

The Augmented Laboratory – a mixed reality setup for physics education

Tommaso ROSI, Pasquale ONORATO, Stefano OSS

Department of Physics, University of Trento - Povo (TN), Italy

Abstract. We discuss an educational project, *The Augmented Laboratory*, aimed to bring innovation in educational physics laboratories in formal and informal contexts. It is based on the capability of obtaining 3D reconstructions of the physical world which can be visualised both live as the data is acquired and later on as interactive playbacks. The setup allows to obtain 3D tracking of multiple objects [1], to project data of interest directly on and around the objects used in a real experiment, and to introduce the new concept of “augmented experiments”. The setup was tested with a group of university students and as a scientific exhibit for hands-on activities.

We present an educational project, *The Augmented Laboratory*, aimed to bring innovation both into the physics laboratory and into physics teaching in informal settings (exhibits, museums). It is based on the capability of obtaining and visualizing a three-dimensional reconstruction of the physical world in real time, using a depth camera and a custom software developed by one the authors [1, 2].

Adding a projector to the setup, mixed/augmented reality is achieved through the projection on the objects and the environment. This opens to new frontiers of exploration of physical phenomena. It is also possible to make simulations interact with the physical world in various ways, introducing the concept of *augmented simulations*. Some videos available at [2] show in more detail how *The Augmented Laboratory* works.

This setup allows for three main categories of activities here presented.

1. *Multiple object, three-dimensional motion tracking* [1]

At first we discuss the capability of acquiring three-dimensional motion data of multiple objects. Some experiments regarding some fundamental features of Newtonian mechanics were performed to test the tracking abilities of our setup. Particular attention is paid to check and visualise constants of motion. In our experiments, at least two objects are tracked simultaneously. Acquired data can be visualised and analysed in a 3D virtual environment to help students understanding the physics behind the performed experiments.

2. *Augmented Experiments*

During and after the experiments it is possible to project information of interest directly on and around the objects used in the experiments. For example, (Figure 1), it is possible to highlight the tracked objects in real time, projecting their trajectories as well as other relevant data.

3. *Augmented Simulations*

A new door opened by this setup is that of exploring new interactions between computer simulations and the real world. We will refer to this new kind of interactions as "*augmented simulations*". An example of *augmented simulation* is that of projecting simulated objects on the real world whose movement is influenced by the physical world itself. This way it is possible to directly see the behaviour of the objects following the same physical laws that are taught, and it also allows to compare the results of measurements and simulations.

A second example of *augmented simulation* is that of the *ripple tank*. It is possible to perform any experiment regarding wave propagation by moving physical objects in the chosen area. The objects represent wave sources, obstacles, lenses, and areas of different wave propagation speed, and the software is capable of recognising and distinguish them. This way, the discussion of topics such as reflection, refraction, diffraction, Doppler effect and the sonic boom can be presented in a very intuitive and straightforward way.

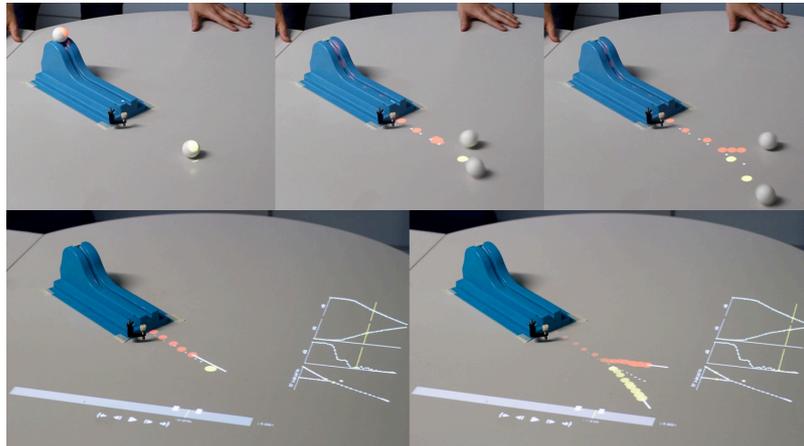


Fig. 1 It is possible to enrich an experiment with information provided by the computer and projected on and near the objects analyzed in real time, such as velocities, the system's center of mass, energies and so on.

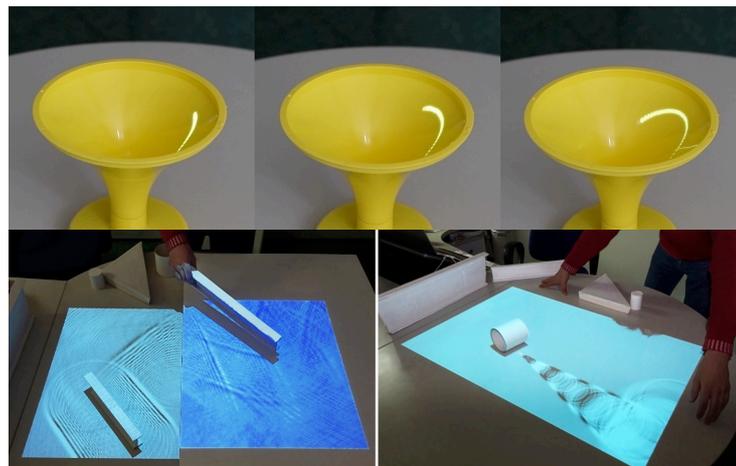


Fig. 2 Augmented simulations – simulated objects can move influenced by the physical environment (top); physical objects can be interpreted as sources, slits, refractive mediums and so on to create an *augmented ripple tank* (bottom).

The setup was tested and discussed with a group of university students attending courses about physics and mathematics didactics. They were asked their opinions about this setup, especially comparing it with other known tools (simulations, video analysis and so on). The Augmented Laboratory has also been used as an installation in the exhibition “Toys and science” held in Trento (Italy) for hands-on activities.

References

- [1] T. Rosi, P. Onorato, S. Oss. *Multiple object, three-dimensional motion tracking using the Xbox Kinect sensor*, European Journal of Physics 38 (6), 065003, 2017
- [2] https://www.youtube.com/channel/UCoafVdWnuyC_zzS0pOkbeg