THE INVISIBLE TRAIN:
A COLLABORATIVE HANDHELD AUGMENTED REALITY DEMONSTRATOR

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Abstract: We describe a software framework for rapidly developing and deploying self-contained, multi-user Augmented Reality applications on a variety of commercially available handheld computers (PDAs).

1. INTRODUCTION

While graphics capabilities are an integral part of generic mobile Augmented Reality (AR) systems, they are by no means the only component required for building successful AR applications. In fact, the advent of hardware-accelerated mobile graphics solutions will likely increase the need for a software infrastructure that permits application development to go beyond simple games and "multimedia gimmicks". Infrastructure-independence, pose tracking and synchronization mechanisms (especially for distributed multi-user applications) are equally important contributors to a mobile system's real-world success. In contrast to the software framework described in this sketch, previous PDA-based AR systems either failed to adequately address these requirements (in at least one of the aforementioned areas), or were unable to yield compelling applications.

2. SYSTEM DESCRIPTION

The software framework described in this sketch builds upon our previous work in the field of software design for AR [1], which we adapted to mobile platforms [2]. The framework itself consists of the following components:

Graphics subsystem: Computer graphics programmers are accustomed to working with standardized low level APIs such as OpenGL. For use within our mobile AR framework, we developed *KLIMT*, a software renderer with an API that is similar to OpenGL and OpenGL|ES. Klimt[1] is being developed with portability and performance in mind and is available under the GPL for Linux, Windows and WindowsCE. We further ported the COIN[2] library to handheld platforms in order to allow for rapid data-driven application development through the use of scene-graphs.

Tracking subsystem: Considering the growing availability of cameras for (and also build-into) mobile devices, we decided to integrate fiducial-based visual pose tracking into our framework by customizing the ARToolKit [3] tracking library. A multi-marker relaxation algorithm is used to further increase tracking accuracy.

Communications subsystem: In order to handle the synchronization tasks mandated by distributed systems, we use a communications layer based on the Adaptive Communications Environment (ACE)[3].

The runtime performance exhibited by our framework in a collaborative two-user setup on Compaq iPAQ 3970 PDAs (400 MHz XScale) is currently in the range of 6 frames/sec (for a display size of 320x240 pixels), which reflects the maximum frame rate achievable by our setup's current camera model (LifeView FlyCam). Without the camera-imposed performance cap, our system delivers frame rates of up to 15 frames/sec.

[1] *KLIMT* is available for download at [http://www.studierstube.org/klimt]

[2] *COIN* is an *OpenInventor* reimplementation by *Systems In Motion*

[3] *ACE is being developed at Washington University in St. Louis*

3. THE INVISIBLE TRAIN

In order to demonstrate our framework's capabilities we have implemented a collaborative multi-user game ("*The Invisible Train*"), in which a wooden miniature railroad track that is populated with virtual trains. These trains are only visible to users through a magic lens [4][5] in form of the PDA's augmented video see-through display (see Fig.1). Players interact with the game environment by selecting and operating track switches and junctions, thereby influencing the paths of their virtual trains. The common goal of the game is to prevent the trains from colliding.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

[1] Schmalstieg, D., Fuhrmann A., Hesina, G., Szalav, Z., *"The Studierstube Augmented Reality Project"*, In Presence: Teleoperators and Virtual Environments, Volume 11, Issue 1, pp.33-54, February 2002

[2] Wagner, D., Schmalstieg, D., *"First Steps Towards Handheld Augmented Reality"*, Proceedings of the 7th IEEE International Symposium on Wearable Computers, 2003

[3] Kato, H., Billinghurst, M., Poupyrev, I., Imamoto, K., Tachibana, K., *"Virtual Object Manipulation on a Table-Top AR Environment"*, In Proceedings of ISAR 2000, Oct 5th-6th, 2000

[4] Bier, E., Stone, M., Pier, K., Buxton, W., DeRose, T., *"Toolglass and Magic Lenses: The See-Through Interface"*, in Computer Graphics, Annual Conference Series, Volume 27, pp.73-80, 1993

[5] Viega, J., Conway, M., Williams, G., Pausch, R., *"3D magic lenses"*, Proceedings of the 9th annual ACM symposium on User interface software and technology, pp.51-58, 1996

Figure 1: The PDA's video see-through display serves as "magic lens" into the game environment.

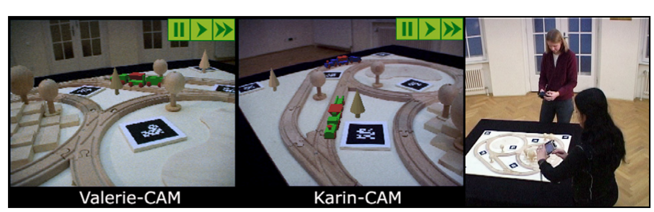

Figure 2: Multiple users (far right) play a collaborative game while being shown individual views (left) of the augmented scenery.