Embedded Virtual Views for Augmented Reality Navigation

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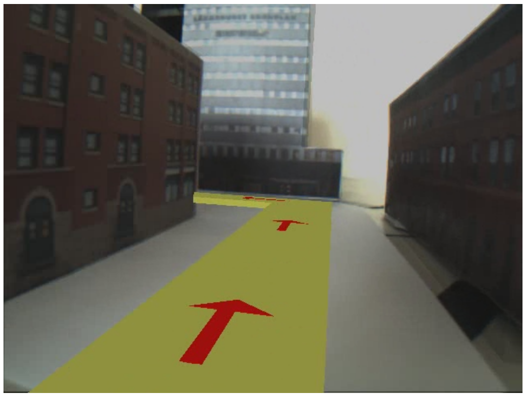
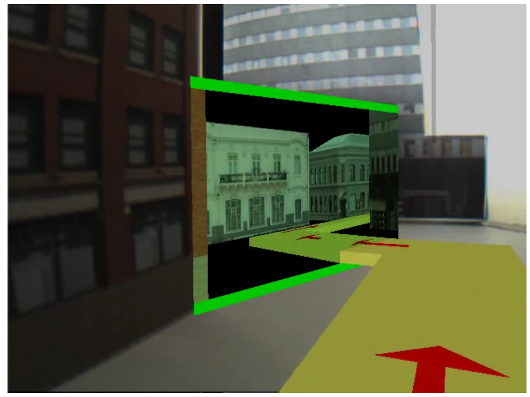


(a)



(b)

Figure 1: *An embedded virtual view allows users to follow a guided route, without leaving the egocentric viewpoint. (a) The navigation aid turns around the corner and the user's view is blocked by the building. (b) By extending the egocentric viewpoint with an additional embedded virtual view, the user is still able to perceive the route indicated by the navigation aid. Note that the additional view embeds the navigation aid correctly in the environment.*

Abstract

In this paper, we present virtual embedded views used for turn-based pedestrian navigation in Augmented Reality (AR). Embedded views allow users to see around occluding structures and at the same time seamlessly integrate the augmented navigation aid into the otherwise occluded view. Users get a preview on upcoming route changes, without the need to consult an additional map view. We compare embedded views to other methods revealing the occluded navigation aids. We demonstrate that the technique is more screen-space efficient when compared to a typical x-ray vision technique, and may better facilitate the mental linking of information, when compared to a mirror.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities;

1 Introduction

A common application of Augmented Reality (AR) is to support users in navigation tasks by overlaying navigation aids on the real world. Compared to a traditional map view, the user does not need to mentally switch anymore between an exocentric map view and a personal view of the real world, because the desired route is indicated directly in the user's current video-based view. Additionally, this approach provides more context and is easier to use than GPS navigation systems, since the real view of the world is presented to the user instead of a virtually simplistic representation used in GPS systems. More recently we have seen this approach adopted in commercial AR applications such as Wikitude Drive[1] or Route66 Follow Me[2] .

1.1 Limitations

Even though the presentation of navigation aids is improved when overlaying them on the current view of the user, the inherent ***egocentric viewpoint*** of mobile AR enforces a strong limitation on the field of view of the user and the range of viewpoint locations. The user has limited range of information due to the limited content that can be presented in the AR egocentric viewpoint. Compared to a map overview, users can only see route changes up to the next visible turn, because ***occlusions*** block the view on the navigation aids. Combining the AR navigation aid with a map overview, shown on a part of the screen, allows users to investigate the route lying further ahead, but at the cost of occupying some of the already limited ***screen-space*** of mobile devices. Furthermore, adding the map as a second spatial representation of the world reintroduces the cognitive effort of switching between different views.

