Constructing an Embodied Interaction for Concept Mapping

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Abstract. Creating learning experiences that are meaningful and motivational is crucial in learning. Research demonstrates that effectively organizing ideas via concept maps allows students to view prior knowledge with new perspectives. Recently, embodied computation has emerged as an effective means of meeting educational objectives due to its intuitive, gesture-based control and to its promotion of associating knowledge with physical events. Unfortunately, a majority of systems tailored for such interaction are expensive prototypes. However, the release of depth cameras has brought embodied interaction into the commercial realm, allowing users' bodies to "become" controllers. This research presents a novel, low cost system that provides embodied interaction with a computer and depth camera, through which learners can create concept maps with gestures. Current work involves defining intuitive gestural controls. Future work will involve evaluating the system for use in a classroom with the aim to create opportunities to easily incorporate embodiment into collaborative learning.

Keywords: embodied learning, computer supported collaborative learning, concept mapping, gestural interaction.

1 Introduction

A discontinuity exists between technological tools and our ability to interact with them in natural, beneficial, and, most importantly, creative ways [1]. Embodied computation has emerged as an effective means of meeting educational objectives due in part to its natural, intuitive, gesture-based control and to its promotion of associating knowledge and concepts with physical events, collaborative interaction, and movement. Embodied interactions provide immersive, novel and memorable educational opportunities, but a majority of systems tailored for such interaction are expensive prototypes and thus not widely employed in classrooms due to both cost and scarcity. However, electronic gaming has brought embodied interaction into the commercial realm with the release of the Microsoft Kinect, a depth-camera controller that allows users' bodies to "become" controllers.

We present a novel, low cost system that allows for embodied interaction with a computer via a depth camera. Through this system learners create and organize

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concept maps with gestures. Concept maps have been shown to encourage meaningful learning by helping students depict a set of relationships between known and new concepts [2], [3], [4]. Additional research demonstrates that effectively organizing ideas via concept maps allows students to view prior knowledge with new perspectives [5], [6]. In constructing a concept map, learners must explicitly define relationships between concepts, considering how to link them in meaningful ways. The skill "requires learners to think harder about the subject matter domain being studied while generating thoughts that would be impossible without the tool" [7].

Our goal is to foster collaboration, creativity, and retention in students through an embodied concept mapping system. In this paper, we discuss our gestural interaction development process for this system, as well as challenges we faced while designing the system. We will introduce our plans for user studies to refine the GUI and future work aimed at evaluating the system for use in a classroom setting. Our ultimate goal is to create opportunities to more easily incorporate embodiment into daily collaborative learning in both educational and professional settings.

2 Related Work

Ishii & Ulmer's interactive physical desktops and ambient office workspace alerts [8], and the RoBallet digitally augmented theatrical performance system [9] provided inspiration for the embodied interaction presented in our system. Several recent efforts in embodied collaborative tools particularly informed our design, including: a touch-table system for creating affinity diagrams in group settings, controlled by tangible tokens and paper Post-It notes [10]; Wilensky's HubNet design allowing participants to "become" interactive nodes of organizational systems via handheld devices [11]; and TRACES, a floor-based system utilizing Kinect for embodied organization of digitized concepts in brainstorming sessions [12]. Additionally, our system was greatly inspired by SMALLab, an interactive digital environment for K-12 educational applications [13].

3 Theoretical Framework: Embodied Cognition

Embodied interactions can offer fun and motivational learning environments. Additionally, research has demonstrated that optimal learning and retention occurs when learning is embodied [14], and gestures influence strategy choices in problem solving [15]. Embodied cognition states that cognitive processes are rooted and derived from the body's interactions with its physical environment [16]. Understanding guides literal action and is closely related to bodily abilities [17]. Lakoff and Johnson have argued that human cognition is inherently embodied, from the metaphors we construct [18] to the way we perceive color, objects, and other concepts in the world. Our perceptions are influenced by our language and by our physical relationship to the world. Furthermore, Glenberg has demonstrated that even abstract concepts are represented in the physical body, through activation of motor circuits [17], [5]. Therefore, students will have a more meaningful and memorable experience if they are able to physically act out activities. Beach's work [19] also validates embodied cognition's role in learning. Experienced thinkers use embodied and tangible tools to aid in memory recall, which allows them to recover from interruptions. Related research affirms that gestures can be used as memory aids as well – for instance, when children learn to count, they may gesture to different points in space as a mnemonic device [20].

