Across the virtual bridge

Objective

The goal of the project is to explore different ways of creating interactions between people evolving in the real world (local players) and people evolving in a virtual representation of the same world (remote players). This latter one will be explored thanks to a virtual reality headset while local players will be geo-located through an app on a mobile device. Actions executed by remote players will be perceived by local players in the form of a sound or visual content and actions performed by local players will impact the virtual world as well. Local players and remote players will be able to exchange information with each other.

Keywords

Virtual world, mixed reality, computer-mediated communication

Background

With the development of mixed reality, we can expect innovating solutions to enable the navigation through the internet. Beyond game domains, virtual and augmented reality provide to the users a visual and immersive solution to interact with computer system. During eighties, some science-fiction authors like William Gibson already predicted the access to a computer network under an immersive or graphical representation named cyberspace. Although the world wide web has not taken this path until now, we notice the current evolution of devices like VR headsets or smartphones accessible to a wide public; this gives the possibility to explore this option by building, e.g., a virtual representation of a city to present the information about this place.

Over the recent past years, augmented reality (AR) and virtual reality (VR) have rapidly been making their way into our daily lives and it could lead to the development of interesting ways of discovering cities and cultural sites. The idea has already been exploited in *Ingress*[1], an AR game in which players are geolocated and have to collaborate to take control of certain parts of a city.

Using a virtual reality headset could help reaching places that are thousands of kilometers away. Google Earth has already been made available for headsets but it is only used in a passive way. The

[1] https://www.ingress.com/

possibility of interacting with people living in those places could enhance the experience. Our work could also be used to create a VR alternative version of tourism websites such as TripAdvisor. This would give tourists a better vision of hotels and restaurants in a city they want to visit.

During this workshop, we will use results from three existing projects developed in collaboration with the University of Mons:

- *Mons3D*[2]: a realistic 3D model of the city of Mons realized conjointly by the Faculty of Applied Sciences and the Faculty of Architectural and Urban Design of UMONS, in collaboration with the Numediart Research Institute, as part of Mons 2015, European Capital of Culture.

Figure 1. Visualization of Grand-Place of Mons in Mons3D.

- *Voix des anges*[3]: an interdisciplinary project involving the Numediart Research Institute, Hovertone, ACAPELA SA, le Manège Mons and Transculture. This project, open to citizens via a web application, provides a sonified geolocation in the city of Mons, allowing to endow urban objects and spaces with expressive synthesized voices. The sound, modulated by user's geographical position, is then streamed to the smartphone.

Figure 2. "Voix des Anges".

[2] https://vimeo.com/68366976
[3] http://www.hovertone.com/voixdesanges/

- A game prototype: in this game, the players of several teams are invited to take possession of the city building by painting graffiti on the walls. The other teams could recover possession of the building by first “breaking” the graffiti (i.e., performing the same graffiti gesture as the previous team did). Then, they could lock it again with their own drawing. This game was designed to be used only in virtual environment.

Deliverables

This project aims to build the basis of an experimental platform to evaluate various setups that promote interactions through a persistent virtual world. We plan to implement a modular architecture that will allow for an app designer to prototype an online software based on a virtual representation of an existing city. The setup can use tools for virtual reality or augmented reality. We will focus here on the use of modal possibilities such as sound, video, 3D rendering and game to promote the communication between users.

Figure 3 shows the proposed structure of the project. It encapsulates different work packages, that are described below. This structure is furthered described in the section WP6: Integration.

The deliverable of this project will be a software framework with different use-case modules that will be tested as a ready-to-use toolbox. These modules will be used as a prototype to evaluate and illustrate the performance of our platform.

