Report on Demonstration Scenario Specifications

Authors

Date

<div align="right">29th September 2004</div>

Del./Task Identifier	D7.9/T7.5
Work Package	WP7: Demonstrators
Partner(s)	
	TUM, ETH, UNIPI, LSC
Work Package Leader	ETH
Confidentiality Level	

Abstract:

TOUCH-HapSys
Towards a Touching Presence:
High-Definition Haptic Systems

http://www.touch-hapsys.org

Table of Contents

1 Introduction
(TUM)

2 State of Art
(TUM, LSC, ETH, UNIPI)

3 Demonstration Scenarios

3.1 Soft Tissue Interaction Simulator

3.1.1 <mark>Force Feedback of Flexible Objects</mark> (LSC)

3.1.2 Interaction with Deformable Objects Using High – Fidelity Redundant Kinesthetic Display (TUM)

3.1.3 ??Realistic Touch to Virtual Human Organs Using The Magnetorheological Device?? (??UNIPI??)

3.2 Haptic Texture and Pattern Demonstrator

3.2.1 <mark>An Example with Multilevel Display Device</mark> (LSC)

Virtual reality aims at copying real-world data so that little difference can be made between both worlds. To achieve this, multi-modal systems have been developed and most of them return visual data as well as sounds and forces but little return haptic data. However some haptic prototypes have been developed and most are based on either single-actuator devices or matrix-arranged-actuator devices but all aim at rendering tactile data to improve realism and perception (see [KHE04a] for more details).

In tactile rendering (one of the two components of haptic data), returning texture data is useful because added to form data, it informs us about the nature of a surface, its material, etc. Many experiments proved the utility of adding this sense when precision is needed in manipulation tasks such as object displacements, distant surgery, etc.

As part of our research, we've interested ourselves in creating a three-level haptic device returning form, roughness and texture data of virtual objects. The aim of such a device is to return all three types of data to a user for him to feel virtual objects simply by moving the fingertip in virtual environment. The present report gives a brief description of a new multistage haptic device designed for computer's virtual scene interaction and haptic perception studies.

Up to now, few devices could return both kinesthetic and tactile data. Our idea was to create a device able to return both data. That is why we have worked at creating a new device based on three levels able to return form, roughness and texture data corresponding to three different wavelength included in a surface profile as shown in Figure 1.
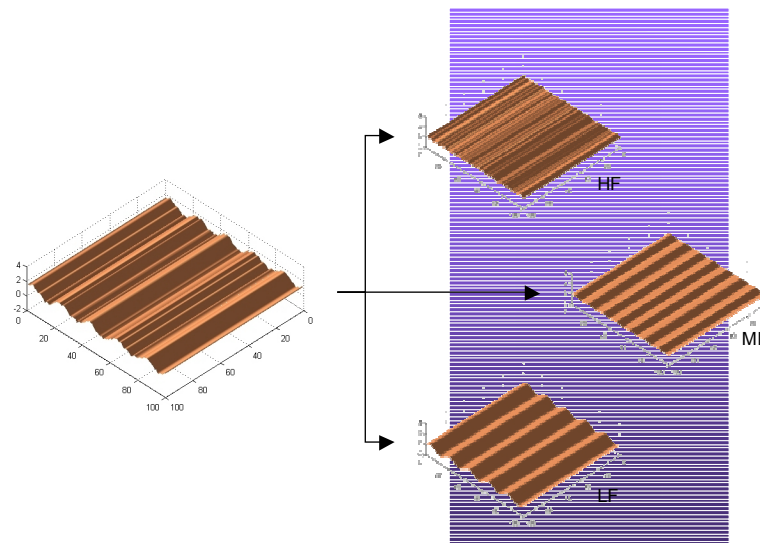
Figure 1: Spectral analysis of a surface profile

Thus, our device is based on a multilevel concept according to surface profiles wavelength distribution (high, middle and low) and to the human perception criterions. Surface information is passed through three main filters where each stage of the device deals with one frequency bandwidth outputted by the corresponding filter. The haptic information rendered is also completed by visual and audio inputs, as illustrated bellow (see [KHE04b] for more details).
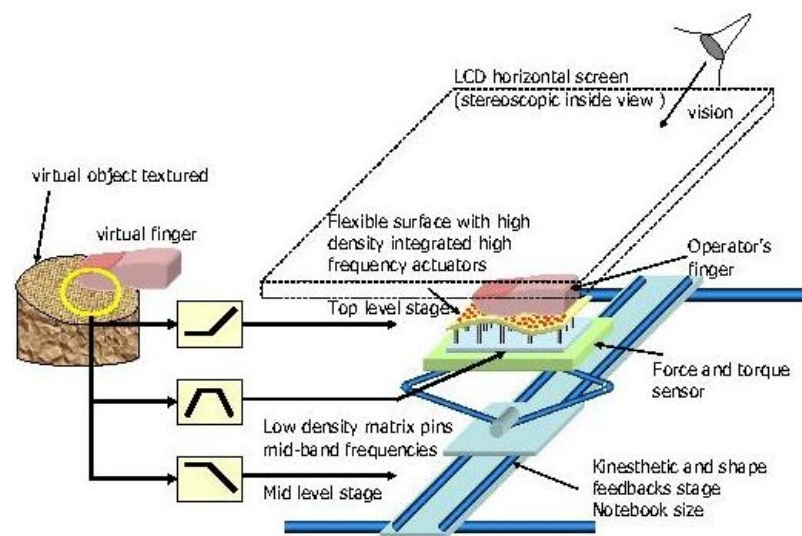

