International Journal of Advances in Computer Science & Its Applications – IJCSIA
Volume 4: Issue 3 *[ISSN 2250-3765]*
Publication Date : 30 September,2014

AR navigation paradigm

(*non-gps prototype for Indian sub-continent)

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***Abstract*— Augmented reality is a promising field to aid the real entities of world for better and ease for understanding the natural existing phenomenon. Though AR equipment's still remains a concern due to their size and portability. To support this perception of digital information and to naturally interact with the pervasive computing landscape, the efforts for accomplishing AR in user interaction has been focused considerably in various economic and research organization .In this paper we try to implement the paradigm over a car front glasses to support AR visualization.**

***Index Terms*— Augmented reality, Navigation systems, Visualization paradigm, User interaction.**

I. Introduction

The AR paradigm opens innovative interaction facilities to users: human natural familiarity with the physical environment and physical objects defines the basic principles for exchanging data between the virtual and the real world, thus allowing gestures, body language, movement, gaze and physical awareness to trigger events in the AR space.

Hence, there are two major concepts that characterize AR systems:

(1) The clear and intuitive depiction and perception of information and

(2) The natural interaction interface for users. Both concepts are supposed to facilitate computer-supported tasks where humans are not confronted with abstract visualizations and synthetic manipulation procedures.

Although beyond doubt this goal is creditable and many research systems demonstrate the applicability of the concepts, hardly any AR application has matured beyond a lab-based prototype.

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II. A new paradigm system

The idea of perceiving graphical information via the windshield (One developed by Mercedes Benz) is not new. With the technology for color head-up displays emerging, car manufacturers are embracing the idea to display speed, fuel level and even fragments of conventional navigation information on the front shield.

III. Ease of Use

However, the potential of the windshield as a see-through instrument for AR applications is much higher. For example, considering the driver's perspective, navigation information could be presented by virtually painting the designated route in a translucent color.

A prototype for Indian vehicles

IV. The concept

The underlying concept is simple and should immediately be understandable by anybody. Conventional navigation systems always present abstractions of navigation data. They either show a flat arrow indicating a turn or pointing in the desired direction, or they present an overcrowded bird's eye view showing a geographical map and the driver's current position and orientation on it. Regardless of which method is used, the information presented is not clear and demands the ability to abstract. By virtually painting the road in a semi-transparent color, the new paradigm eliminates the ambiguity that might arise, e.g., when conventional navigation systems require the driver to turn left with two junction's back-to-back.

Junctions that are hidden from the driver in the real world (e.g., because other vehicles or rises in the landscape restrict the driver's view) can be made visible via AR. Conventional navigation systems require users to count exits, which is tricky and may again be ambiguous when the driver is not sure whether to additionally count a small auxiliary exit. AR navigation systems relieve the driver from this burden and clearly color the designated exit.

Finally, since the driver is no longer impeded by a constrained view of the current traffic and driving situation while diverting his eyes from the street and looking at the navigation display of conventional navigation systems, she or he always surveys the road ahead and is capable of recognizing hazards without any delay.

In the context of this paper, this paradigm is considered to be a self-explanatory and easy to understand visualization method. Furthermore, it is a working example of an AR application where users need not carry bothersome equipment, maintain their unrestricted freedom and interact naturally with the system by simply following the colored route.

A. Conceptual design

B. Framework

The AR navigation system is built upon a core framework where state-of-the-art Edge matching (primarily image-detection algorithms) are used for keeping track of the car. Image recognition algorithms for tracking are included in the framework, which requires calculating power and enables applications to be executed on devices with suitable CPU power (laptop, smart-phone etc.).*Beneficial for Indian subcontinent cause not every city in India is so enriched in GPS technology with significant speed for GPS data updates*.

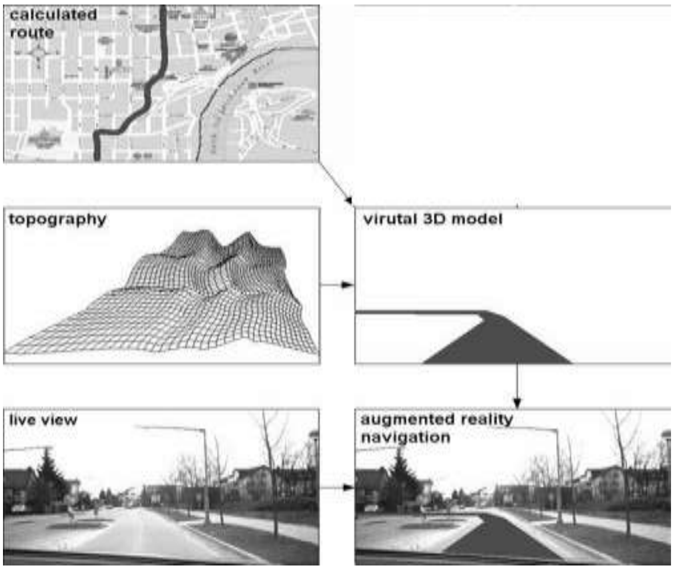
Like many other modern AR architectures, the framework also enables software developers to easily construct virtual geometric models of the digital annotations, and to rotate, shift and translate them relative to the observer's eye position.

