Nanoworld Telepresence

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Currently, BIOLOGY could be defined as the science of nanostructures.

The supreme aim for biology is the knowledge of molecular, subcellular, cellular and multicellular systems in terms of quantitative models that are supported by the rigorous principles of the physical sciences and mathematics.

This can only be achieved by *interdisciplinary* approaches that are based on the expertise and technologies of the physical sciences, engineering, computation and mathematics.

Methods for manipulating single molecules generate new information about both the forces that hold biomolecules together and the mechanics of molecular motors.

Until recently, scientists could only investigate chemical processes on a bulk level.

The forces and stresses that molecules exert on each other or develop in the course of reactions were not directly measurable.

In the past few years, this situation has changed rapidly thanks to the improvement of methods for manipulating single molecules.

Manipulating and controlling things on a nanometer scale is still difficult.

Handling nanoscale objects involves finding these objects, tracking and moving them.

The most important line of investigation towards nanomanipulation is NANOTELEROBOTICS, where the nanoworld is translated into virtual reality that allows us to interact with smallest objects.

Virtual instrumentation has grown significantly since its inception in the late 1970s, and recently the concept of a synthetic instrument was defined as a virtual instrument that is purely software and performs specific synthesis, analysis or measurement function on completely generic measurement agnostic hardware.

Modern Scanning Probe Microscopes based on virtual instrumentation concepts are designed primary to obtain high resolution images and they may be used in material processing application with limited performance.

The ideal human interface for a Scanning Probe Microscopy (SPM) might present its user with a scaled-up 3D representation of the surface that can be probed and modified with a physical hand-held tool.

The control system translates tool motion into a motion of the SPM tip and translates measured surface parameters into a pushing back force on the tool, as well as visual representations of surface data.

When using such a system, the scientist is interacting directly with the surface itself.

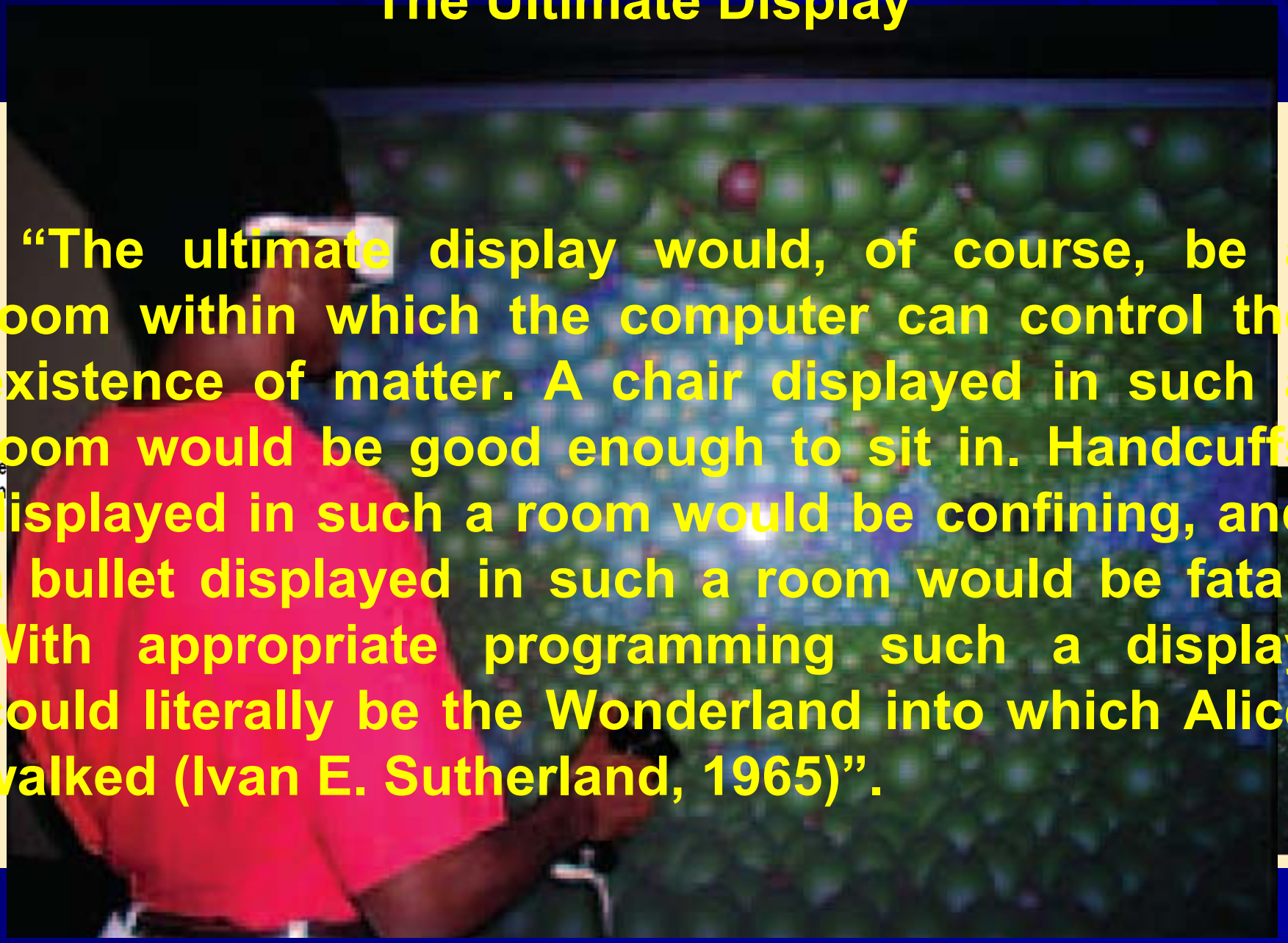
Natural motions of head and hands are used to investigate and sculpt the nanosurface like this is physically present at the scale of the scientist.

