Head-mounted Augmented Reality Visualisation for Outdoor Pedestrian Navigation

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Abstract. Head-mounted augmented reality (AR) displays offer a great potential for pedestrian navigation that has not been fully explored so far. Here, we introduce the design of four visualisations for pedestrian navigation in outdoor settings. The first visualisation consists of cubes floating above ground and placed along the route ahead of the user. The second visualisation shows floating arrows that are positioned at turning points of the route. The third visualisation indicates the geometry with a flat line placed slightly above ground. The fourth visualisation is an animated bird avatar that is flying in front of the user. We describe the design of the four visualisations and document the implementation using the Unity game engine software and the Microsoft HoloLens hardware.

Keywords. Augmented reality, pedestrian navigation, Microsoft HoloLens

1. Introduction

Augmented reality (AR) has become a mainstream technology for pedestrian navigation with the recent introduction of Google Maps AR for smartphones (Google 2018). Our research investigates the next level of pedestrian outdoor navigation by designing visualisations for head-mounted AR displays such as the Microsoft HoloLens. These head-mounted AR devices augment the physical environment by displaying virtual objects on a screen in front of the user's eyes.

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So far, head-mounted AR displays have only been used for experimental outdoor navigation of pedestrians. Examples include the seminal “touring machine” by Feiner *et al.* (2012), the development of a campus navigation system for the Google Glass AR headset (Ang *et al.* 2018) or navigation with the Microsoft HoloLens in difficult terrain (Anandapadmanaban *et al.* 2018).

Most AR applications for pedestrian navigation are designed for mobile phones and other handheld devices. Visualisations for handheld AR devices proposed so far either consist of polyline geometry placed at ground level (for example, Huang *et al.* 2012) or virtual arrows (for example, Wenig *et al.* 2012, Rehman and Cao 2017, Google 2018). We are not aware of any work that uses more advanced geometry for outdoor pedestrian AR navigation.

2. AR Visualisations for Pedestrian Navigation

We investigated the design space of AR route visualisations by prototyping a variety of exploratory ideas. Prototypes included, for example, a virtual frog jumping along the route in front of the user, and an oversized human avatar positioned at turning points to indicate changes of direction with rhythmic arm movements.

Figure 1 shows the basic geometric elements of the four selected visualisations that we implemented in the Microsoft HoloLens: floating cubes, arrows placed at turning points, a tapered polyline placed along the route, and an animated bird avatar.

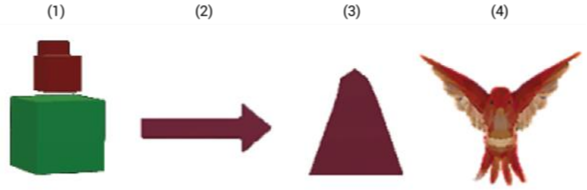

Figure 1. Geometric elements of the four route visualisations: (1) floating cubes, (2) arrows placed at turning points, (3) tapered polyline, and (4) animated bird avatar.

2.1. Floating cubes

Figure 2 shows the visualisation with floating cubes placed along the route. Three cubes float 1 metre above the ground, which reduces the likelihood for the cubes to intersect with the physical ground. To indicate the direction of movement, the floating cube closest to the viewer is coloured green and the following two cubes are red. If the distance between the user and the closest cube is less than 5 metres, the cube is hidden, a new cube is added beyond the last cube, and the colours of the three cubes are updated.

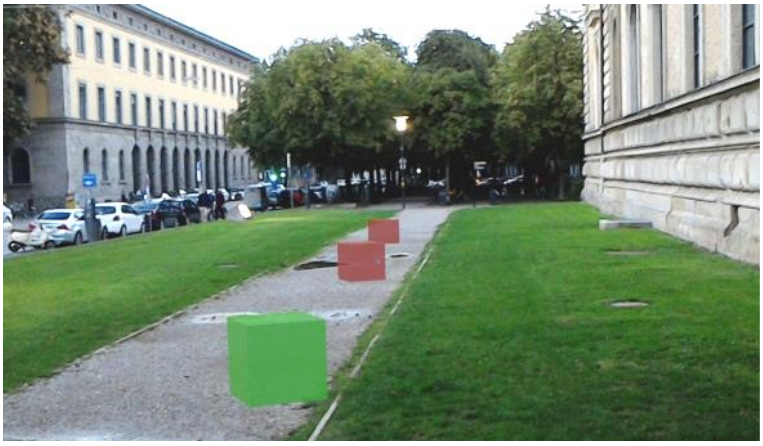

Figure 2. Floating cubes placed along the route.

2.2. Arrows placed at turning points

In this visualisation three-dimensional arrows are placed at turning points. The arrows float in the air and point in the direction of the route (Figure 3). Up to three arrows are shown, but the second and third arrows may be hidden when buildings block them. If an arrow is less than 5 metres from the user, the closest arrow disappears, and a new arrow is added at a distance.

Figure 3. Arrow placed at a turning point.

2.3. Tapered polyline

In this visualisation a flat, two-dimensional polyline is placed slightly above the ground along the route (Figure 4). The line width is tapered, pointing in a forward direction. The line geometry is periodically adjusted to the user location. The line is drawn between the route point that is closest to the current user location and the subsequent three waypoints. The line geometry is updated every few seconds.

Figure 4. Tapered polyline placed slightly above ground.

2.4 Animated bird avatar

In this visualisation an animated bird avatar either flies along the route or hovers and flaps its wings in front of the user (Figure 5). A flying bird instead of an avatar moving at ground level was chosen to avoid intersections and occlusion issues of the avatar with the physical environment. The bird avatar has a moving state and an idle state. In the moving state, the bird flies in forward direction along the route. When the distance between the avatar and the user is greater than 5 metres, the bird switches to idle state, turns to the user, and hovers (with flapping wings) over its current location to wait for the user.

Figure 5. Bird avatar.

3. Implementation

A custom application running on the Microsoft HoloLens was built for creating the four visualisations. We used the Unity game engine, which provides the required methods for constructing a 3D scene (unity3d.com).

To supply GNSS position and compass orientation data to the HoloLens, an app running on an Android smartphone was developed. It captures the latitude–longitude position and compass orientation using standard smartphone sensors, and periodically broadcasts this information via Bluetooth.

A custom Bluetooth receiver module was built into the Unity game engine application. It uses the broadcast position and orientation information to align the user and the visualisations in a common coordinate reference system.

The Unity collider mechanism detects and reacts on nearness events, which are triggered when the user's position "collides" with invisible objects that are placed in the virtual scene. This was necessary for hiding and creating cubes and arrows and for switching the bird avatar between idle and moving states. Using invisible spherical colliders with a diameter of 5 metres meant the user triggered functionality when within 5 metres.

4. Conclusion

We will conduct a user study to evaluate the four presented visualisations using the Microsoft HoloLens AR headset. The task will consist in following a route indicated by the four visualisations in an outdoor setting. We plan to collect user feedback on preference, trustworthiness, confidence, as well as visibility of the four visualisations in a real-world setting.

We believe there is a great potential for designing engaging new AR experiences for pedestrian navigation, and hope that the proposed four visualisations will inspire others to further explore this design space.

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