Finally, for drawing the AR scene on any display, the framework provides state-of-the-art rendering techniques, encapsulating the underlying operating systems and standard graphics rendering techniques.

C. Computation procedure

Technologies, e.g., in underground garages, the frame-work is also prepared for indoor tracking systems and other wireless positioning approaches. Static model data (i.e., 2D and 3D maps typically stored on a compact disc), dynamic model data (i.e., ongoing road construction and accidents) and the route-planning algorithm enable the system to compute the virtual 3D road image.

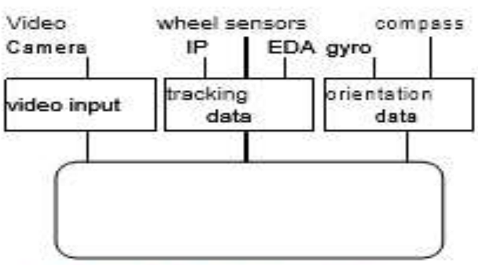
Unfortunately, current head-up displays for cars are not yet able to cover the full area of the windshield, which would be required in order to support the pro-posed paradigm. Instead, the annotation of the route is superimposed on a live-stream video (coming from a camera behind the rear-view mirror) showing the road.



. Calculation of AR path

V. SYSTEM ARCHITECTURE

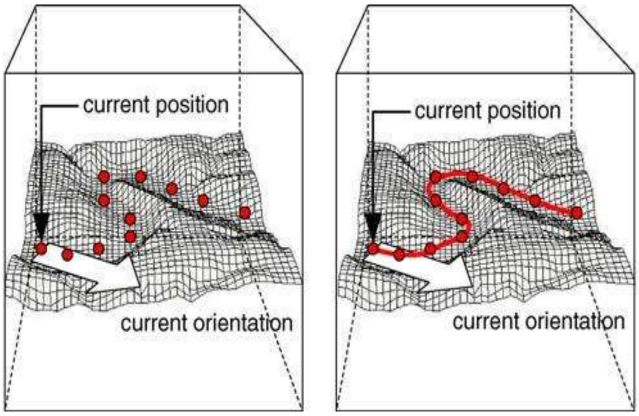
The framework architecture provides a variety of input interfaces for receiving the required data from the navigation system. Most car navigation systems are equipped with a GPS receiver for locating the current position of the car. Additionally, they keep track of the car using wheel sensors (e.g., within city areas or tunnels), and they utilize alternative orientation trackers (compasses, gyros, etc.) for improving the orientation information. But we here are trying to accomplish it through image-processing techniques which basically work over edge detection and matching. Matching is done with inscribed data-base regarding the place of interest (our model city).



Augmented reality video output

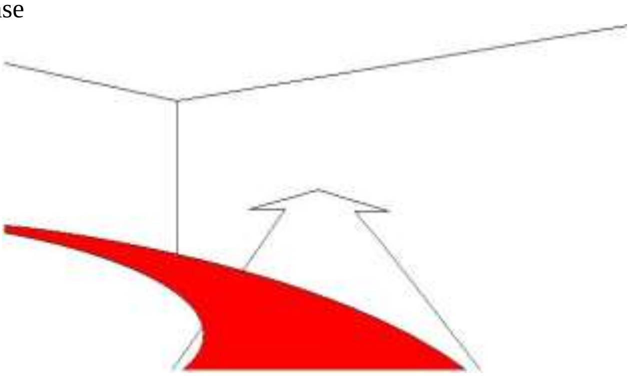
Once the current position and orientation are known, the system is ready to calculate the virtual path representing the designated route. The route from the navigation system is provided by sequence of geographical points in the 3D space (see left part). A distinction is drawn between shape points tagging the route in front of the car and maneuver points indicating upcoming navigation maneuvers.