This system allows the scientist to concentrate fully on investigating the surface and its features, rather than on programming the Graphical User Interface.

The nanomanipulator is obtained by integration of a scanning probe microscope (NTegra Vita) with its controller, a SPIDAR (SPace Interface Devices for Artificial Reality) force-feedback device with its controller and PC computers with high graphics facilities.

A 3D image processing introduces the augmented reality concept using a mix of images in a head-mounted display.

The Ultimate Display



"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked (Ivan E. Sutherland, 1965)".

The augmented reality environment provides enhanced media for scientist to view the real time SPM image and to feel the force feedback during nanomanipulation – HAPTIC.

This concept is expected to have wide applications: for example, during nanomanipulation in complex situations, computer graphics may combine surface rendering with hidden features.

The significance of the virtual reality interface to the SPM is to simulate the presence of the scientist on the sample surface – TELEPRESENCE.

What is Haptic?

HAPTIC (*'hap-tik*) comes from Greek ἁπτικός (*haptikos*) = touch; ἅπτεσθαι (*haptesthai*) = to contact, to touch.

- relating to or based on the sense of touch;
- characterized by a predilection for the sense of touch.

What is a haptic?

Physical interaction via touch.

Uniquely bi-lateral sensory modality.

Touching and interacting with real, virtual and remote environments.

Why is it interesting and important?

- primary;
- intuitive;
- pervasive;
- expressive;
- unexplored….

The HUMAN HAPTIC SYSTEM is *the entire sensory, motor and cognitive components of the body brain system.*