Figure 2: Surface information decomposed and shared on the three stages of the device.

As mentioned in Figure 2, each stage of the display deals with one or more haptic actuation technology best suited to work in one of the three frequencies bands. These stages are:

- The low stage is a pure kinesthetic feedback responsible for rendering the low frequency surface profile data that is to say the surface shape and the geometric features, the contact force reaction and pressure during static contacts including object's stiffness and hardness; thus when exploring virtual surface, the contact forces

are fed back from the virtual surface to the operator finger/hand without obstructing the exploration process.

- The intermediate stage, mounted on the top of the lower stage, is responsible for rendering the band-pass frequencies of the surfaces, that is to say the static and the low dynamics roughness and local shape roughness.

- The top level of the device is responsible for rendering the high frequency surface profile that is to say the fine texture surface and high dynamic roughness. This stage is made of an array of vibrotactile-actuators spaced 1mm apart one another.
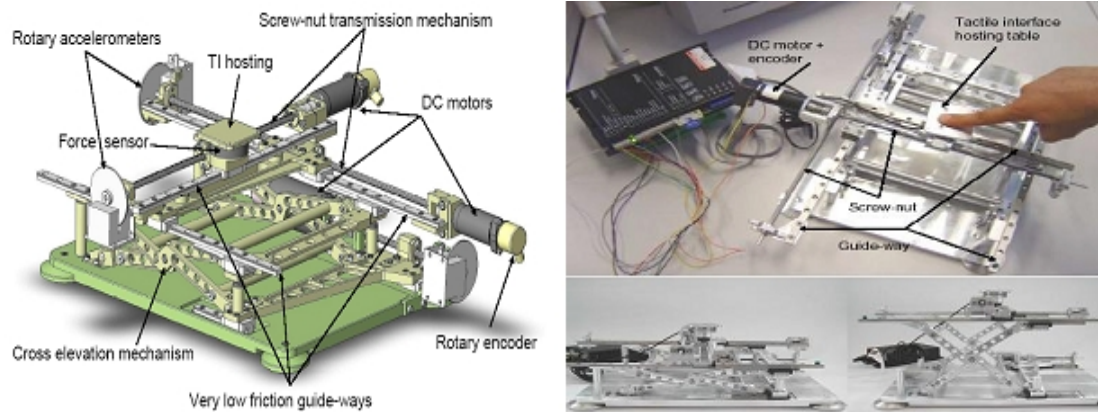

Figure 3: The CAD model of the kinesthetic stage.

As can be seen in Figure 3, the operator is placed on the front of the LCD screen and explores a virtual surface by his hand (projected as a virtual hand within the VE) under the LCD screen. The exploration process is done by moving his fingertip in contact with a flexible membrane on the top stage of the device and under the flat LCD screen.

Such a device will be very useful in medical applications such as distant surgery where tactile information is often needed for diagnostic (i.e. cancerology) and all applications were precise movements are required. For blind people, this device could be used to allow reading books written in Braille on the Internet. By simply moving the finger across the virtual book, they would be able to feel the different "letters". Other applications could be found in textile industry. For instance, such a device could be used to feel a tissue not yet created but just simulated.

Thus, because of its new three-level architecture, many applications can be found for this device in public as well as professional fields.

3.2.2 Virtual Fashion Store – Combination of Tactile Display and High Fidelity Kinesthetic Display (TUM)

3.3 Rigid Haptic Prototyping Demonstrator

3.3.1 Rigid Force Feedback in An Industrial Scenario (LSC)

Nowadays, we are seeing the emerging of a new way to test CADM results: virtual prototyping (VP). However, virtual prototyping, for now, often lony covers offline tests such as physical constraints, or feasibility tests. Other tests, such as assembling feasibility, are

