HybridEarth: Social Mixed Reality at Planet Scale

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***Abstract*—Using Google Street View navigable imagery and adding users' avatars to it, we have implemented a virtual world copy of the real world. Thanks to a geolocation technique with a precision in centimeters, users wearing augmented reality devices are inserted at their actual location in the mirror virtual world and can see all its virtual elements, including avatars. As HybridEarth can potentially host millions of avatars –much more than today's virtual worlds– we have built it on top of Kiwano, a distributed infrastructure for scaling virtual worlds, designed and implemented by our team.**

HybridEarth is accessible from http://hybridearth.net where users can enter the world either by installing an application on their Android device or by walking their avatar in the virtual world. Running inside any recent web browser, the virtual world covers the planet wherever Google Street View is available and can be extended by adding new imagery with the provided smartphone application.

I. Introduction

When walking in Street View we almost have the feeling of being for real in the street. With HybridEarth we are also able to see and chat with other's avatars and, more noteworthy, with people really in the street, physically there. That's what is called mixed reality: a hybrid world, half real, half virtual, with avatars and people side by side in a same space.

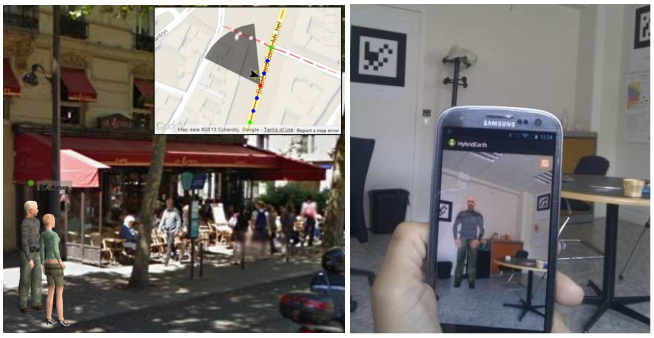
The ongoing exponential growth of the number of geolocated sensors has given birth to what we call mirror worlds. The typical example is Google Street View, deploying all over the planet cars full of sensors: spherical cameras, rotating lasers for 3D scanning, antennas to map the wifi hotspots, et cetera. For HybridEarth, we have in addition developed a smartphone application to extend Street View mirror world to indoor locations and any other uncovered places.

Wisely mapping the Street View navigable imagery on WebGL elements, we have implemented a web application to enter the mirror world in a classical virtual world fashion: users are represented as animated avatars that can interact and walk in the streets and inside buildings.

Augmented reality (AR) devices –smartphone, tablet or glasses– allow users to see the virtual elements added to the mirror world. But, as these devices are geolocated, they also make the wearer visible in the virtual world at her/his actual position.

Although smartphone geolocation has become more and more accurate, precision in the centimeter range is still uncommon. To reach this precision, we take advantage of the always active camera of the augmented reality devices and implement a method making use of visual markers to compute the position of the wearer.

Today's virtual worlds can support at most few thousands users together in a contiguous space. A social mixed reality world covering the whole planet should be able to host more than that. HybridEarth relies on Kiwano, a novel distributed system to scale virtual worlds, conceived and developed within our team.



(a) Avatars in StreetView (b) Mobile app

II. A Mirror World based on Street View

Google Street View is a navigable imagery composed of geolocated spherical panoramas connected by paths matching actual pathways. Camera movements are constrained: they can only rotate and zoom from the center of a panorama and jump from one panorama to another following the allowed paths.

As many 3D virtual worlds, HybridEarth implements a "tracking camera" that follows the user's avatar from a third-person point of view. The imagery is acquired using the Google Maps API. Therefore, avatars can move wherever Street View imagery is available.

This imagery already covers many of the streets and roads of the planet and even indoor venues in selected places. However, many places of interest (our own office for instance) are not in Google's imagery. We have then implemented a smartphone application to easily extend it. With this app users take spherical pictures, locate them on the map and draw the connecting paths. This application is available for anyone to collaboratively build the HybridEarth imagery database.

III. Augmented Reality and Geolocation

Augmented reality devices add virtual elements at exact positions in the sensory field. To do so, the device must know precisely its location and orientation. A popular solution employs a camera and a visual marker. The position of the device is computed using the size and angle at which the marker is seen.