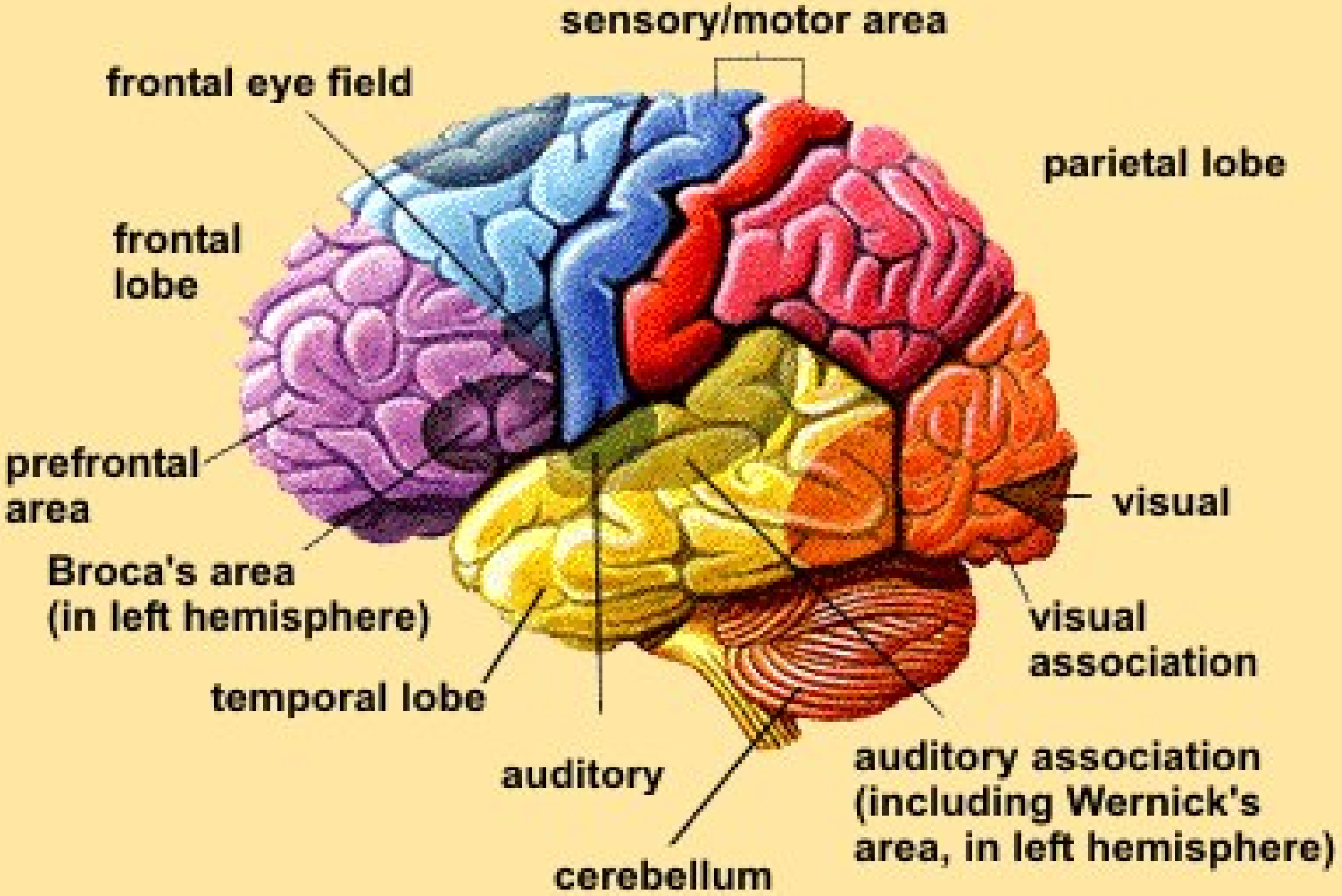
Tactile information **is gathered from different types of receptors that exist in the outer layers of the skin.**

These different types of RECEPTORS respond well to different frequencies of vibration.

Low frequencies **would correspond to pressure on, or stretching of, the skin, where as *high frequencies* would correspond to a vibrating or buzzing sensation on the skin.**

The human cutaneous system can perceive vibrations in the range of 0.4 Hz to over 500 Hz.

