University of Geneva

Presentation of the BBL-IS

Brain and Behavior Laboratory - Immersive System

CISA-NeuroCenter-BBL

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v. 2.5

Evolution table

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I. Introduction

BBL-IS stands for « BBL-Immersive System », the immersive virtual reality (VR) system of the « Brain and Behavior Laboratory » (BBL). This platform is unique in Switzerland and it's in complete synergy with all others BBL facilities (fMRI, EEG, psycho-physiology…). The BBL-IS is under the academic responsibility of Prof. Didier Grandjean and the technical responsibility of software engineer Emmanuel Badier.

Following a general definition of VR, this document presents the BBL-IS in details before explaining the multiple interests it offers.

↗ BBL-IS website

II. Virtual Reality

The VR domain gathers the technics aimed at simulating various situations. Simulations can get different degrees of realism, thus for the most advanced, we use the term « immersive virtual reality ». The technics of IVR are centered on the user's perception to achieve the immersion in a virtual environment.

IVR uses multiple technical solutions, hardware and software, to form an immersive system. Those systems influence the human senses, mainly the view and the audition, to manipulate the user's perception. The most advanced systems are able to surround the user with images in the form of multiple screens structured to optimally cover the field of view. Mostly, they take a cubic shape:

Each side of the cube is a screen displaying a part of the virtual world. The user perceives the environment at 1:1 scale and he can interact with various actions: body movements, using a remote controller, using the voice…

Immersion in a virtual world allows to perform some tasks impossible in other conditions, like the handling of different environmental characteristics, the simulation of high-risk situations, quick prototyping, mock-up visualization…

All those capabilities lead IVR as an overgrowing domain.

III. Presentation of the BBL-IS

1. BBL immersive system

The BBL-IS is a high-end immersive system due to its structure and visual quality. It benefits of a large cubic space allowing users to walk inside.

- The four faces are acrylic screens (one frontal, two laterals, and one on the ground) linked to four professional video projectors driven using a single powerful graphic server.
- The frontal screen is 2.8 m wide and 2.4 m height.
- The images benefit from a high contrast (white/black ratio) and a high resolution (pixel size: 1.3 mm).
- Projectors display 120 images per second. They are synchronized with 3D glasses allowing the depth perception using the active stereoscopy technic.
- Users' movements are captured in real time with sub-millimeter accuracy, at 240 Hz.
- Spatialized sound is delivered using a surround system composed of five speakers and one subwoofer.

