Printing Virtual Reality Interfaces - The Cognitive Map Probe

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Abstract

The Cognitive Map Probe (CMP) is a novel Virtual Reality interface that attempts to assess the cognitive mapping abilities of its users. The CMP uses a tangible user interface (TUI) in order to support natural acquisition and straightforward assessment of cognitive maps. It is directed at the assessment of early Alzheimer Disease (AD) by measuring the decline in cognitive mapping abilities, a decline associated with early phases of AD. The CMP uses an adaptation of a pioneering "Machine-Readable Model", the Segal Model, which enables the user to interact with a virtual neighborhood environment by manipulating highly realistic, highly detailed, physical 3D models. All the CMP's TUI subparts were designed as realistic 3D small-scale models of physical landmarks and later printed using a 3D printer. This affords a very simple mapping between the virtual and physical elements of the CMP interface. In this short paper we briefly describe the CMP project's fundamentals and the concept of literally printing 3D VR interfaces.

1. Cognitive Mapping and early AD

Cognitive Maps can be defined as: ***an overall mental image or representation of the space and layout of a setting***. Cognitive mapping can be defined as: ***the mental structuring process leading to the creation of a cognitive map*** [2].

The most widely accepted model for cognitive mapping is the Landmark-Route-Survey (LRS) model [4,8]. The highest level of cognitive mapping ability - survey knowledge - is the ability to integrate landmark and route knowledge of an environment into a detailed geometrical representation in a fixed and relatively precise global coordinate system (e.g., the ability to draw a detailed map).

Although different manners of interaction with an environment will lead to different levels of knowledge and might result in different cognitive maps [2], both physical and virtual environments are valid means of acquiring cognitive maps as both are external to the learner [8]. Cognitive mapping using VR is an active research domain [5], with great attention given to the question of knowledge transfer, i.e. *was the cognitive map acquired in the virtual environment useful in the physical world?* Currently there is no clear-cut answer to this question [5,9]. Another open question is the level of immersion actually needed for effective cognitive mapping [11].

Cognitive maps can be probed using several techniques, e.g. verbal, bearing and distance, map-based and functional techniques [5,9]. Related to our efforts is the map placement technique in which the user is asked to point to objects' position on a grid, or to place objects' representation tangibly [3,9,11]. Very few attempts have been made to semi-automate the probing of cognitive maps. Baird et al. [3] displayed a 13x13 grid for computerized map placement. Later, direct computerized bearing input was implemented in various efforts [4,12].

Assessment of the high-levels of cognitive mapping abilities, i.e. survey knowledge, is expected to achieve high discrimination between early AD patients and healthy elderly persons [10]. Early assessment of AD is extremely important since these phases of the disease have major implications on the person's ability to perform everyday activities that were previously well within her capabilities.

2. TUIs and the Segal Model

Tangible user interfaces can be defined as: *interface devices that use physical objects as means of inputting shape, space and structure into the virtual domain*. Several research groups are active in the field (see [13]). Pioneering work in this field was performed by Frazer and his group [6,7] and by Aish [1] more than 20 years ago. Generally, good TUIs will offer the user good affordances, unification of input and output, and support for "false starts" and "dead ends" in task execution.

The Segal model was built by Frazer and his group to enable users to interact with a floor plan both tangibly and virtually [6,7]. The model is a large board with an array of edge connector slots enabling the connection of numerous objects (each carrying a unique diode-based code) while tracing their location and identification in real-time (see figure 1). Recently, the Segal model was modernized so it can connect to a PC through a standard parallel port, using a Linux driver to scan the board and a Half-life® computer-game-engine to perform the rendering [14].

3. The CMP

The CMP is designed to enable automatic assessment of early AD by attempting to probe the more advanced cognitive mapping abilities, (survey knowledge). The CMP consists of the Segal model as the input device and a large display screen for output. The CMP assessment process begins by familiarizing the subject with a new environment, resembling a typical neighborhood, by enabling exploration of a virtual representation of the environment. The CMP then queries the subject's cognitive map by asking her to reconstruct the virtual environment, or parts of it, using realistic small-scale models of the environment's landmarks as interfaces, placing them on top of the Segal model.

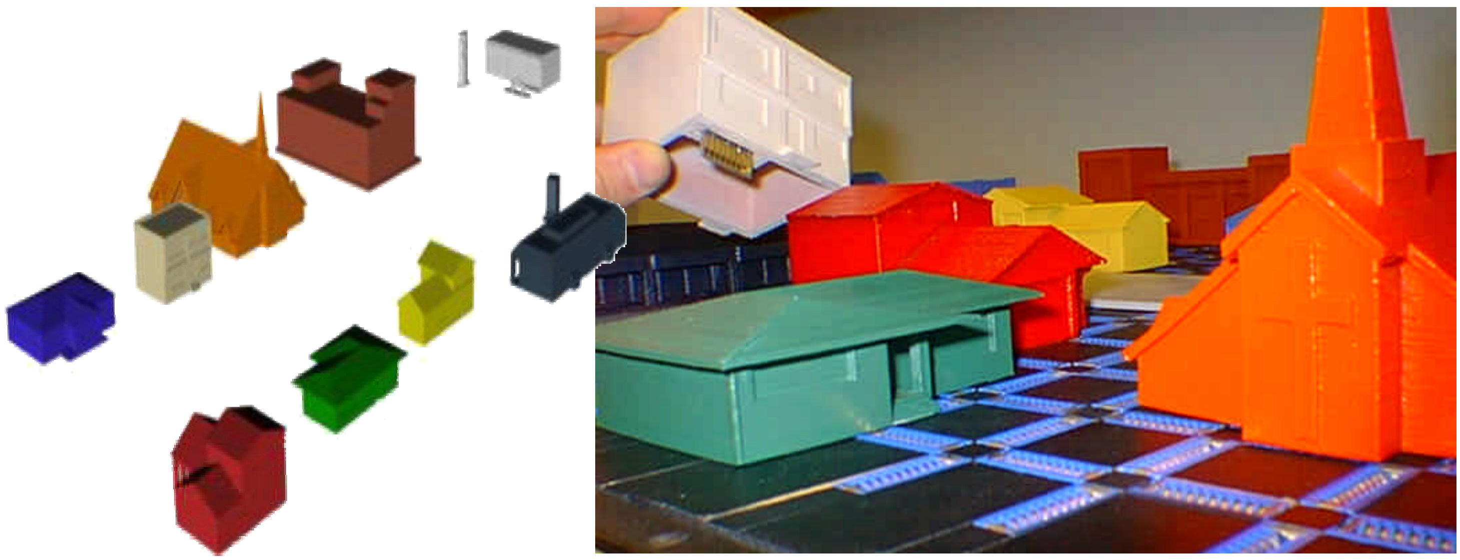

Figure 1. Virtual (left) and physical (right) overviews of the CMP

The tangible interaction is supported by a set of realistic small-scale models of unique landmarks, such as residential houses, a church, a grocery store, gasoline station and a fire department (see figure 1). All the models were designed in high detail using 3D-CAD tools and later printed at a consistent scale using a 3D printer. A unique diode ID was manually inserted to a socket printed in each model. While the user manipulates the small-scale physical models, the CMP detects each model's ID and location and renders the model's virtual counterpart accordingly.

We believe that tangible instancing of virtual objects with 3D printers, and use of those instances in VR interfaces, is a worthy topic for future research.

While the CMP hardware is mostly done, the work on the assessment software is ongoing and preliminary user evaluations are expected by mid 2001.

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