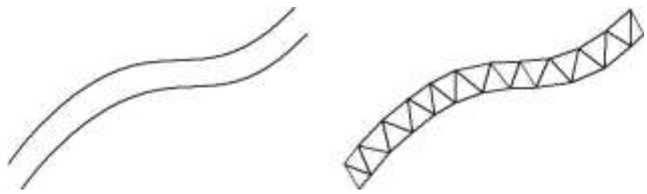
The concatenation of these points (e.g., through a cubic spline or by nurbs) results in the desired virtual path (see right part of figure). Accordingly, the static topography information for calculating a virtual 3D route (as depicted in Fig) is not retrieved directly from the 3D maps of the navigation computer, but comes indirectly through the shape and maneuver points



The system calculates a virtual 3D model of the spline relative to a fictive origin within a virtual space. Corresponding graphical matrix transformations rotate, shift and zoom this 3D model relative to the current position and orientation of the car (and respectively several other parameters such as the current speed, wheel sensor data, etc.), so that the spline finally resembles a colored part of the street viewed from the driver's perspective.

The calculation procedure is fast. All the shape points of a route are transmitted to the framework just once—as soon as the navigation computer has calculated them, implicating a singular spline or nurbs calculation during an initialization phase



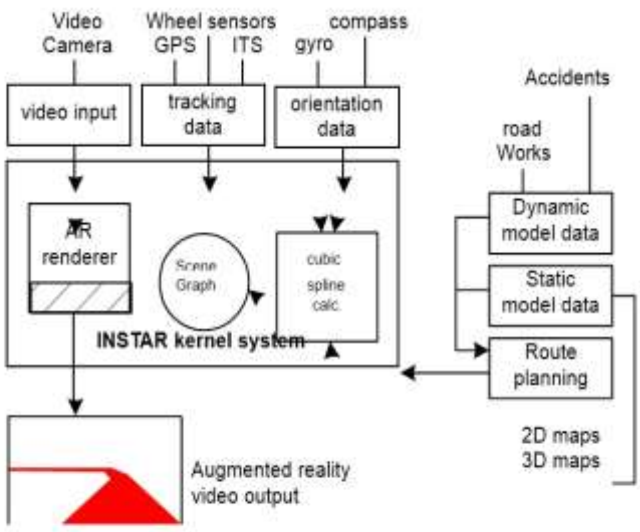


The path is a tri strip

The 3D transformation of the path has to be done continuously within a selected time cycle as the observer position changes permanently. However, the complexity of the geometric objects to be transformed is low. The path consists of a sequence of triangles (a so called tri-strip) which is characterized by only a few current orientation points that can be transformed quickly by the algorithms of the graphic renderers. Besides, not the whole path is considered but only a short, predefined length of it beginning at the current position.

A. *Generic rendering*

The AR navigation framework stores the calculated 3D path in an appropriate data structure, a scene graph, which is used by many popular 3D renderers. The scene graph is detached from any graphical library or operating system needed to illustrate the routing information.



VI. RESULTS

All the navigation data coming from a commercially available car navigation system were recorded synchronously together with a video stream from a digital camera mounted inside a test car. These data repetitively served as the simulation input for the initial AR navigation system running on a personal computer. At the back end, OpenGL is to be used to combine the computed 3D route and the video stream to an AR navigation view.

Figure shows an OpenGL window in front of the simulation environment with a semi-transparent yellow path guiding the way. The various colors of the path borders serve different purposes, e.g., red indicates a left turn and green indicates a right turn. The shape points representing the path already traveled are easy to recognize in the lower window.

A. *AR car navigation system (what other did)*

Initially, the system was still executed on a laptop computer connected to the built-in Siemens VDO navigation system via a serial port. A digital fire wire camera mounted behind the rear-view mirror provided the live stream of the scene in front of the car. Thus, the new visualization concept could be experienced in a real testing environment.

Although the prototypical implementation was restricted to use the navigation display for the augmentation instead of the windshield—the results are still valuable. The developed AR car navigation system is successful in providing to users natural interaction. Safety issues are also addressed: the driver is always aware of the road ahead, even while looking at the navigation display, because the live-stream video simultaneously shows the current driving situation in real time.

AR system running on a PDA AR car navigation proto

Mobile phone as AR display moved onto a handheld using "Pocket GL" as a graphic renderer. In the same way as in the laptop version, the handheld was directly connected to the car navigation computer and additionally plugged into a video jacket in order to receive the video signals from the camera. This step simultaneously proved the exchangeability aspect of the navigation displays.

Pedestrian navigation systems differ from car navigation systems in one important aspect: whereas the camera in the car constantly captures the scene ahead, the mobile device can arbitrarily be moved in any direction. This demands the supplementary use of an orientation tracker, not only indicating the user's alignment to the compass, but also the device's orientation in the 3D space.

B. Experiences

AR system on a smart phone

Due to the restriction that the AR navigation system has been undisclosed during the development phase, and because it is now available only in one test car and on one test cell phone, no empirical research could be done so far to formally evaluate the acceptance of the new human/machine interaction method. However, the developer crew has acknowledged the intuitive and easily understandable presentation of the navigation information in several test runs in the test field.