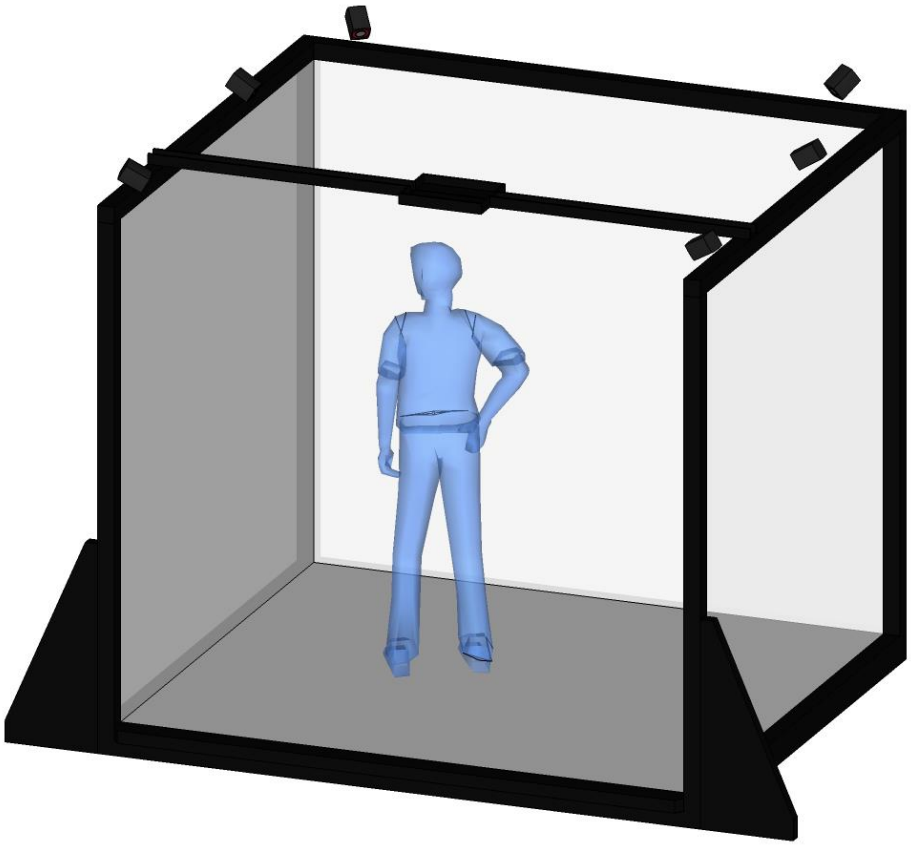


Figure 1 : BBL-IS schema.

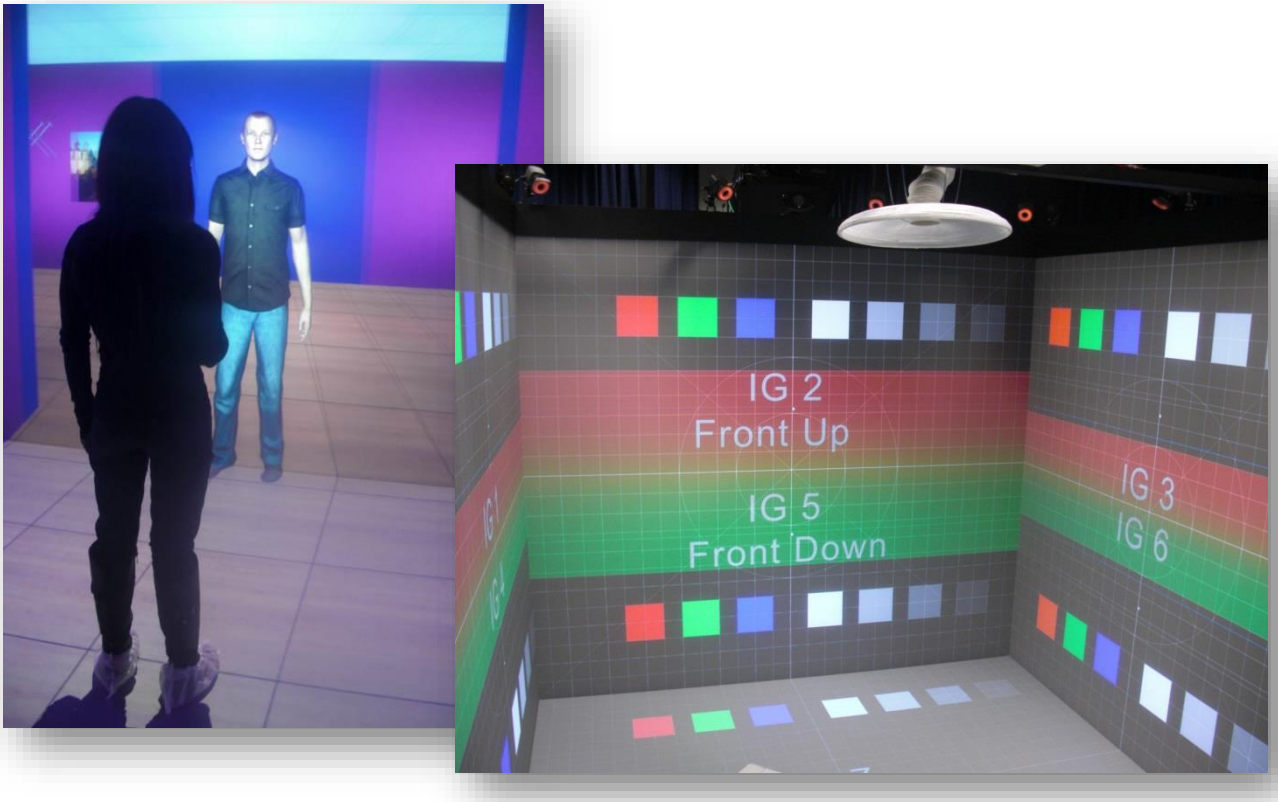


Figure 2 : Meeting a virtual character; Picture of the BBL-IS installation.

