A virtual nanomanipulator coupling with a multi-sensorial interface: a serious interactive game for the 'grand public' and students to explore the nanoworld

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Nanosciences and nanotechnology constitute a research field with two complementary objectives: (1) to study and to characterize the physical and chemical properties of the materials and structures at the nanoscopic scale, (2) to take advantage of these specific properties to develop smart applications in key areas of our daily life as medicine or computer and communication technology...

As these potential smart applications should impact strongly our daily life, it is crucial that the general public understand their interest in order to be able to evaluate objectively their positive and negative impacts. In this frame, the large audience should understand the key points of the chemical and physical behavior of material and object at the nanoscale. To face this challenge, we have developed a virtual nanomanipulator coupling with a multi-sensorial interface (haptic, visual and sound rendering) to illustrate the notion of the contact at the macro and the nanoscale (figure 1). This virtual and interactive nanomanipulator is an original output of scientific research carried out by a group of physicist specialist in nanophysics and using scanning probe microscopy and a group of engineers working in the field of virtual reality and haptic system.

Thanks to the general public version of the force feedback virtual nanomanipulator, every person can experiment and compares the notion of contact between the macroscopic and the nanoscopic scale in few minutes. Indeed in the virtual macro-scene, the person manipulates thanks to a force feedback system (a joystick), a soft stick to hit a piece of wood; during the manipulation the person feels in his/her hand the force and at the same time hears the sound induced by the impact of the stick on the surface and sees the movement of the stick on the screen. In this condition, the person experiments with the classical hard contact happening in the daily life. In the nanoscene, the person performs the same task with a nano-stick (an Atomic Force Microscope probe) to interact with the atomic structure of a nanosurface. During the manipulation, the person feels in his/her hand the Lennard-Jones force: an attractive force then the repulsive one. To improve the person immersion in the virtual scenes, sound and visual renderings are implemented; they are produced directly by the physical model and amplified.

This general audience version of the virtual and multi-sensorial nanomanipulator has been one of the more appreciated module of the exhibition show on Nanotechnology developed by the scientific museum Grenoble (CCSTI: Centre de Culture Scientifique Technique et Industrielle), more than 200 000 persons have used it in France and around Europe.

Based on this success we have developed an educative version of the virtual and multi-sensorial nanomanipulator called the Nanolearner. Scientific students from first years of university to Master level use the Nanolearner during practical work dealing with scanning probe microscopie.

Three complementary virtual nanoscenes are available on the Nanolearner. All the virtual nanoscenes deal with the AFM in contact mode probing a sample where several parameters as the spring constant of the cantilever, the sample stiffness or the type of tip-surface interaction, can be adjusted via a specific interface. The first nanoscene is dedicated to the force curve, a well-known mode in AFM technique to study in one dimension (1D) the evolution of the tip-sample interaction according the tip-sample distance. Thanks to the specific interface, the student can explore in less than one hour, several classical configurations as probing hard or soft materials with short or long range interactions with a soft or rigid cantilever. Students explore the impact of these various configurations with their perception

senses but also they could record several signals during the manipulations to plot them in order to obtain formal representation as with a standard and real AFM instrument.

The second nanoscene representes a surface in 2D where students can map the surface in different points and feel the well known stick and slip effect. In addition student can spot what is happening when an AFM tip probes a soft membraneby chosing suitable parameters. This configuration constitutes a relevant case for biological applications.

The third virtual nanoscene is in 2 Dimensions and deals with the manipulation (push or pull) of an nano-object on a surface with the AFM tip. This nanoscene underlines that the manipulation process at the nanoscale relies on surface effect rather than on the volume effect leading students to think about basic manipulation strategy for grabbing and depositing an object at the nanoscale.

Thanks to these three nanoscenes, students can explore in less than 4 hours most of the working situations that appears in AFM techniques. This could not be performing with a classic AFM instrument during a 4 hours practical work. The impact of each rendering (haptic, visual and sound) in the learning process of the students has been carried on in details [1].

From a more general point of view, the Nanolearner system is part of the emergent field of “serious games” whose one of the goals is to get comprehensible complex phenomenon that are not easy to transmit through classical pedagogical media (images or formal equations). In this frame our research group is developing some other serious games as example one dedicated to Brownian motion where its effect is translated into a force in the hand of the serious gamer. We believe that the development of serious games constitutes a pedagogical innovation to improve the interest of scientific and non scientific students for physics.

During the ImagineNano conference experts and large audience will have the opportunity to test the NanoLearner instrument and the Brownian motion serious game on the Grenoble stand of the Nanosociety session.

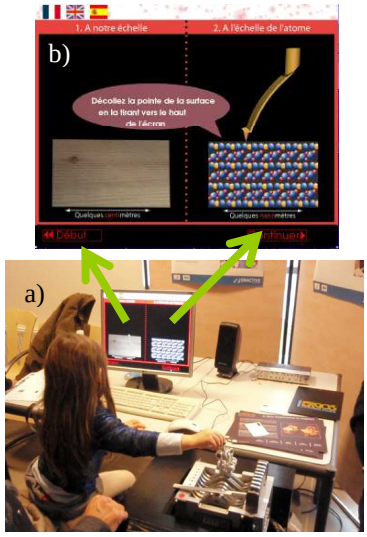

Figure 1: a) the whole virtual nanomanipulator platform with the loudspeaker, the screen and the force feedback system manipulated by a child; b) Zoom on the visual representation displayed on the screen.

[1] “An Augmented Reality Nanomanipulator for Learning Nanophysics: The NanoLearner Platform”, F.Marchi, S. Marliere, J.L. Florens, A Luciani and J. Chevrier, Transactions on Edutainment IV, LNCS 6250, Springer, pp. 157–175, 2010.