One of the next tasks will be to systematically study the acceptance of this concept by end users, in order to confirm the objectives and advantages of the new visualization paradigm outside the developer team, and to potentially improve the developed system. As an example, we argue that the driver is always aware of the current driving situation. Strictly speaking, the AR view has a different level of detail for the driver, and thus can create various problems, e.g., the augmentation might distract the driver from paying attention to the real scene outside the car.

Another example concerns the degree to which pedestrians would like to have their normal view superimposed by AR or would they find it intrusive and disturbing. Maybe the average user would prefer to remember a short route on an abstract 2D map instead of constantly holding a cell phone to see the augmented route ahead.

Nevertheless, the authors regard the AR navigation paradigm as a potentially very powerful contribution to improving user interaction, but also refer to unexplored problems like the two examples above, which can only be investigated by systematic usability evaluations, where not only user acceptance but also security and liability aspects in case of an accident have to be considered.

VII. The Future

The prototypical implementations have shown the feasibility of the concepts presented in the introductory sections of this paper, and their practical transformation is imminent.

For future applications, design studies are being carried out on the augmentation of digital information. One promising modification could arise by considering that the easiest way to find a destination is to follow somebody who knows the way. This idea leads to an alternative augmentation variant showing a virtual car in front of one's own car, blinking, braking and accelerating, making the navigation aspect in cars as natural as possible.

As soon as the technology of head-up displays enables the coverage of larger parts of the windshield, the augmentation of the route will be directly displayed on the front shield (e.g., by pressing a button on the steering wheel). This would signify a major step toward fully implementing the proposed paradigm.

Beyond that, pervasive and ubiquitous computing techniques might extend the features of AR navigation systems, e.g., by adding context-sensitive services.

In coordination with external sensors or smart devices, these services can call attention to points of interest along the route. Figure depicts this idea: the system considers the fuel gauge of a car and, when necessary, displays the location of the nearest gas station along the route and maybe further information, e.g., the price, if available, within a pervasive computing environment.

VIII. Related Work

Work at the University of Nottingham focuses on human factors design issues in general and also on human factors of in-car technology. The researchers present established work as well as innovative and creative design issues concerning the perception of navigation information. However, they do not consider AR as an alternative visual presentation of information. The research community for AR proposes ideas for easily comprehensible, innovative AR user interfaces for location-based services. As an example, the Mobile

Augmented Reality System project presents an approach where AR is used for path finding and orientation. Equipped with a huge backpack including a GPS receiver for position determination and a head-mounted display, users are guided within a delimited area by textual location-based instructions and a graphical route displayed as a pipe system. However, this system narrows the user's freedom of movement significantly; in the perspective adopted in this paper, a head-mounted display is not considered to be a natural interaction instrument.

The Studiers tube Augmented Reality project also considers similar navigation information by using an AR pipe system to indicate a route, but again, unwieldy equipment discourages practical use.

The University of Graz in Austria presents a hybrid positioning technique for an AR outdoor tracking system using wearable apparatus. However, the methods for locating and identifying points and objects in the real world by coordinating dissimilar positioning techniques represents the main focus of their research, with less attention to the AR view.

One application related very closely to the one presented in this paper was developed by the United States Coast Guard. Their prototype Virtual Aids to Navigation (vATON) provides mariners with navigation information and virtual representations via see-through AR eyewear. vATON allows lane marking, ship identification and virtual placement of markers and map symbols that would be difficult or impossible to maintain in any cost effective manner. Unfortunately, no publications are available to provide deeper insight into their approach.

Several other research projects in this area deal with human interaction factors, AR views and the growing range of divergent positioning techniques. Nevertheless, none of the approaches developed so far enhances the navigation information by simply coloring the route to the destination, and thereby decreasing the level of abstraction at the user interface to a minimum, and consequently making navigation intuitive and natural.

IX. Conclusion

Augmented reality applications provide fascinating views onto annotated worlds, enabling its users to easily grasp computer-generated digital information. As this information is primarily presented via virtual geometric objects seamlessly placed in the real world, likewise the offered interaction possibilities appear to be exciting, where users can trigger actions by simply pointing at virtual objects with their fingers.

However, inconvenient and distracting wearable AR apparatus restricting the users' freedom of movement are limiting factors for building usable AR applications. Considering the visualization and interaction possibilities of AR on the one hand, and social issues on the other, an innovative visualization paradigm has been created for navigation systems, where users intuitively perceive navigation information through the windshield of a car and maintain their unrestricted freedom of movement as the AR apparatus is integrated into the users' environment. User interaction can be carried out naturally because users are not locked up in a cage and chained to wearable equipment

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