Carnegie Mellon

Human-Computer Interaction Institute

Research Abstract

- **Research Topic:**
  Windshield-based 2.5D Display - Cognitive Mapping Aid for Senior Driver's Navigation.

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Overview

This research is initiated to find the way to facilitate situation awareness in mobile context by reducing the sense of distance between the virtual space of the visualization and the real physical space, especially for people who have or get into difficulties in interacting with computing and visualization. As the task domain, we focus on driving and navigating in which many of ad-hoc decision makings are accomplished in mobile context, and most of them should be based on situation awareness that highly concerns spatial configuration of road network and current traffic conditions. Also, to evaluate our study, target population will be older drivers (+65) who feel difficulty in appreciating traffic situations in mobile context.

As our society is aging, the number of older drivers is rapidly growing; however there is consistent evidence that spatial cognition ability declines with increasing age. Particularly, older adults have more difficulty in cognitive mapping (the ability to accurately represent a spatial environment mentally) and way finding (the ability to navigate efficiently in an environment). In addition, as reported in the literature, they are slower at rotating images and almost two times slower at mental rotation than young adults. As an example, it has been found that older adults have difficulty in understanding and using "you-are-here" maps.

Above all, older drivers' quality of life is impacted as their ability to drive independently decreases. It has been reported that for older adults who cease driving, the reduced mobility has a substantial impact on the individual, their family, the community and the society in which they live. Frequency of work and business-related social trips decrease, but multipurpose trips and shopping trips increase with age. In other words, older people more often need daily trips and different kind of social activities than before; nevertheless they easily abandon these trips because of their decreased ability to drive responsively and difficulty in using technical driving and mobility aids.

In actuality, driving-related conflicts can be lessened by providing well-designed situational awareness when it promotes immediate and reliable decision making of driver in mobile context. As a typical instance, with the advent of GPS-based navigation system driver could more easily appreciate current driving situations even in motion (e.g. where they now drive over whole road network, what kind of road they will next encounter, and so on) so come to less hesitate in entering the proper road in front of intersections or complicatedly-forked roads; however at the same time the intervention of such in-vehicle information also creates extra cognitive load in matching it to 3D perspective driving view in his/her current sight again. To this extent, for our target population, not surprisingly, technology such as GPS-based in-vehicle navigation systems is still too difficult to use to be easily accepted as a convenient driving aid, despite it seeming promise to support the mobility of elders.

In our study, specifically we propose a novel in-vehicle information visualization concept on the assumption that the whole windshield (or at least a considerable portion) will be used as a large display screen in the future. Since service is requested, computer-generated 2D map image of the area where driver now navigates will be dynamically displayed as if it is sliding down over the upper part of windshield. By synchronizing it with current car movement, we can make driver feel as if it is being seamlessly transformed into real road in his/her view during driving (See Figure 1). Our goal is to decrease the cognitive load induced by frequenting both the virtual space of the visualization and the real physical space. In doing so, we hope to improve drivers' sense of comfort and their ability to engage in safe driving practices with enhanced situation awareness.

For evaluation study, we have developed a 3D driving simulator in which two test sites, Pittsburgh and Chicago, are graphically rendered based on the geospatial information in Google Map site and virtual driving is also available by using a wheel joystick and two pedals. During driving, subjects will meet a number of traffic events such as signal lights, stop signs, pedestrians crossing street to which they should

respond as in real driving situation. Most of all, it incorporates two different visualizations (See Figure 2); one is for our Augmented Reality (AR)-based display and the other is for a typical 2D bird-view map display currently employed in GPS-based navigation systems. In our display that employs adaptive visualization concept of AR technology, the reference coordinate system to sense and track will be the motion of vehicle that reflects human's motional intention rather than human motion itself. Further, information items to be contextually displayed will be designed to help older drivers have a strong sense of awareness of spatial contexts between their current driving location and the local area events occurring around them (*e.g.*, car accident, traffic congestion, *etc*) as well as the road network near their location by visually coupling both contexts seamlessly.

For now, based on the results of our prior pilot test conducted for younger drivers, we have been adjusting specific configurations for driving simulation and designing an evaluation method incorporating the measurement of divided attention caused by the displays. In the main evaluation study for older drivers, our display will be compared with a typical 2D bird's eye view map style display along the dimensions of navigation performance and driver distraction in more detail with the use of eye gaze tracker. We expect that our novel visualization will provide improved navigation ability as its heads-up display is more comfortable to use, and it creates less cognitive load in interpreting spatial relationships between real streets and computer-generated streets.

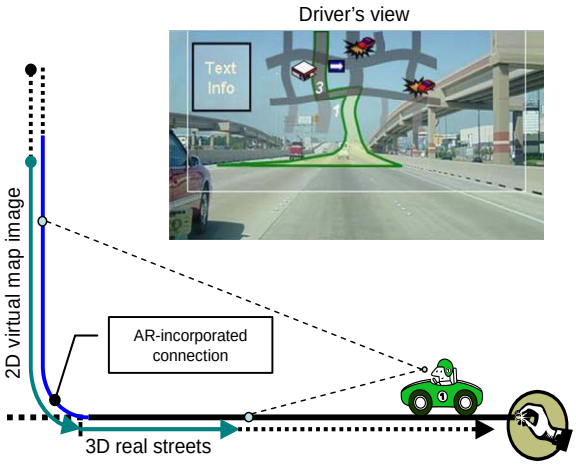

Figure 1: Concept of our in-vehicle information visualization

Figure 2: Comparison of two display conditions – 2.5D AR-based display vs. 2D map-based display