performed only after real prototype creation. It only then that misconception can be uncovered. A typical flow for traditional prototype creation if shown below.
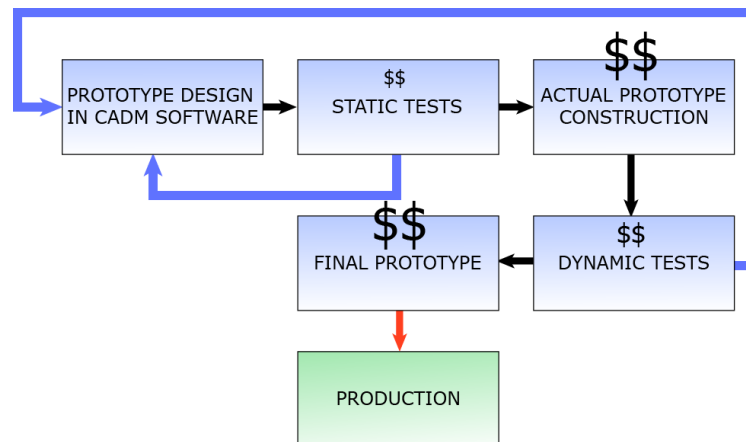
Figure X : Normal production flow

There is indubitably a market for virtual prototyping: it equals more or less the CADM one. Design areas, from kitchenware to car assembly, could use virtual prototyping in a wide range of applications. The cost of a prototype is varying from application to application, but is generally priced more than $1000, and can easily reach $10000. These costs are to be multiplied by the number of prototypes. These costs are far from the cost associated with tradional software. For example, mouting/unmounting car parts are an essential area for car manufacturers, since it directly impacts on costs. If a software could provide a simple and easy way to test such cases before actual constrution, it would be more than welcome by industrials.
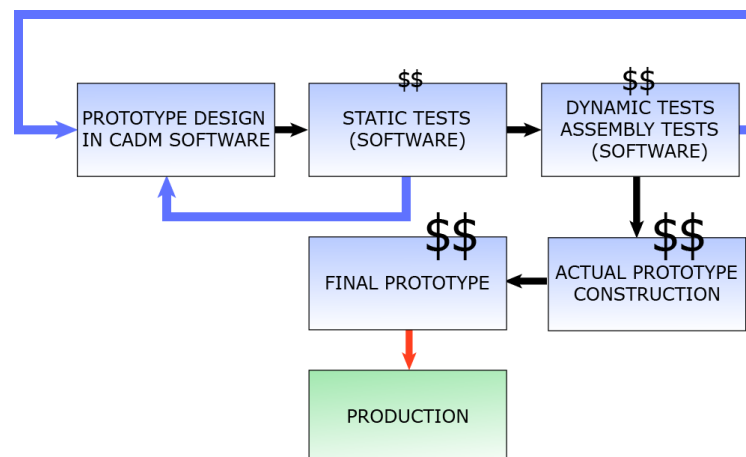
Figure X : accelerated production flow.

As we can see, costs associated with physical construction are totally different in this scenario. We are working, at the LSC, on such a demonstrator, as part of the haptic framework I-TOUCH. Moreover, a also very insterresting fact is that timings are accelerated, which reduces time between design and sales.

We are currently developing a virtual prototyping case, which uses our built-in collision detection, behavior model and haptic proxies. Steps required to create such a program are the following:

- Identify the virtual prototyping tasks and involved objects.

- Import/Export 3D models of these objects from industry internal format (CADM software).

- Configure objects.

- Bind a haptic interface (PHANToM, Virtuose, etc.) to the manipulated virtual object.

- Use default or specify algorithms for physics and collision detection (the choice option is still under development).

- Perform VP tasks within I-TOUCH.

- Measure what ever must benchmark (not yet envisaged).

Of course, I-TOUCH use latests technologies to improve immersion.

Figure 4 : Virtual prototyping with two different haptic devices

The VP scenario consists in mounting/dismounting of a window-winder motor in/out of a car door (the 3D models are kindly provided from RENAULT car industry and the CEA (French nuclear authority)). The operator can test if the window-winder does really fit, and if it is possible to put it in place, accounting for the shape of the door car. What is gained here is the intuitiveness of the operation. The CADM engineer disposes a powerful tool that allows him quick changes of CAD models. Operation timing can also be monitored as well as forecasting maintenance operation procedure and eventual requested tools.

3.3.2 Interactive Bone Assembly (ETH)

3.3.3 Bone Drilling Medical Training Simulator (TUM)

3.4 Interactive 3D Data Exploration System

3.4.1 ??Interactive Segmentation of Volumetric Radiological Data?? (??ETH, UNIPI??)

3.4.2 ??Exploration of Activation Patterns in fMRI Images ?? (??ETH, UNIPI??)

4 Conclusion

(TUM)

5 References

(TUM, LSC, ETH, UNIPI)

[KHE04a] A. Kheddar, "Problems in designing inclusive haptic displays," in *Touch and Haptics Workshop, IEEE/RSJ International Conference*

[KHE04b] A. Kheddar, A. Drif, J. Citérin, and B. Le Mercier, "A multi-level haptic rendering concept," in *EUROHAPTICS*, 2004.

[KHE04c] A. Drif, J. Citérin and A. Kheddar, "A multilevel haptic display design", in *IEEE/RSJ International Conference on Intelligent Robot and Systems* 2004.