Joint-Construction of Graphical Representations in a Collaborative Tabletop Environment

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ABSTRACT

We present a tabletop environment that implements a small-scale model of a warehouse, used to teach logistics concepts to apprentices in logistics management. Users interact with the system through a Tangible User Interface and Pen-based Input, and Augmented Reality is used for the feedback. Our goal is to support the development of abstract reasoning by progressively moving from a very concrete representation of a warehouse towards a more abstract one, asking apprentices to create and work on graphical representations of increasing complexity. Immediate feedback and propositions from the system are used to help the apprentices in this task. We propose to adapt existing computational models of dialogue to enable this joint-construction of graphical representations by a computer and a group of apprentices.

Categories and Subject Descriptors: H.5.2 - [**User Interfaces**]: Input devices and strategies, Haptic I/O; K.3.1 - [**Computer Uses in Education**]: Collaborative learning

Additional Keywords and Phrases: Pen-based input, Computational Models of Dialogue, Tangible User Interfaces, Augmented Reality, Human-Computer Interaction, Computer Supported Collaborative Learning

INTRODUCTION

We present a tabletop environment mixing a Tangible User Interface (TUI), Pen-based Input and Augmented Reality, used to teach logistics concepts to apprentices in logistics management.

Logistics managers usually work in a warehouse and are responsible for the reception, storage and expedition of goods. Their main tasks consist of moving boxes in the storage area, preparing customer orders, organizing the warehouse and managing storage levels. The particularity of the swiss vocational training system is that apprentices go to school one or two days per week, and spend the rest of the week working in a company. A qualitative study we did between april and september 2006 has shown that apprentices are usually given low level tasks, and are thus barely introduced to the managerial skills necessary for their job. The school tries to teach them theoretical logistics concepts, but apprentices have problems to understand and learn them as they can not relate them to any practical experience.

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Our system aims at bridging the gap between school and workplace by providing apprentices with more practical exercises that should allow them to learn theoretical concepts in a setting more closely related to their own experience. Apprentices work on a small scale model of a warehouse, made of wooden shelves, pillars, boxes and remote controlled forklifts (see figure 1). The physical setting also evolves during the progession from concrete to abstract, moving from a very realistic representation of a warehouse towards a more symbolic one, which features charts of storage levels and customer orders.

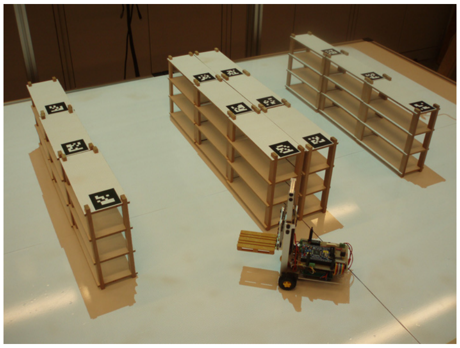

Figure 1: Physical setting of our tabletop environment.

The main contribution of this work is on the use of pen as a main input modality to the system, in complementarity with a tangible user interface and augmented reality. We plan to adapt existing computational models of dialogue to both create an efficient user interface, providing apprentices with appropriate feedback about their input, and support the construction of graphical representations, creating a common ground between the system and the humans through dialogue. There is an agreement among researchers that grounding is a very important aspect of collaboration and communication, and has thus been studied in the field of Computer Supported Collaborative Learning [2], and computational models of grounding have been developed with the goal to analyze the grounding process in collaborative settings [1, 3].

RESEARCH QUESTIONS

Question 1: *Does a computational model of dialogue enable the joint construction of a graphical representation by a computer and a group of apprentices in a tabletop environment?*

In other terms, we want to study wether it is possible to create an efficient user interface, allowing apprentices to create graphical representations in collaboration with a computer, considering this joint construction as a dialogue between humans and the computer. The main challenges will be to find a suitable model for these interactions, as well as a visual grammar apprentices could easily understand.

Question 2: *Does this form of human-computer interaction enable a smooth transition from concrete to abstract representations?*

The question here is wether this kind of interaction, creating a consistent interface among different settings, may help apprentices to draw progressively more abstract representations. We will have to define natural transitions between different types of interaction, and ways to encourage apprentices to make use of more abstract information.

Question 3: *Does this form of interaction enable new forms of pedagogical activities that have not been developed in standard learning environments?*

By new forms of pedagogical activities, we mean types of interactions that are difficult to implement in traditional educational software. Our hypothesis is that the ability to use a pen to make drawings, which is a difficult task with a mouse, may allow us to create new learning activities. For example, we could ask the apprentices to make predictions about the evolution of inventory levels by completing a line on a graph. The simulated curve would then be progressively drawn, allowing the apprentices to directly compare it to their prediction.

EXAMPLES OF USE

This section describes several examples of pen-based input and feedback given by the computer.

Path planning

Apprentices have to solve the problem of the *double-jeu*: five boxes have to be entered in the storage area, while five others have to be taken out to fulfill a customer order. The goal is to define the sequence of movements of a forklift that minimizes the total distance traveled. Apprentices use dry-erase markers to draw sequences of paths directly on the table surface. Augmented reality is used to give them an immediate feedback as soon as the system detects their input and interprets it. The trajectory is automatically corrected to take into account the size of the forklift and thus avoid collisions with shelves. If a path can not be followed by a forklift (i.e. there is not enough space), the system informs the apprentices and proposes them a new trajectory. If apprentices agree with the proposition, they acknowledge it by erasing their input and redrawing on the proposed trajectory. If they prefer another solution, they simply draw it and if it corresponds to a possible move, the system acknowledges it by erasing its proposition and giving a positive feedback on the new trace.

Grouping

Apprentices have to classify the products stored in the warehouse according to their relative sales. After doing the analysis (they can use the table to take notes during the discussion), they communicate their classification to the system by drawing circles aroung groups of shelves and writing a given symbol or letter in the circle to define its type (class A, B or C). As soon as it detects a class, the system acknowledges its understanding by giving a specific color to the area surrounded by the user input. If the input is ambiguous, it is made clear to the apprentices, who have to add new information to disambiguate their drawing.

Creating graphs

Apprentices draw graphs to query information about the evolution of storage levels. If the system detects a straight line, it draws a line perpendicular to it, which helps the apprentice to draw the second axis. After that, the system indicates that it needs variables to be defined to be able to display information by drawing small squares at the positions where it expects to detect variables. Apprentices then define the variables they want to explore by drawing either letters or pre-defined symbols at those places. If the system does not recognize a symbol, it asks the apprentices for more precise information, by either making propositions or indicating that the drawn symbol can not be understood.

CONCLUSION AND FUTURE WORK

We have described the research issues our project will address, and gave several examples of its use. We just finished the construction of the first prototype, which supports tangible input and feedback through projections on top of the table. We are currently starting preliminary observations with apprentices, and will begin to work on the specification of the compuational model of dialogue and implement it progressively, testing it on a very regular basis with apprentices.

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