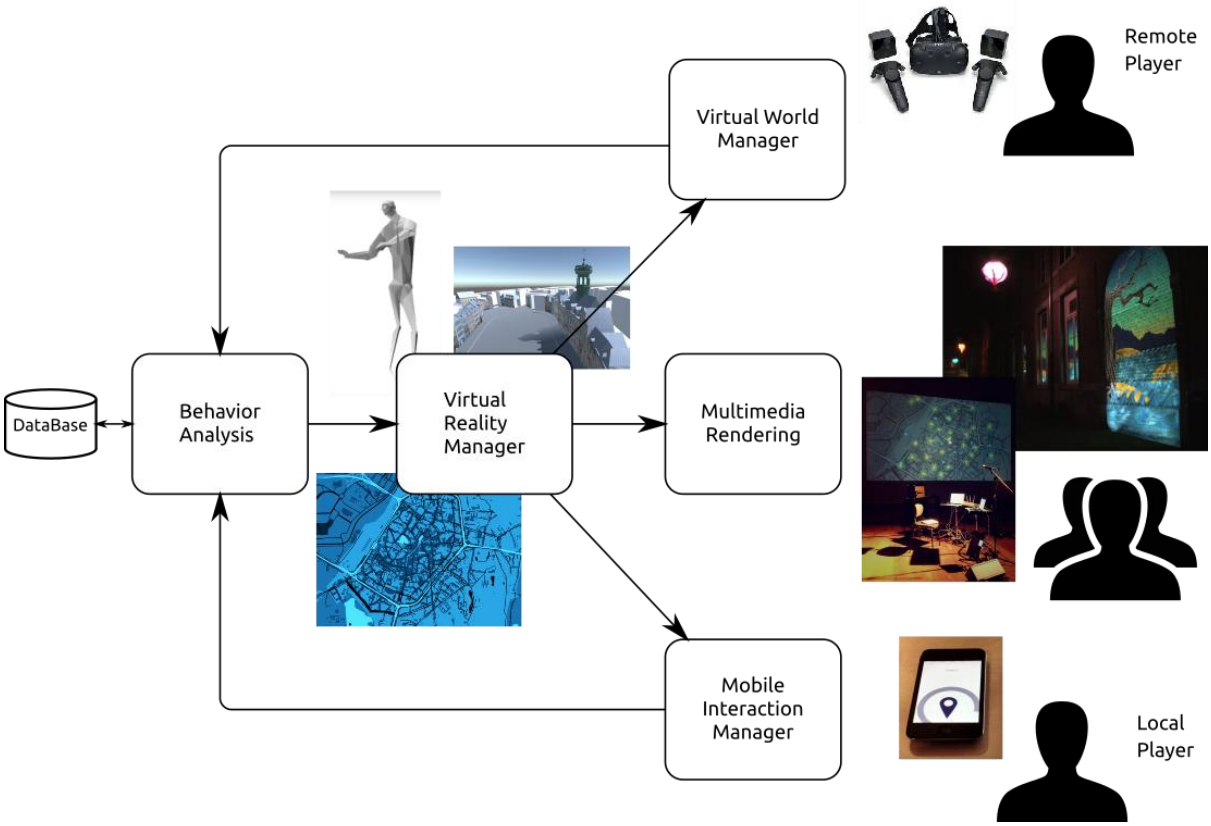

Figure 3. Project architecture.

Work packages

As shown in Figure 3, we divide the framework in five packages and we add the integration step. In the following sections, we detail the tools that we plan to gather or to implement when they do not exist.

Work package 1: Setup of the 3D environment

In this package, we will define the virtual space and the evolving properties of this world (map, interaction zone, 3D models, …). We need to put in place an urban 3D environment into a graphics engine. A geometrical relation will exist between this virtual model and the real world. This environment must be customized to allow playable actions.
This work package is partitioned into 3 tasks: acquisition and implementation of the 3D model in Unity, addition of non-player characters and addition of environmental effects.

Acquisition and implementation of the 3D model in Unity

Our first experimental place will be Mons. We plan to use a 3D model of Mons that was used in a previous project called *Mons3D*[2].

If we need to test our platform with other cities, we will use tools like *VECTILER*[4] that allows with *MAPTILER*[5] to generate such 3D model. Although the models produced with this method are in a lower quality, it will be already sufficient for the prototype.

Various interactive virtual objects will be present in this world. We call them *totems*. The description of the environment will include a manager system to update, store and share the state properties of these totems.

Addition of non-player characters and objects

In order to make the virtual world livelier and also to allow more interactions, the 3D world will be populated with non-player characters. These ones will have different appearances and can move everywhere in the city. Moreover, the players will be able to interact with them in order for example to obtain information on the place in which they are.

Addition of environment evolution

The virtual environment will be able to evolve. This will modify the visual aspect of the game and consequently the interaction possibilities.
Among these effects, we can quote for example the cycle in the daytime or weather conditions (rain, snow, sun). The interactions related to these two examples could be visual, with the hour shown on the belfry of Mons, or ludic, by proposing thematic games like snowball fights (or water balloon).

[4] https://github.com/karimnaaji/vectiler
[5] http://www.maptiler.com/

Work package 2: Game mechanics in the virtual world

To immerse remote users in the synthetic environment, a virtual reality headset (HTC Vive[6]) will be used. In this work package, we will define and implement a gameplay to promote social exchanges between remote and local players.

Remote player displacement

Remote players need to be able to move in the virtual environment. For short displacements, the VR setup gives enough freedom to move about one meter around the center of its coordinates system. For longer journeys, we will use the Vive teleportation system which uses a parabolic pointer. This system is available in the *STEAMVR* plugin for Unity and provides a natural way to move around a scene about a hundred meters wide. To travel faster through the map, we propose to create bus lines mirroring the ones that really exist in the city, allowing the user to teleport from one bus stop to the next.
To help the player to position himself in a virtual world he does not necessarily know, we will add the possibility to pop up a classic 2D map on which the position is reported by a cursor.

Interaction with the virtual world

The interaction between the remote player and the virtual world will be possible thanks to “totems” scattered throughout the city, in areas which present a particular cultural or touristic interest. Those totems can be seen as control terminal used to alter intrinsic properties of the virtual environment in the totem perimeter. For example, if a totem is attached to a virtual voice as in *Voix des Anges*, the remote user could modify the pitch of this voice.

Social exchanges mechanics

We propose an asynchronous way to exchange messages by letting the possibility for both remote and local players to leave written, drawn or audio messages in the city. Those messages will then be part of the environment.