1.2 Approach

In this paper, we present embedded virtual views, which provide additional, spatially registered and virtual views on upcoming changes

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[1]http://www.wikitude.com/en/drive
[2]http://www.66.com/route66

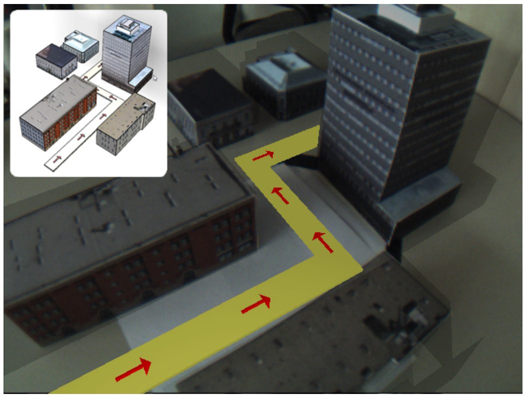


Figure 2: *The test bed used for testing the different embedded views. The models are made from paper. The small image shows the corresponding virtual geometry.*

of the route. As presented in Figure 1b, the embedded view naturally extends the ***egocentric viewpoint*** of the user and shows the otherwise ***occluded navigation aid*** in the real world context (Figure 1a). The technique is intended to support pedestrians using their mobile handheld device for navigation.

Typically users are ***navigating turn-based*** and do not walk with the device always extended in front of them. They orient themselves at key locations like crossings using the provided navigation aid, and then the walk to the next key location. We believe that the presented technique can reduce the time required for orientation and make users more confident during navigation, because the look-ahead view allows them to see more than only the next route change and also provides visual context for the navigation aid.

The example images provided in this paper were created in a table-top, real world test bed consisting of paper models and their virtual counterparts. A virtual navigation aid shows a path through the model (see 2). The images were recorded from a handheld camera moving through the scene.

2 RELATED WORK

In the following, we present a selection of related work on navigation, and multi-perspective presentation methods, which were already investigated in AR.

2.1 Navigation in AR

AR Navigation has been explored in earlier work such as the Touring Machine [7] demonstrating collaborative AR navigation around a campus using a wearable AR system. More recently, Tönnis et al. [12] explored and studied different visualization techniques for AR heads-up displays used in car navigation. SignPost [14] was one of the first works to introduce arrows as navigation aids, and an overview map for indoor navigation on a mobile setup. Other techniques, such as temporally switching between two views was introduced in mobile system by Mulloni et al. [1]. It allows users to seamlessly zoom to an exocentric map view or an extended egocentric view presented as a 360 degrees panorama.

2.2 Multi-perspective Rendering

There exists a large body on the creation of multi-view visualizations for virtual environments [5, 6, 15, 10, 16], which integrates multiple points of view into the same image. Vallance et al. [13] presented an interesting idea for improving the navigation in the egocentric viewpoint. They bent the world upwards in front of the user. Lorenz et al. [9] created a real-time implementation of this method for VR applications. Recently, Kim et al. [8] evaluated a virtual car navigation system using the same method. Instead of providing a common GPS map to the users, the streets were bent upwards in front of the user.

Only few related work projects deal with multi-perspective presentations in AR. Bichlmeier et al. [3] used a mirror for revealing parts of an object, which do not face the user. The approach was demonstrated for small objects, and was not applied to large environments. However, very recently Au et al. [2] showed how mirrored views from live video can be used for orienting in city environments. We compare the presented embedded virtual views to such an approach. Sandor et al. [11] expanded the egocentric view of the user by deforming the real world around the user to reveal occluded buildings, and to increase the current field of view of the user. Instead of deforming 3d geometry, we bend the viewing rays of the camera to create multi-perspective renderings. The panoramic view presented by Mulloni et al. [1] also extends the current field of view of the user. However, their approach does not handle occlusions.

3 EMBEDDED VIRTUAL VIEWS

An embedded virtual view is used to reveal an AR navigation aid, which is occluded by real world structures such as buildings in urban environments, lines of houses in residential area or hills in rural areas. For this purpose, the view is spatially registered with the world and placed at the location where the navigation aid disappears and shows a view around the occluding object. The navigation aid naturally passes into this view and provides the user with a view on otherwise occluded upcoming route changes (see Figure 1b).

