Employing location-aware handheld augmented reality to assist utilities field personnel

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Abstract

Employing mobile augmented reality (AR) to assist utility field personnel is a novel approach, which has become considerable in recent years with the advent of AR applications running on handheld computing devices. Unlike conventional solutions, AR provides a more intuitive interface to access complex underground utility network data in the field. As a result, common field tasks concerning maintenance and operation are accomplished more efficiently while reducing unintended damage and increasing general safety on site. In this scope we present VIDENTE – an outdoor handheld AR system, which provides 3D information of the local underground network infrastructure which is visualised to field personnel on a handheld device.

Fig. 1: VIDENTE handheld augmented reality client setup.

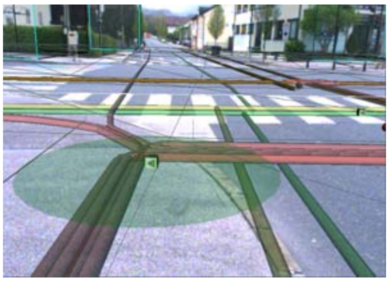

Fig. 2: Screenshot: Presentation of the subsurface infrastructure information on the client device (data courtesy of *Salzburg AG*).

Fig. 3: Field worker using the VIDENTE client to interact with the environment.

1 Introduction

Augmented reality comprises a set of methods to supplement a user's perception of the real world with virtual elements such as computer graphics, sound or haptics. Unlike virtual reality (VR) providing completely synthetic environments, AR aims at enriching the physical surroundings with synthetic information to facilitate decision-making.

In our research we focus on handheld applications of AR. In recent years mobile AR has undergone a remarkable transformation from rather bulky setups (Höllerer et al. 1999, Piekarski & Thomas 2001) towards more user-accepted handheld setups based on devices such as Ultra-Mobile PCs (UMPC), PDAs or smart phones (cf. Izkara et al. 2007, Ki-Hong et al. 2008, Schmalstieg & Wagner 2008). The increasing availability of AR on such consumer platforms make it a powerful tool to assist field personnel of utility and infrastructure companies in accomplishing common field tasks more efficiently.

An integration of location-aware mobile AR solutions with existing mobile asset management solutions may notably contribute to meet recent needs of utilities to optimise their technical business processes. By means of mobile AR, underground utility network information is made accessible through a more intuitive interface reducing error-prone decisions and accelerating localisation, identification, modification and capture of buried assets remarkably. Recent research activities have proven the potential outlined above (cf. Hammad et al. 2002, Roberts et al. 2002, UK Water Industry Research 2007) exploring possibilities of modelling and presenting subsurface infrastructure.

2 VIDENTE – a location-aware handheld augmented reality system

2.1 What is it about?

In order to address the afore-mentioned motivation we have developed VIDENTE – an outdoor handheld augmented reality system (cf. TU Graz & GRINTEC 2008) providing users with an intuitive visualisation of the local underground network infrastructure in their immediate environs (Fig. 1-3). Unlike common approaches of locating hidden utility assets by means of paper maps or mobile GIS solutions, VIDENTE conveys the underground network information directly in three dimensions employing an egocentric view. Users no longer have to transform map space into the real world since they obtain an integrated view of both at a time. That is, they simply see the hidden asset of interest superimposed as a computer graphics overlay on the road surface in front of them (Fig. 5).

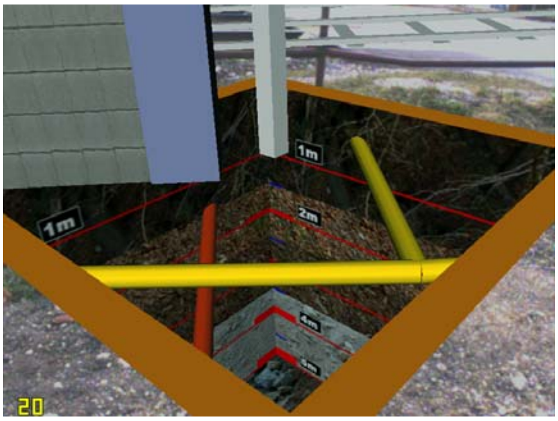

Fig. 4: Screenshot demonstrating improved depth perception by adding specific depth cues (data courtesy of *ÖBB Infrastruktur Bau AG*)

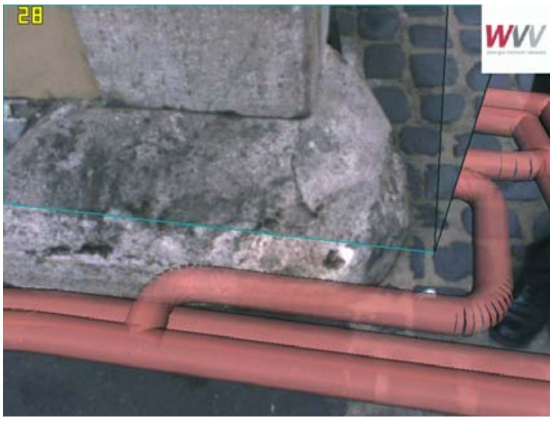

Fig. 5: Screenshot: close-up inspection of an underground asset (data courtesy of *WVV*)

The VIDENTE handheld client implements the video see-through metaphor. Hence, scenes are assembled at the client device in real-time by merging continuously streamed video footage with geo-referenced computer graphics considering the client's currently tracked position and orientation. Consequently, the rendered AR scenes are adjusted continuously as the user moves around.