Sensitive Skin

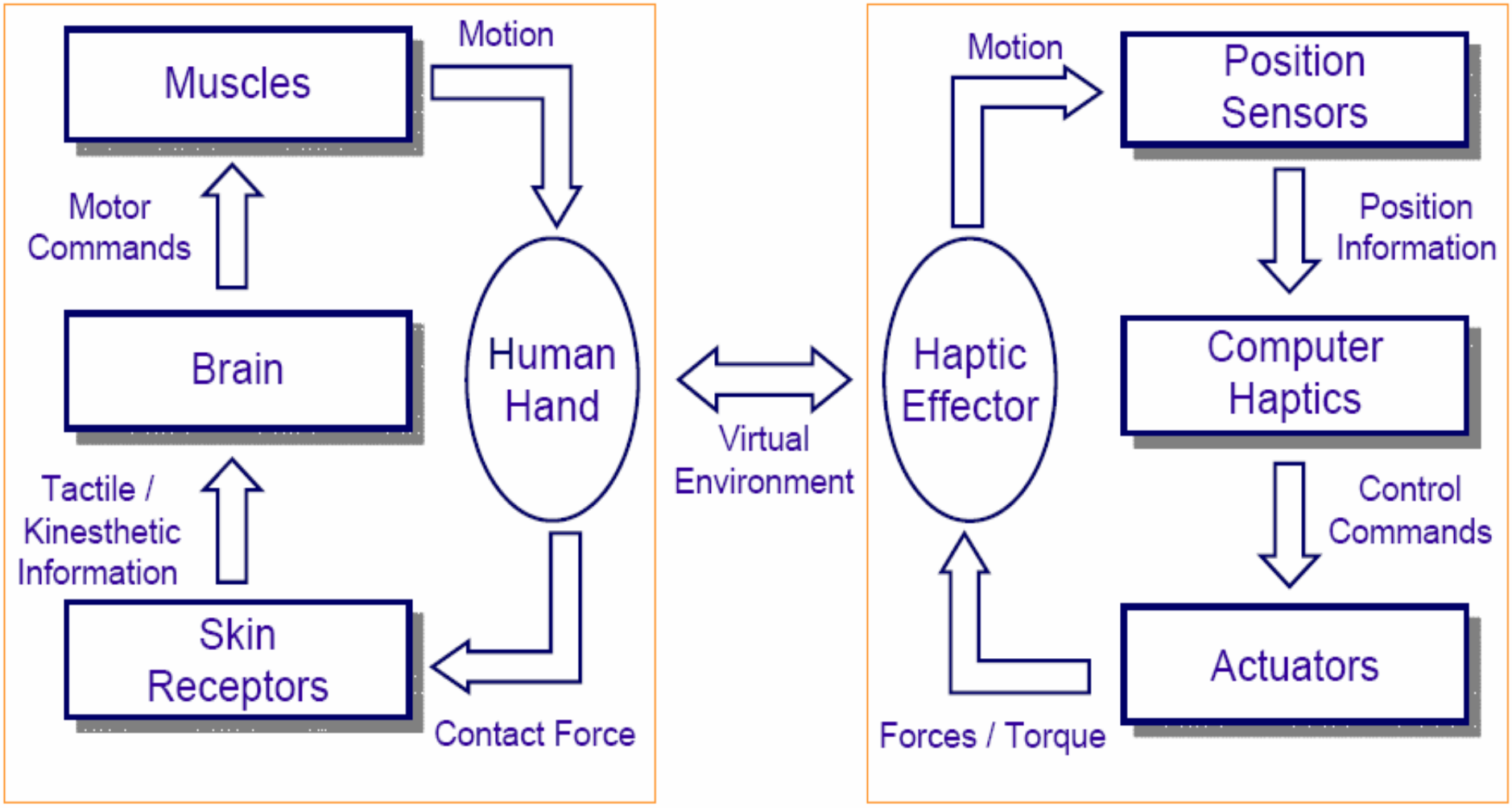


HUMAN HAPTICS: human touch perception and manipulation (every-day manipulation, tools, controls, music, art, etc.)

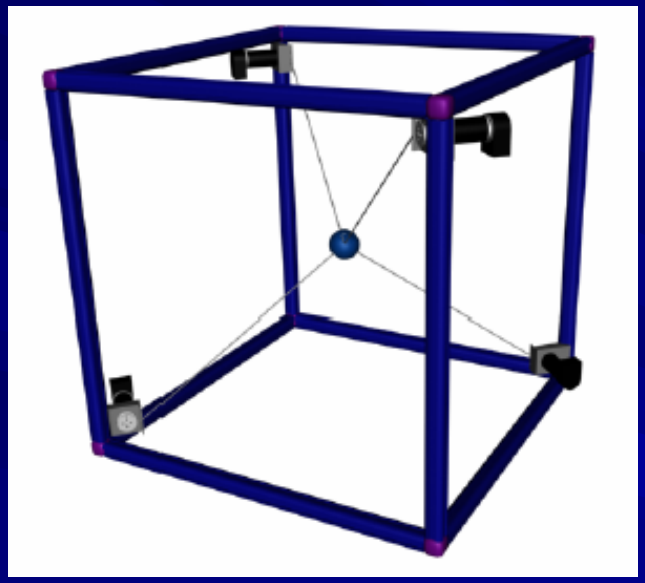
MACHINE HAPTICS: concerned with robot arms and hands (autonomous robots, remote manipulator systems, surgical robots, etc.).