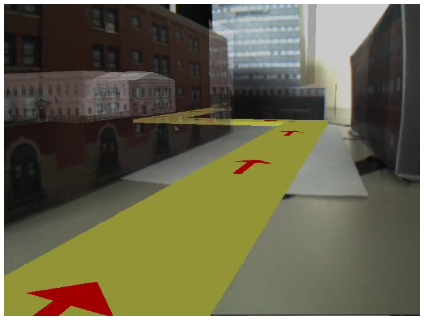
An embedded virtual view should ultimately seamlessly integrate with the surrounding environment. The integration is already indicated in the example image, where the left and right borders are left open so that the content of the embedded view merges with the respective scene elements, such as the red building on the left. In Figure 1b, the embedded view is projected onto a rectangular portal surface. However, bent portals such as shown in Figure 4 are also possible, which increase the field of view of the embedded image and thus reveal more of the occluded scene.

3.1 Additional Virtual Views

Aside from the described embedded views, our system also supports two simple mirror techniques, which we implemented for comparison. The first one places a ***mirror*** at the location, where the navigation aid is occluded. The approach is similar to common traffic mirrors, which allow car drivers to see otherwise invisible parts of the street (see Figure 3b). We decided to increase the size of the mirror compared to a traffic mirror, so that users can already recognize structures from afar. The image shown in the mirror is view dependent, and thus changes with the location of the user. To always show the same view around the corner we created a variation of the real mirror, which always provides the same view around the corner. Hence, in this ***fake mirror*** the view stays static, even if the user changes location. The fake mirror is similar to the video mirror presented by Au et al [2].

3.2 Comparison of Virtual Views

In the following we compare an embedded view with the fake mirror view and with ghosting, which is a traditional occlusion management technique. Aside from the view-dependency, real mirrors have the same properties as fake mirrors and therefore are not part of the comparison. Consider Figure 1a, where an artificial navigation aid indicates a path for the user. The path turns around the corner and is occluded by a building. Using x-ray vision techniques (see Figure 3a), the occluder is removed and the route is revealed. To enhance the integration of the navigation aid in the environment, additional buildings along the path are also shown. This approach removes a large portion of the occluding building and requires half of the screen-space.



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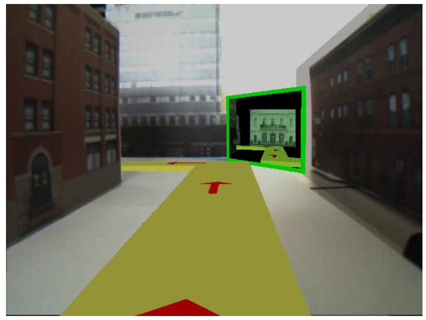

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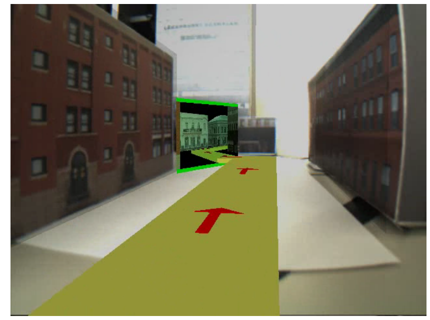

(c)

Figure 3: *Comparison of egocentric occlusion management techniques for revealing a navigation aid. (a) A standard x-ray visualization making the occluding building transparent. The route augmentation and the context it is embedded into are revealed at the cost of screen-space. (b) A mirror also reveals route and context, and saves screen-space. However, mentally linking the mirror image and the world may be hard. (c) An integrated image reveals the occluded information and its context, and also uses less screen-space than the ghosting technique. Compared to the mirror the mental linking between the view and the real world may be easier.*

An artificial mirror (Figure 3b) uses less screen-space and allows the user to see around the occluder, but users may not be able to mentally link the revealed content and the occluded data, because the view is separated from the scene. Furthermore, the mirror image is view dependent and changes with the position of the user. Exchanging the mirror against the fake mirror technique would remove the view-dependence, but still requires effort to mentally link the content with the real world. Using an embedded virtual view the user can look around the occluding building (Figure 3c). Like the mirrors, the view resolves the occlusion and at the same time saves screen-space. The integrated image is smaller than the structures revealed with the ghosting technique, while still showing the navigation aid and buildings along the path. However, we believe that the mental linking of the shown content with the real world is easier than with virtual mirrors.