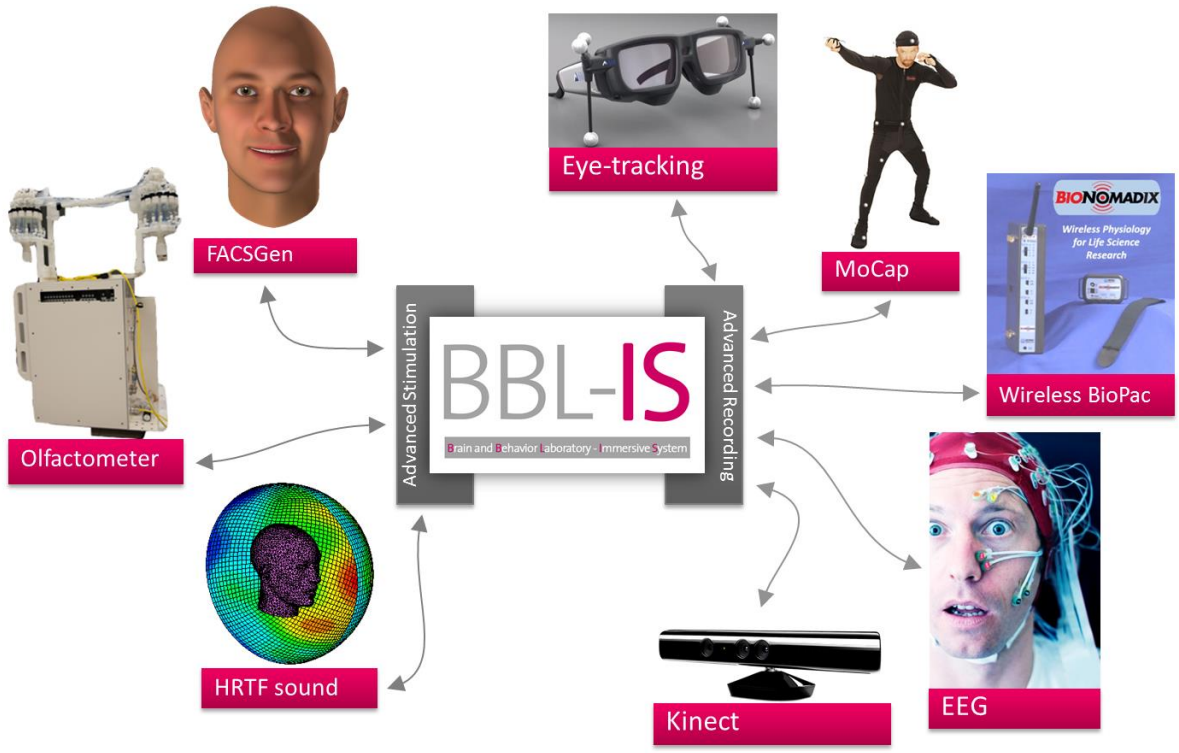
2. Software

The BBL-IS is powered with a couple of software responsible to create realistic simulations. Unity3D is the game engine used to build virtual environments with a library of components (3d models, sound, scripts, etc.). Unity3D is well documented, and it can be installed on both PC and Mac: https://unity3d.com/.

Additional software libraries are developed internally to configure and run the experiments with all the VR features (Mocap, Asymmetric projection, Stereoscopy, Data recording & synchronization). These features are required to address the specific needs of the BBL and the associated research. They are updated regularly to provide the latest VR technologies to the researchers.