COMPUTER HAPTICS: concerned with computer mediated haptics (training, design, entertainment, etc.).

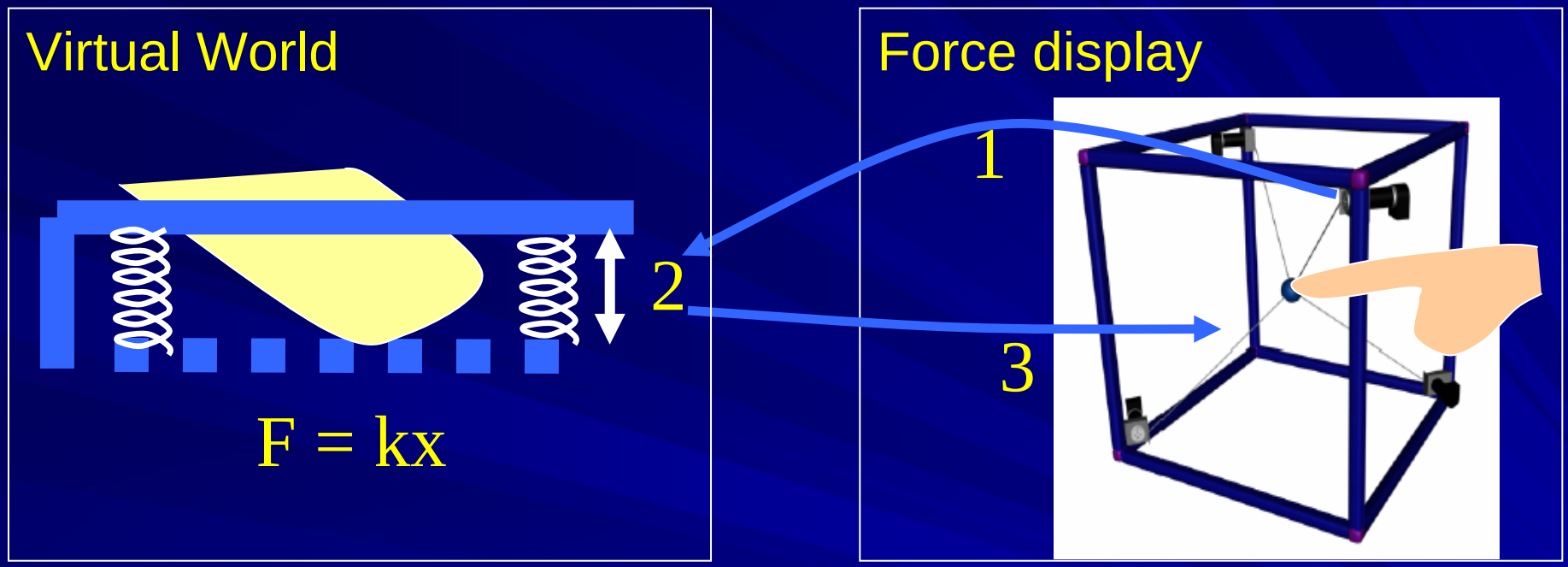
Haptic Human Computer Interaction



SPIDAR is the best device in performance

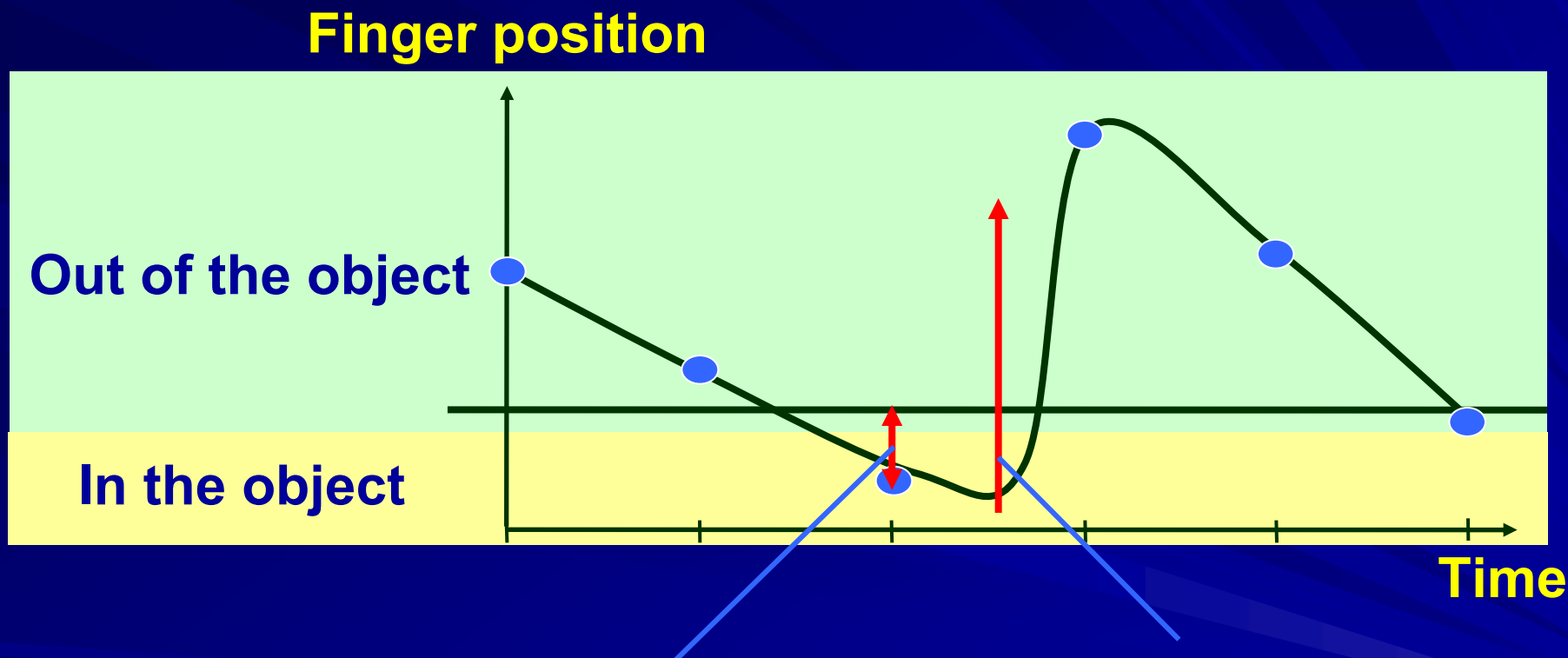
	SPIDAR	PHANTOM
Shape		
Stiffness	20 N/mm	1 N/mm
Weight	10g	75g

Haptic rendering



1. **Measure finger position.**
2. **Collision detection and force calculation.**
3. **Display the force.**

Haptic rendering



Stiff objects (large k)
make too much force

We have combined SPM with a SPIDAR in a virtual reality environment to provide the intuitive display of instrument data and natural control of the SPM instrument functions.