3.3 Implementation

We use CUDA ray tracing to create the virtual views in real-time. Ray tracing allowed us to quickly prototype and test the different approaches. The virtual mirrors were created by simple reflecting the rays at the mirror surfaces. The embedded view is achieved by bending the viewing rays of the camera at a portal placed at the corner of the building, similar to the technique presented in Cui et al. [4].

Rays are emitted from the camera center located at the location of the user. When they intersect the portal geometry, they are redirected using the surface normal at the intersection, and re-emitted through the portal into the virtual representation of the world.

4 Discussion

The approach currently requires spatial knowledge data provided by a virtual model of the occluded scene. Although Google Earth[3] and Bing Maps[4] contain collections of 3d models of certain urban areas, in general such dense 3d models are not yet available. Therefore, we want to explore other input sources such as geo-located photos which can be drawn from online photo collections.

Furthermore, our current technique does not provide an efficient visual registration between video camera and virtual content. Hence, the embedded views do not merge seamlessly merge with the scene. We want to investigate how we can provide seamless visual registration between the video image and the virtual content using more advanced rendering techniques and image analysis algorithms. The integration of the image is already indicated in Figures 1b, 3c and 4. Note that the embedded view shows part of the red building in the left region.

Currently, we place the embedded views manually. However, the placement of the embedded views can be automatized by analyzing the route indicated by the navigation aid, and the real world scene to detect upcoming occlusions. The embedded views are then placed at locations where the route is occluded. Another improvement s providing a seamless transition from the current view to one with an additional embedded view. The transition should be animated, so that users can follow the transformation.

We are also aiming to conduct a comparative user study evaluating the different virtual views presented in the paper, such as mirrors and embedded views. The study should assess the effects of image deformation on the perceptual and spatial understanding of a scene. Aside from using embedded views for turn-based navigation, they can be used as starting point for engaging into route exploration. Then, the views are interfaces for switching into an offline exploration mode using data drawn from Google Streetview[5]

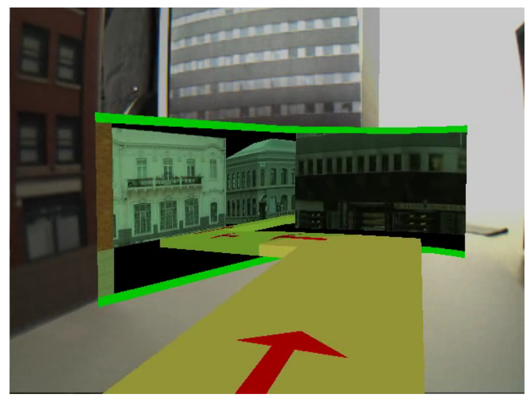

Figure 4: *The embedded view is not limited to rectangular surfaces. This view uses a bent shape to provide an increased field of view on the occluded regions.*

[3]http://www.google.de/intl/de/earth/index.html

[4]http://www.bing.com/maps/

[5]http://maps.google.ch/intl/de/help/maps/streetview/

or Bing Streetside[6].

5 Conclusion

In this paper, we presented a prototype system for creating embedded views for navigation, which allow users to look around occluding structures by locally bending the viewing rays of the camera. We showed how a navigation aid can be integrated into such an embedded view so that users get a peak on upcoming changes of the route. We demonstrated how the method can save screen-space, when compared to x-ray vision techniques and may enhance the mental linking of the depicted content and the actually occluded content, when compared to virtual mirrors. We also outlines future work, such as improving the integration, creating a transition between current view and the embedded view and substituting the virtual view for real world imagery. Furthermore, the integrated images can be used as an interface for further exploring the real world in an offline mode using other data sources.

Acknowledgements

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