Work-in-Progress-—Improve Spatial Learning by Chunking Navigation Instructions in Mixed Reality

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Work-in-Progress—Improve Spatial Learning by Chunking Navigation Instructions in Mixed Reality

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***Abstract*—Although navigation system allows users reach destination easily, spatial learning is always necessary, especially in emergency situations. Intentional spatial learning is effective but always requires more attention. In this work-in-progress, we explore ways to improve incidental spatial learning with mixed reality-based (MR) navigation. We analyze how people structure space from volunteered geographic information (VGI) verbal navigation instructions, chunk the space accordingly and use different visual instructions among chunks in MR user interface. A user study is to be conducted to test if spatial learning is improved such design. The findings contribute to the design principles of MR-based navigation.**

***Index Terms*—spatial learning, chunking, volunteered geographic information (VGI), navigation instruction, mixed reality**

I. Introduction

Current navigation aids can guide users to the destinations conveniently. However, too much passive following navigation results in declined spatial ability, which causes severe problems in emergency situations and especially for elder people. Researchers are seeking opportunities to improve spatial learning and preserve people's spatial ability.

In this work-in-progress, we explore the possibility to improve users' spatial learning during MR-based navigation by chunking navigation instruction. We analyze how people learn space by categorizing volunteered geographic information (VGI) navigation instructions, chunk route instructions accordingly and apply different visualizations among chunks in mixed reality-based (MR) navigation. User studies are to be conducted to test if such design indeed improves spatial learning.

II. Background

A. Navigation and Spatial Learning

Negative effect of navigation systems on spatial learning has long been studied [1]. Spatial learning happens both intentionally and incidentally. Intentional spatial learning, e.g. active decision making, has proved to be effective [1], [2]. However, it interferes the navigation process, requires users to pay more attention and thus introduces more cognition workload. Incidental spatial learning takes place naturally and is the main difference between people with good and poor sense of direction [3]. Therefore, we propose to improve incidental spatial learning by well-designed visualizations. We aim to help users to learn spatial layout without interfering other tasks during navigation, such as taking phone calls and chatting with colleagues.

B. Spatial Chunking

A possible solution to improve learning is to chunk the information. Chunking is the process that people group the individual pieces of information into larger units, for example, we remember a phone number as three or four groups instead of 11 separate numbers. Chunking allows people to bypass the limit of working memory capacity. It also helps content processing and help users process, understand and remember text and multimedia content better [4]. Diverse ways are used to chunk text content or multimedia content, e.g. use bold, black headings and meaningful pictures to separate the long articles.

In navigation, chunking orientation instructions results better spatial learning than metric instruction [5]. Min and Ha [6] found that color scheme significantly contributed to landmark and route knowledge acquirement, which also implies that chunked space can be better remembered.

With highly interactive MR, many visualizations are available for navigation instruction. In this work in progress, we apply different visualizations to indicate chunks within the same route and test if chunked navigation instruction can improve spatial learning. We also explore if repeated use of chunked navigation instruction could encourage users to chunk space and navigation spontaneously.

C. VGI and Spatial Learning

Spatial layout influences how people learn the space. For example, Cock et al. [7] has found that users' preferences of type of route instruction (3D-simulation video, text or photo) varies according to decision point type and adapted system reduces wayfinding errors. We used VGI to understand how people chunk the space.

VGI is the harnessing of tools for collecting, analyzing, and sharing geographic data provided by individuals. VGI is used in this work for two reasons: a) the crowdsourced geospatial data from VGI are usually fully or at least partially accessible, thus this approach can be applied to different spaces; b) the VGI is based on random and pervasive individuals with their personal and local knowledge. The spatial knowledge contained in the VGI is the outcome of a long term perception of their daily living

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and working environment [8], which reveals people's general and natural perception of the local space.

Over the past decade, VGI in navigation has collected massive verbal route descriptions to advance navigation research [9], [10]. Verbal route instructions reflect how people describe routes in order to navigate and are proved to be an effective tool to study how humans chunk space [11].

In this work, we explore how people structure and learn space based on the crowdsourced route instructions and apply the results into chunking of navigation instructions. Our hypothesis is that similar to non-spatial chunking, the chunked navigation instruction can improve spatial learning.

III. Method

An example of the chunking is to use a different visualization to show the heading direction after each turn, i.e. different visualization in different route segment. If chunking does improve spatial learning, users shall remember more spatial knowledge when using chunked instruction than using non-chunked one.

A. VGI Analysis

To conclude the spatial chunking pattern, a linguistic analysis will be carried out to analyze three main components of route descriptions: movement descriptions, direction descriptions, and place descriptions [12]. The route instructions analysis will preliminarily study route segments in route descriptions and where the decision point is.

Further analysis is required to classify decision points which divide a route into several route segments, some potential candidate points, e.g., a turn and a transfer of the floor in the route are likely to cut the route into route segments based on preliminary verbal instruction observation.

Several spatial chunking patterns with different granularities are identified in different verbal route descriptions of the same route. The relationship between the types of decision points and granularities of spatial chunking is to be identified and applied in chunking the route in the user study. We performed statistical analysis on a route description collection of one route in S8 building of Ghent University. The instructions were collected from employees who work in the building. The initial results show an average of three times spatial chunking. The route descriptions are chunked in a hierarchical structure in which the three most important chunking points are the location where floor change is required (100% chance), the location where an orientation change is required (88.9% chance) and the location where a transition between two spatial units (66.7% chance), for example, a hall and a corridor.

B. Device and Interface Design

Microsoft HoloLens 2 is used in the user study. We use visualizations for pedestrian navigation proposed by Cron et al. [13], which includes floating cubes, arrows, tapered polyline and animated bird avatar (Fig.1), in different chunks.

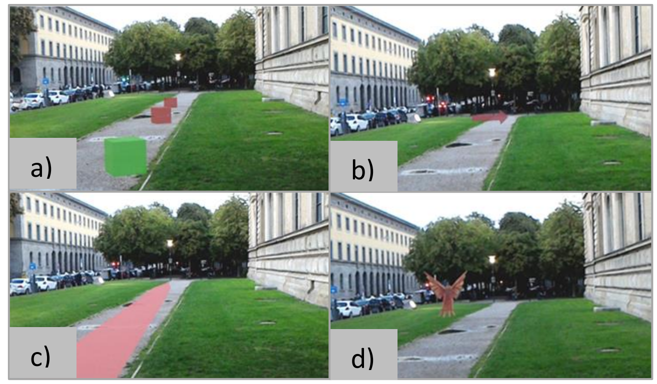

Fig. 1. Visualizations for pedestrian navigation [13] a) floating cubes, b) arrows, c) tapered polyline, d) animated bird avatar.

C. Experiement Design

We use within-subjects design in the user design. Forty users are to be recruited to assure the reliability of the study. The users are to navigate 3 routes with different levels of chunks HoloLens 2: a) no chunks, where only one visualization is used for the whole route; b) rough chunks, where the route is chunked based on a rough level of chunks; and c) detailed chunks, where the route is chunked into more chunks than in b).

The spatial learning results are to be tested with scene recognition, sketch map [14] and landmark locating tasks.

IV. Expected Results

If our hypothesis holds true, we expect the users to perform better in routes with roughly and highly chunked instructions than in route with no chunks. However, the difference between the two chunked routes are to be tested.

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