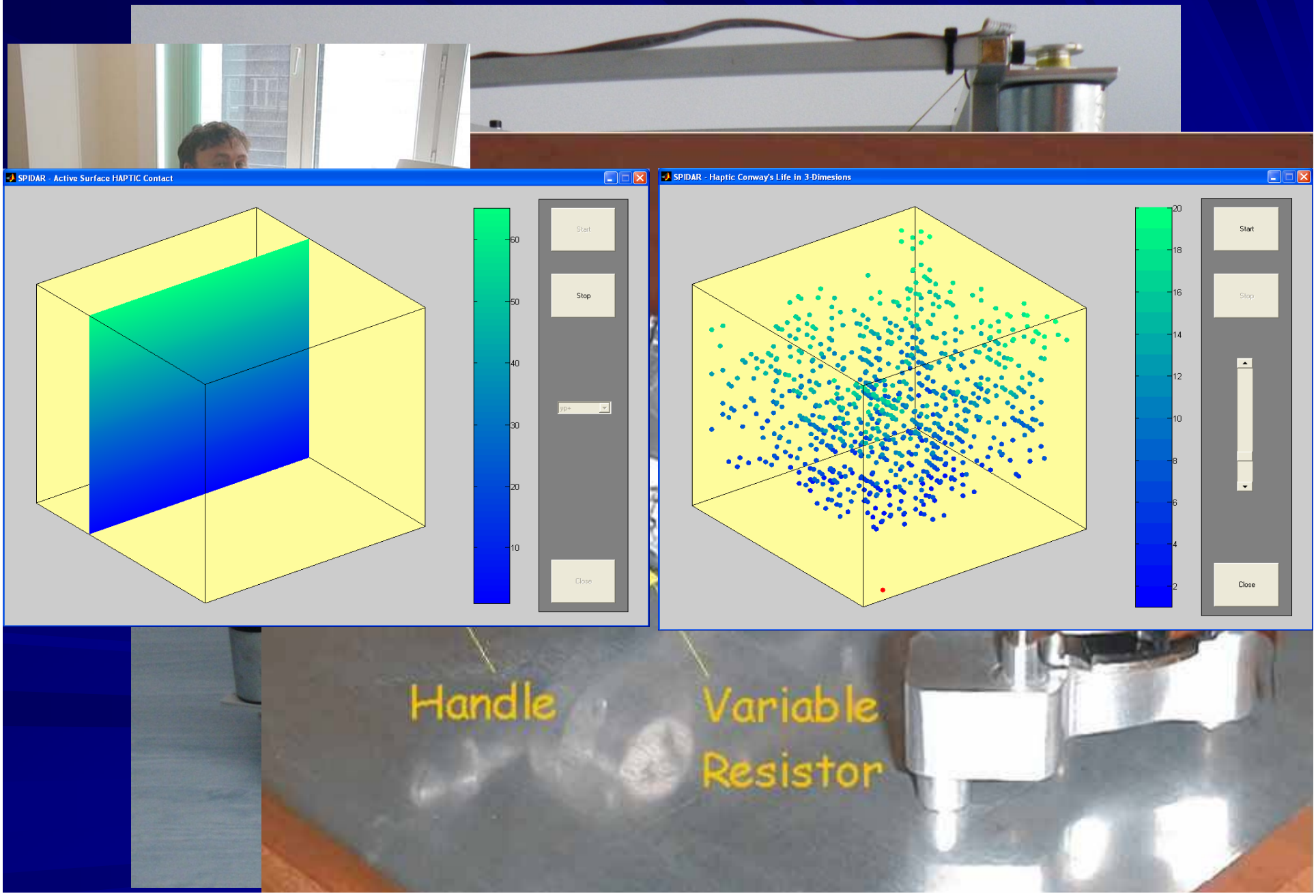
The significance of the virtual reality interface to the SPM is that it gives the scientist simulated presence on the sample surface – NANOWORLD TELEPRESENCE.

There are presented two main areas of results obtained with our haptic interface (SPIDAR):