3. Additional devices

The BBL-IS can control and communicate with various complementary devices to extend its capabilities for research and immersion:



- An eye-tracker « Eye Tracking Glasses » from SMI **to accurately estimate the objects looked by the user** and to calculate the convergence of the gaze. This device also measures the pupil's diameter which is an important indicator of the sympathetic system activity.
- An olfactometer build by Firmenich SA in collaboration with the CISA can diffuse 28 different odors **to simulate an olfactive environment in real time with a modulation of the intensity according to the distance with specific objects.**
- A Vicon motion capture system composed of 10x Bonita cameras to capture and record **users and objects motions**.
- Biopac and Biosemi physiological measurement systems to record the **heart rate, muscular activity, skin conductance, surface cerebral activity** and other signals while exposed to various stimulations.
- FACSGen software **to generate complex facial expression for virtual characters** to manipulate emotions and social interactions in real time.
- An HRTF sound generator (Head Related Transfer Function) to generate accurate spatialized audio.
- A Cyberith Virtualizer treadmill to **allow natural locomotion for users** in VR environments.
- Low-latency response boxes to **accurately measure response times of subjects**.
- A Kinect2 for Windows system for **voice control and simplified motion capture**.

4. Technical details

DaLite acrylic screens with high contrast ratio and brightness
Frontal screen is 2.8 m wide for 2.4 m height
Ground area of about 7 m²

More than 10 million pixels
Pixel size: 1.3 mm
Resolution: 4 AM/OLP

Brightness up to 8000 lumens
Up to 1600 cd/m² for each screen

Active stereoscopic system with 120 images per second
powered by 4x Barco F70-4K8 projectors

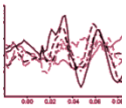
Powerful graphic server (2x Intel Xeon Gold 6144 processors, 128 GB RAM, 2x nvidia Quadro RTX 6000 graphic cards with NVLink)

5.1 audio system powered by a Denon AVR-1312
for sound spatialization

Eye-tracker from SMI for an accurate measurement of gaze's direction and pupil's diameter. 0.5° of angular error at 30 Hz

Odors generation controlled in real time capable of diffusing 28 different scents with lateralization feature (left nostrils vs right nostrils)

Vicon motion capture system composed of 10x Bonita cameras
with sub-millimeter accuracy at 240Hz



Wireless physiological signals measurement system: electro dermal activity, heart rate, breath rate, skin temperature, 2 channels muscular activity…

Natural locomotion with Cyberith Virtualizer threadmill
Users inputs (direction, speed, height) are collected at 100 Hz to navigate in VR environments

The general qualities of the BBL-IS added to those devices integration leads to a **multimodal system unique in Switzerland and in the world**. For scientific research, the interests are various in term of exploratory capabilities: using adapted environments it is also possible to benefit to psychological and psychiatric rehabilitation research. For industries, the recorded data can be useful for multiple domains: marketing, safety research, prototyping…

IV. Interests

1. For scientific research

The BBL-IS is in complete synergy with the high-end devices used in other facilities of the BBL. Studies will be able to couple physiological data with cerebral measurements recorded in the fMRI[1] scanner, before and after virtual exploration sessions. Other experiments could take advantage of the 256 channels EEG[2] to evaluate in real time the cerebral activity while exposed to virtual stimulations. Sleep and Psychophysiology laboratories are other opportunities to use this IVR system. Moreover, the olfactometer allows to diffuse multiple odors according to the user's position or while interacting with virtual characters. The BBL-IS is the first tool offering those features, it opens new perspective for the study of the relation between behavior, physiology, cerebral mechanisms, and complex emotional situations.

By gathering all those disciplines and technical capacities, the BBL-IS offers novel axes in the study of affective sciences, neurosciences, and therapeutics.

2. For industries

VR offers numerous opportunities in marketing, prototyping, and visualization for various fields of industry: automotive, architecture, food, aerospace, construction, chemical, household appliances...

Its location in Geneva and its uniqueness in Switzerland is a great advantage for the BBL-IS. A system for collaborative research or specific rent allows access to companies willing to expand their resources by taking advantage of VR. The development of virtual worlds and VR software can be outsourced or be part of a partnership.

[1] functional Magnetic Resonance Imagery
[2] Electro-encephalography