Comparing Augmented Reality and Street View Navigation

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ABSTRACT
Prior research has shown that looking away from the road on an in-vehicle display negatively affects driving performance [1]. The same problem exists with personal navigation devices (PNDs) [2]. In order to keep visual attention on the road, an augmented reality (AR) PND can be used, which uses a head-up display (HUD) and overlays the navigation route on the road. In this paper, we compare AR PND with a standard map-based PND (SPND) and an egocentric street view (SV) PND. Results indicate that AR PND facilitated better visual attention and was preferred by participants.

Categories and Subject Descriptors
H.5.2 [**Information Interf. and Presentation**]: User Interfaces.

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Augmented reality, Personal navigation, Driving simulator.

1. INTRODUCTION
Mobile devices are very commonly used in vehicles. However, the influence of these devices on driving remains largely unanswered. One notable example is the personal navigation device. Current PNDs rely on a head-down display (HDD) for presenting navigation instructions. Since looking at a HDD requires diverting visual attention away from the road which may negatively affect driving [2], we propose using AR PND to circumvent this problem. Since full windshield HUDs for presenting AR navigation are still not technologically available, we decided to do a comparison with street view (SV) PNDs such as Google Maps Navigation. We hypothesize that AR PNDs will impact driving less than both SV and SPND.

2. RELATED RESEARCH
In our previous study [2] we compared a standard PND with one that uses only voice to deliver navigation directions. The results showed that the voice-only PND promoted higher visual attention to the road ahead, which resulted in improved driving performance in comparison to SPND. However, subjects preferred the SPND. This may be due to the fact that SPND displayed a visible navigation route at all times, which provided drivers with a more holistic awareness of their global position as well as visual confirmation about still being on track after completing a turn. Since AR PNDs visually display navigation directions on HUDs, we believe that they can deliver high visual attention to the road with little impact on driving, while still providing for high user satisfaction.

3. EXPERIMENT
The experiment we conducted utilized a high-fidelity driving simulator. A total of 12 subjects participated. We chose a within-subjects factorial design experiment with type of PND as our independent variable. We used three PNDs: AR, SPND, and SV. AR PND seamlessly integrates navigation route into the real world scene by projecting it on the windshield using a HUD. SPND uses a map with the navigation route displayed on a HDD. SV PND also uses a HDD, which displays a sequence of images of the world taken at a prior time from the driver's perspective with the embedded navigation route. All three PNDs also utilized identical turn-by-turn voice directions. Each subject drove through a simulated city environment using each PND. In order to avoid learning effects and order bias, we counterbalanced the presentation order of the PNDs between subjects. Although we measured other dependent variables as well, in this report we focus only on visual attention and subjective assessment. Visual attention was assessed through the average percent dwell time (PDT) on the road ahead, while the subjective assessment was based on ranking the agreement with preferential statements.

4. RESULTS
Using a repeated measures ANOVA, we discovered a significant main effect of the PND on PDT ($F_{2,12}$=81.351, $p < 0.0001$). As expected, PDT for AR was the highest 96.1%, while for SPND and SV it was 89.1% and 87.2%, respectively. A post-hoc comparison revealed significant differences for AR vs. SPND and AR vs. SV ($p<0.001$ in both cases). After concluding the study, participants ranked their agreement on a 5-point Likert scale with three statements of the form: "My driving performance was best when using *X* PND," where *X* identified one of the three PNDs. Using a Friedman non-parametric test, we found a significant main effect of PND on the agreement with the above statement ($p=0.027$). Specifically, participants ranked AR very highly (75% agreed), while SPND and SV had equally detrimental perceived influence on driving (58.3% disagreed).

5. CONCLUSION
The above results for visual attention and subjective assessment suggest that AR should be the PND of choice in vehicles. This indicates that our assessment of AR being able to provide smaller impact on driving and high user satisfaction may be supported.

6. REFERENCES
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