4 Embodied Concept Mapping

Our embodied concept mapping system consists of a depth camera, a projection screen, and a computer with an attached webcam. Users can create both image and text concepts. Mouse interaction is currently provided for concept creation. Once the concepts are created, users use the gestural interface to move the newly created concepts, create relationships between concepts, and group concepts.

The Kinect is a motion sensing input device originally intended for the Xbox 360 video game console. It allows users to move around and interact with a computer or console through gestural movements. Our system maps the user's hand positions to cursors, and uses z-depth to trigger click events. Two hand silhouettes mirror the tracked position of the user's hands and serve as pointers (See Figure 1). The current supported actions are: selecting, deselecting, dragging, linking, deleting, and grouping. The gestures used are similar to those used on multi-touch devices (for example, pushing towards the screen to select), but on a larger scale. Large buttons replace right-click contextual menus, which are unwieldy in a gestural interface.

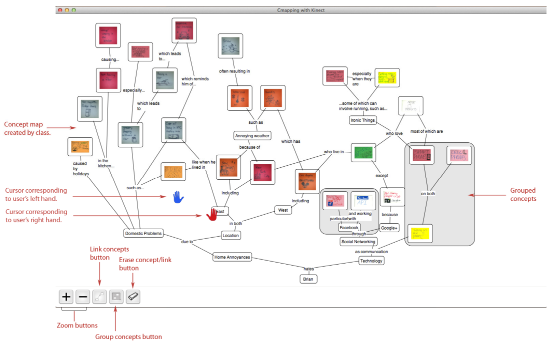

Fig. 1. Annotated screenshot of the concept mapping application

We envision the system to be used in the following way in a classroom: The activity begins with a focus question posed for the students. Students then brainstorm concepts and ideas related to that question. These ideas can be written, drawn, or photographed and become the "nodes" for the concept map. The brainstormed concepts are input into the computer system by scanning them, taking pictures of them, or importing digital images. The images will automatically appear in a concept-mapping workspace, as seen in Figure 2. This, in turn, is projected onto a whiteboard or screen. Using the embodied concept-mapping workspace, the images are organized and links are created defining their relationships to each other.

Although the system only supports one user at a time, this design is still conducive to collaboration due to its enlarged scale. Another user can use the computer keyboard to enter text labels, since the Kinect system affords node manipulation and linking. Ultimately users will be able to create a complete concept map through embodied interaction, as shown in Figure 1.

5 Conclusion and Future Work

We have described a novel concept mapping system for encouraging collaborative embodied learning. We have collected survey results from the larger university student population on user expectations when using a Kinect to interact with a computer. We have also distributed the survey as Mechanical Turk task. 267 responses have been collected and we are currently analyzing the results. We will further refine our gestural interaction based on these results before beginning pilot studies. We hope to integrate our embodied concept mapping application into a classroom and evaluate its effectiveness in motivating students to learn, as well as measuring learning gains using embodied concept mapping compared to traditional concept mapping techniques (paper and pencil, and standard desktop based concept mapping). It is our aim that by further development of this system will create opportunities to more easily incorporate embodiment into daily collaborative learning in both educational and professional settings.

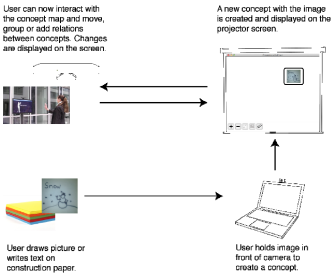

Fig. 2. System diagram showing the process a user would take to create a concept map in the embodied concept mapping application

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