Work package 3: Development of a mobile application

The aim of this work package is the creation of a mobile application linking users in the real world and in the virtual world. The local players will interact with the platform through a mobile device. We plan to use controls like the real-time geo-localization and the touch screen. The application will be developed for android and/or iOS. This work package is divided into two modules: the first one concerns the instrumentation and the communication, and the second consists of the user interface creation and the mobile gameplay.

[6] https://www.vive.com/

Instrumentation & communication

In this module, we will acquire the data captured by different sensors in order to be able to localize the user in the real world, typically the position information (GPS) but also the data of the accelerometer, the gyroscope and the magnetometer. In addition, we will use an internet connection to exchange messages with the game server in order to enable the interactions with the virtual world and the remote players.

GUI & gameplay

In this module, we will design the interactions the local users could have with the virtual world. The goal is to achieve a simple way to interact with the system but in the same time, to give to the user a clear feedback on his impact on the virtual world (see work package 4 for more details). In practice, the role of the app will be to communicate with the server in both direction and to display information (triggered actions according to his position, communication / interactions with virtual users, etc.). This module will also aim to design the graphical user interface of the mobile application.

Work-package 4: Sound and video generation and diffusion

To enhance the global users' involvement, we will experiment solutions of reactive video and sound texture generation based on players' behavior and actions. This could give local players a rough idea of how interesting their city appears to foreigners.

Sound texture generation

This part will heavily rely on the past project *Voix des anges.* Players from both worlds will hear sounds whose parameters are modified in real-time by actions such as wandering in the streets. Our goal is to let people from one world feel the presence of players from the other one without necessarily seeing them. We also want players to understand clearly how their behavior changes the sound.

Video generation

Videos are mainly intended to be seen by local players while being controlled by remote players. Screens and projectors located in interesting spots will be used to display videos chosen from an existing collection or created by the players. Live drawings could also be displayed on the same screens.

Work package 5: Behavior analysis

In this work package, we will analyze the available information on the players. This analysis will help to understand how they behave in the game, to adapt the game and hence improve their experience. Geo-localization and accelerometer information of the local players will be used, as well as the virtual positions and the controllers of the remote players.

Individual behavior

The pathway and dynamics of each user during a game session will be analyzed, as well as their interactions with other users or points of interest in the game. Game mechanisms will be adapted to their behavior, to encourage an optimal discovery or the city, and interactions with other users.

Global behavior

A database will be recorded on the participants of the game, enabling global behavior analysis. From this database, a profile of the typical user will be dressed, highlighting the most attractive places or activities in the game environment. The global game mechanics and the environment properties will be adapted accordingly to improve user experience.

Work package 6: Integration and user feedback evaluation

The purpose of this work package is to integrate the results of the previous ones in a unique solution aimed in the above deliverable paragraph.

Game narrative background

To ensure a coherence between the different game modules of the targeted prototype, we propose to write and to respect a narrative background. Of course, If necessary for the technical needs of the project, we will adapt this narrative description.

Software Integration

We will define the communication protocol between the modules of this project.
As shown in Figure 3, the software structure will be coordinated around the Virtual World Manager (WP1). This package will give the information to the Virtual Reality Manager (WP2) and the Mobile Interaction Manager (WP3) to generate the game environment for the respective players. Both of these last blocks will transmit the user's actions to the behavior analysis toolbox (WP5) that will store this information and will use this database in its behavior analysis process. The Virtual World Manager will provide a way to transfer the result of this analysis to the multimedia rendering engine (WP4) to generate a reactive video and audio content in the real world.

Evaluation

The modular software architecture will be evaluated regarding the possibilities and the performance that we will be able to obtain for the prototype.

Schedule

		W1	W2	W3	W4
WP1	Virtual World Formatting	■	■		
	Life and animation in the virtual World		■	■	■
WP2	VR Setup Design in Unity	■			
	Gameplay definition and implementation		■	■	■
WP3	Mobile app development	■	■		
	Gameplay definition and implementation		■	■	
WP4	Rendering setup	■	■		
	Media Content Management			■	■
WP5	Implementation of the behavior data storage system	■	■		
	Behavior processing		■	■	■
WP6	Narrative background	■			
	Network communication		■	■	
	Test, performance evaluation and users' feedback				■

Team Profile

Project Coordinators:
Thierry RAVET[1](software design, motion signal processing, machine learning), Fabien GRISARD[1] (software design, human-computer interface), Ambroise MOREAU[1] (computer vision, software design), Pierre-Henri DE DEKEN[1] (software design, game engine).

Team proposed:
Mickael TITS[1] (Motion Signal Processing, Machine learning), François ROCCA[1] (computer vision, behaviour analysis), Radhwan BEN MADHKOUR[1] (computer vision, software design), François ZAJEGA[2] (3D design, Game engine).

Affiliation
[1] Numediart Institute, University of Mons, Belgium.
[2] ARTS[2], Mons, Belgium.

Other researchers needed:
- Researcher/artist in sound design
- Researcher in artificial intelligence for games
- Researcher in social science studying mixed reality, serious gaming or video game design.