a concept map individually at a personal computer. Then, each group of three students was asked to build a concept map collaboratively at the tabletop. Afterwards, they had to draw an individual concept map again. Pre- and post-tests were conducted as shown in Figure 2. All individual and group actions were logged and recorded from the personal computer application (CmapTools [7]) and the Tabletop environment (Cmate [4]).

3. WORK IN PROGRESS

3.1 Dataset challenges

Two key attributes of this tabletop dataset are the sequential order of the actions and the authorship of each. This dataset poses challenges for data mining because the user actions can occur in parallel, be performed by multiple users in a defined order and students can speak while they perform physical actions. We took into account the nature of the data to design data mining objectives to extract frequent patterns of activity and explore which groups favour specific patterns in relation to their performance, nature of collaboration and process followed.

3.2 Data mining

One technique that has proven successful in analysing the timing and order of the events is the sequential pattern mining. A sequential pattern is a very frequent consecutive or non-consecutive ordered sub-set of a sequence of events. The data mining objectives for this study are:

Objective 1: sequence mining by group. The first approach that can be explored is to mine frequent sequential patterns of interactions and to cluster similar actions to observe whether certain groups favour some strategies used to draw the concept map. This method was introduced by Martinez et. al. [5]. However, that study did not use the verbal participation of students. The verbal actions can either be considered within the sequences, using a proper alphabet, or as a feature present in each sequence or similar sequences.

Objective 2: sequence mining by student. This aims to discover the frequent sequences of interactions performed per user at the tabletop. Previous research in group work [1], and more specifically on interactive tabletops [6], found that students behave differently within a group. Some of them work independently, others dominate the activity, under-participate or, in the best of cases, contribute and collaborate equally.

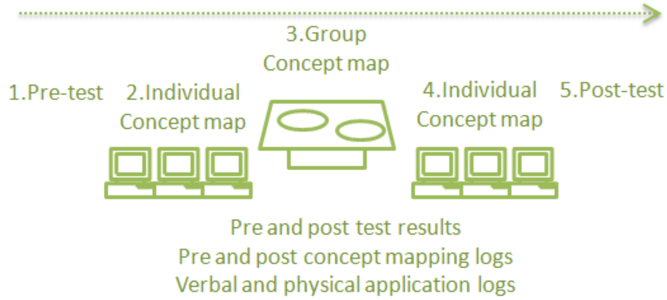

Figure. 2. Method

Objective 3: discovering the building process. The third objective is to discover and create a visual representation of the process followed by each group to build their final solution. Different strategies can be used to create a concept map. Some groups start by arranging nodes of the graph before creating links. Others start creating links in early stages and others apply a divide and conquer strategy. Different methods for modelling the process using Hidden Markov models or process mining techniques can be used to discover the building process.

3.3 Limitations

Current technology limitations forced us to carry out this study in a controlled environment, to assure the quality and consistency of the collected data (e.g. speaker identification and user touch pairing). We observed that our collaborative setting permitted learners to focus on the task, rather than learning particular interaction techniques. A parallel study using the same learning environment is currently being carried out in a real classroom scenario. The present study does not include speech recognition.

5. REFERENCES

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