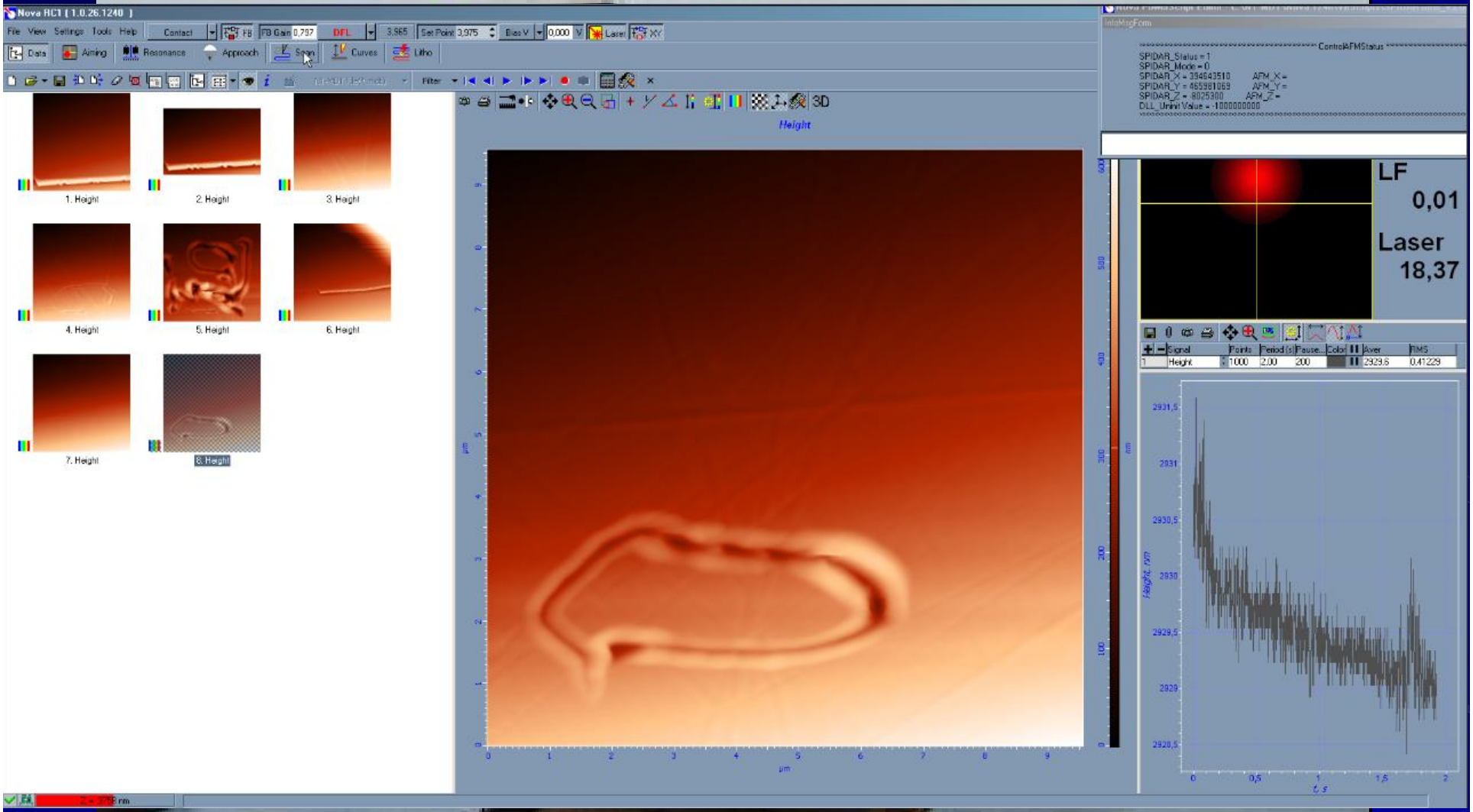
a) using topography information like haptic signal to generate virtual sticky surface sensation;

b) normal cantilever deflection to ensure full interaction between the scientist and the sample.

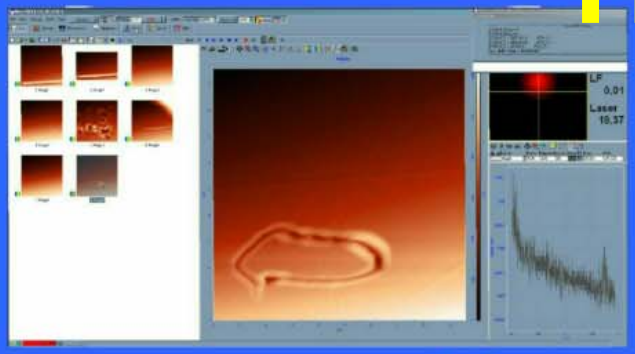
3 DOF haptic device



3 DOF haptic device



AFM - Slave

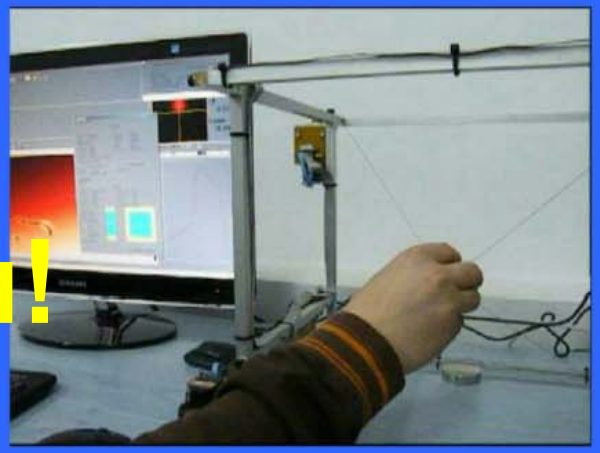


Nanoworld : atomic interactions

POSITION

FORCE

Haptic - Master



Macroworld : force feedback

Thank you!