To enact a shared augmented reality, in HybridEarth, the virtual elements –including others avatars– have an absolute position. As AR devices only compute relative positions to visual markers, we store the absolute positions of markers in a spatial database. When a marker is detected, its position, orientation and size are loaded, allowing the computation of the absolute position and orientation of the device. This positioning is essential: to make the virtual elements visible at the right positions and also to insert an avatar of the wearer/holder of the device inside the mirror world at her actual location.

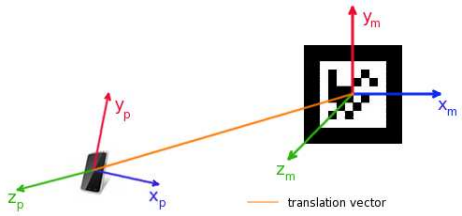


Fig. 1: Relative position

Today's techniques and smartphone computing power do not allow fast image identification against a large database. This is why we use a set of 512 simple visual markers. When one of the markers is detected by the device, the database is queried with an approximate position (provided by other means), and the nearest matching marker data is returned and used to compute the device absolute position. Our experiments have shown precisions in the centimeter range. Also when the marker goes out of sight the position is kept for a short time using accelerometers and gyroscopes. When no markers are available, HybridEarth uses the Android standard location service based on satellite positioning systems and wifi.

In a near future we can expect improved techniques for accurate geolocation to be widely available. For example we can foresee collaborative databases of natural markers [1] and commoditization of real-time kinematics [2] for centimeter precision GPS.

IV. Connecting Everyone

To see others avatars, both HybridEarth clients, web and mobile, receive avatar's positions and state changes from Kiwano.

Kiwano [3] is a scalable distributed infrastructure for virtual worlds, designed to support an unlimited number of moving objects updating their position at arbitrary high frequencies. In Kiwano the set of avatars is distributed onto many zone servers, each taking care of a group of avatars based on their geographical proximity. In order to scale, Kiwano spawns as many servers as needed.

To free the application layer from the distributed internals, Kiwano provides an API [4] to developers. When connecting, a client is assigned a proxy, the entry point for the entire session. Avatar positions are sent to Kiwano which sends back notifications about the neighbors.

Being aware of all avatars in their neighborhood, everyone is in the same contiguous mixed reality world.

V. Demonstration

Prior to the demonstration we will extend the imagery taking spherical panoramas from the street to the presentation site. Inside the demo room and nearby corridors we will place visual markers on the walls.

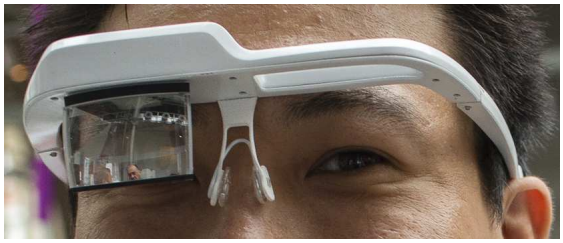


Fig. 2: Laster Android Smartglass Prototype

On the desktop computer screens, we will see the avatars walking in the street and entering the presentation room. With Android devices in the flesh attendees will be able to join and see the avatars evolving in the room. Moreover, we will bring a prototype of augmented reality glasses running on Android from Laster Technologies to show how social mixed reality will feel when such devices will be available to the general public.

As HybridEarth is accessible to everyone from http://hybridearth.net, we expect remote attendees to join us during the demonstration.

VI. Conclusion

HybridEarth is a mixed reality world: it that can be entered either from a desktop as a classical virtual world; or using an augmented reality device to see the surrounding virtual elements.

It demonstrates several technology advances developed within our team: a dual use of AR markers to visualize virtual content and geolocate with a precision in the centimeter range; a virtual world based on spherical panoramas accessible with a web browser; and a scalable distributed infrastructure for virtual worlds.

Future works include designing and implementing a service for social networks and games. Stay tuned.

References

[1] D. Zou and P. Tan, "Coslam: Collaborative visual slam in dynamic environments," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 2013.

[2] K. D. Atherton, "New gps receiver offers navigation accurate to an inch," *Popular Science*, September 2013.

[3] R. Diaconu and J. Keller, "Kiwano: A scalable distributed infrastructure for virtual worlds," in *HPCS*, July 2013.

[4] "Kiwano application programming interface," http://kiwano.li/.