VIDENTE enables users to visualise both hidden underground objects such as cables, pipes and joins and abstract information such as legal boundaries or safety buffers. Corresponding semantic object data may be queried, as well. Buried assets projected at the office can be taken out to the field to be matched against the real world situation. VIDENTE's x-ray vision permits rapid perception of complex subsurface network layouts (Fig. 4). Spots of interest can be virtually marked employing an annotation tool ("redlining"). The full range of tools available in VIDENTE is described in detail in Schall et al. (2008b).

2.2 Technical details

VIDENTE is based on a multi-tier system architecture with a mobile frontend and a geospatial database as a backend. The mobile frontend is built around a UMPC (Sony Vaio UX1) mounted on a special handheld frame equipped with joystick-like controls for mobile spatial user interaction (Fig. 1, cf. Kruijff & Veas 2007). Furthermore, the client platform comprises a GPS module (Novatel OEM1 RTK receiver) and an inertial measurement unit (Intersense InertiaCube3) for respective position and orientation tracking, a highly compact video camera (Ueye 2210) and a UMTS adapter for wireless data exchange.

The handheld client runs the VIDENTE application, which was built on top of *Studierstube*, a powerful framework for application development of mobile, collaborative and ubiquitous AR applications (cf. TU Graz 2008). The VIDENTE application is in charge of merging geo-referenced three-dimensional computer graphics, video footage and tracking information in order to provide an appropriate AR scene assembly in real-time.

For the purpose of position tracking, we employ GPS with satellite-based correction data by EGNOS. However, this only allows for a horizontal position accuracy of about 5-10 m whereas a level of accuracy of about 15 cm is preferable to permit meaningful visualisations. For this reason we currently work on the integration of terrestrial correction data services (DGPS / RTK-GPS) leveraging the required cm-accuracy.

Any data relevant for visualisation is piped through a multi-stage data translation pipeline. Geospatial objects originating from an operational geospatial database (GE Smallworld) are delivered to the client application in offline or online mode employing a lean GML3-based encoding for geospatial data exchange. The client application converts the delivered geospatial data into a corresponding three-dimensional computer graphics data structure – a context-sensitive scene graph, which is also capable of storing semantic object information. A detailed description of our data translation pipeline is given in Schall et al. (2008a).

3 Fields of Application

The development of VIDENTE has been driven by close collaboration with potential end users. Several workshops with utilities staff members have revealed that mobile AR may prove useful to the accomplishment of field tasks embedded within technical business processes of asset maintenance, outage management, asset record keeping, network planning and construction. Doing so VIDENTE is not meant to fully replace existing mobile asset management solutions, but rather to supplement them with an additional mode of information providing. Among others the following use cases have been considered:

- Trench inspection tasks (e. g. guidance for gas leak detection)
- Planning and preparation of digging activities on site (e. g. assisting with spray marking)
- Visual guidance while digging (e. g. by means of a dashboard mounted AR device in a shovel excavator telling the operator where to dig in real-time)
- Locating of damaged buried cables
- On-site verification of assets projected at the office
- On-site correction of legacy datasets
- Assistance for operation and maintenance works

4 Outlook

We presented a location- and context-aware handheld AR system, which addresses the work-flow optimisation of common field tasks with utilities. By means of a more intuitive way of information conveying remarkable time saving can be achieved employing such a system. Potential fields of application were outlined. A first fully functional prototype of our handheld AR system VIDENTE is available and provides a set of tools for direct user interaction with the presented information on buried utility assets. However, further improvements remain to be dealt with and concern the following issues:

- Integration of improved tracking in terms of DGPS / RTK-GPS employing terrestrial correction data services while keeping an ergonomically acceptable form factor. An option for support of dead reckoning might be considered to bridge areas of poor GPS signal coverage.
- Enhancement of the current VIDENTE handheld client hardware allowing for both appropriate ergonomics and sufficient ruggedness for outdoor use.
- Improvement of flexibility and degree of automation of the current data translation pipeline, which transforms geospatial objects into their corresponding three-dimensional computer graphics representation. In addition to that, the pipeline is to be extended by a write-back mode enabling reconciliation of modified or newly captured data with the geospatial backend employing web services.
- Field studies verifying the performance of VIDENTE under real-world conditions within the scope of the use cases given in section 3.

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