The HAPTEX project is working on a new type of computer interface to simulate touch, specifically with fabrics and textures. Imagine the impact this could have for the online experience when used in conjunction with shopping for clothes for instance. It would mean 'feeling' the difference

New interface within touching distance

The daily use of personal computers has accustomed people to experience a variety of animated multimedia content featuring 3D simulations and special effects. Despite the high visual realism of these applications, the way users interact with PCs is still limited to the use of a mouse and a keyboard. However, this old-fashioned and non-ergonomic means of interaction is about to be swept away by novel interfaces which mediate a virtual sense of touch. With this new interface, we could touch many objects from the web, and we could evaluate a dress seen on the website of a famous fashion designer by feeling the surface and texture of the material. But is it possible that we could actually create a device allowing for HAPtic sensing of virtual TEXtiles?

To give an answer to this question is exactly the aim of HAPTEX, an innovative project funded by the 'Future and Emerging Technology' area of the European Union's research funding program (FP6-IST). HAPTEX tackles many challenges in the domains of computer simulation and human-computer-interaction modalities. Its goal is to revolutionise the way we interact with 3D objects, providing a complete virtual reality system composed of a new interaction device connected to a PC running the HAPTEX platform. This system displays a highly realistic three-dimensional model of a square of fabric, which has its dynamic behavior accurately described by its mechanical properties (such as stiffness or elasticity). The user of the system is able to interact with this piece of textile using the HAPTEX interface, which allows feeling its shape and texture, as well as the forces acting on it. This innovative haptic device (haptic refers to the sense of touch) provides both force- and tactile feedback and aims to reproduce the feeling of touching a cloth surface with two fingertips.

This system displays a highly realistic three-dimensional model of a square of fabric, whose dynamic behavior is accurately described by its mechanical properties

Users of the HAPTEX System can perform textile handling actions such as touching, stroking and stretching the virtual garment, selecting the simulated textile from a range of samples and feeling the different physical characteristics between them.

But HAPTEX is not limited to the applications in the textile industry area. Through the achieved progress in multimodal interaction tools, techniques and know-how, this project is destined to influence the long-term evolution of human-computer-interfaces. Moreover, the mass production of the technology developed within the HAPTEX Project would have a significant impact on the online shopping markets, where the use of the HAPTEX System would bring the texture of the products literally to the fingertips of internet users.

In order to bring its innovative technology to the popular domain, the HAPTEX Consortium is very active in disseminating the project results and demonstrating visual and haptic simulation. The project partners regularly organise and participate in research conferences, PhD seminars, networking workshops and public events. Moreover, the HAPTEX website and newsletter provide regularly update information about the project itself, the milestones reached and the future work.

A closer look at the research

The research concerning new ways of rendering virtual objects both visually and haptically in a fast and stable way represents a particular challenge when dealing with physically based, complex deformable objects. In this field, researchers need to reproduce the object's aspect and behaviour in a physically accurate way and provide a simulation model able to calculate the deformations of the object occurring during interaction. Typically, the simulated interaction is tool-based, i.e. the user interacts with the object indirectly, feeling the forces arising during manipulation only at one specific point.

Complexity increases in the case of multipoint interactions, as collisions and deformations must be computed for each contact point. Direct haptic interaction, e.g. the simulation of the real contact between the human hand and a deformable object, is very demanding not only because of the number of deformations arising all over the contact surface and affecting each other, but also because of the technical difficulties in rendering the contact forces over a distributed area. HAPTEX tackles direct multipoint interaction, providing haptic feedback directed both to the skin of the fingertip (through tactile stimulation

arrays) and to the muscle spindles and joints (through force-feedback actuators).

A particular highlight of the HAPTEX System is that both the visual simulation and the haptic rendering are based on the physical properties measured from real textiles. Modeling the behavior of textiles is a complex task because of its dependency on several parameters such as flexibility, compressibility, elasticity, resilience, density, surface contour (roughness, smoothness), surface friction and thermal character. The process of handling fabrics to understand their properties and structure is called 'fabric hand'. Understanding the way people are used to handling the objects to simulate (in this case, textiles) is of crucial relevance for designing and developing a haptic system. The HAPTEX approach is to analyse all perceptual and practical implications of fabric hand, in order to derive a set of requirements to the system. From these ideal requirements, the system is realised according to the possibilities offered by today's technology. The research and developments done in the context of the HAPTEX project cover textile measurements, real-time cloth simulation, tactile interfaces, force-feedback devices, haptic rendering (both tactile and force-feedback) and the integration of the complete haptic system.

The partners involved in the HAPTEX are coming from different research areas, including textile engineering, computer graphics/3D simulation, fashion design, perceptual robotics, and biomedical physics

Definition of the components of the HAPTEX System:

Measured physical parameters: The 'Kawabata Evaluation System for Fabrics' (KES-F) is one of the main standards in the field of objective measurements of fabric hand. The KES-F equipment is able to test for textile properties and extract physical parameters of textiles. These vary depending on the fibre type or fabric type and dimension. Alternatively, other equipments such as tensile testers can be used to obtain specific physical parameters of fabric samples.

The physical parameters are used by the cloth simulation, the tactile renderer and the force-feedback renderer. Specific measurement modalities have been developed, in the context of HAPTEX, to comply with the specific needs of the different domains in which the measured parameters are used. Cloth simulation: The HAPTEX textile simulation is driven by a mechanical model which takes as input part of the mechanical parameters obtained from measurements on fabrics.

The simulated piece of textile is approximated as a thin surface and its mechanical behavior is decomposed in in-plane deformations (the 2D deformations along the cloth surface plane) and bending deformation (the 3D surface curvature). The main challenge consists in defining a mechanical model which is able to represent accurately the complex anisotropic nonlinear mechanical behavior of cloth, but still is able to perform in real time, using a simulation technique offering the best trade-off between computational speed, accuracy and robustness.

Tactile component: Time-varying spatial distributions of touch stimuli are provided by arrays of moving contactors on the tips of the user's thumb and index finger. Each array has 24 contactors in a six by four pattern with two mm spacing.

The contactors are provided with piezoelectric drive mechanisms which have a maximum output of around 100 µm and a working bandwidth of 20–500 Hz, designed to match the response of touch receptors in the fingertips.

During active exploration of a virtual environment, tactile-rendering software provides the arrays with 48 channels of

Fingers are inserted into the device, through which touch stimuli provide information about the contact being made with the object

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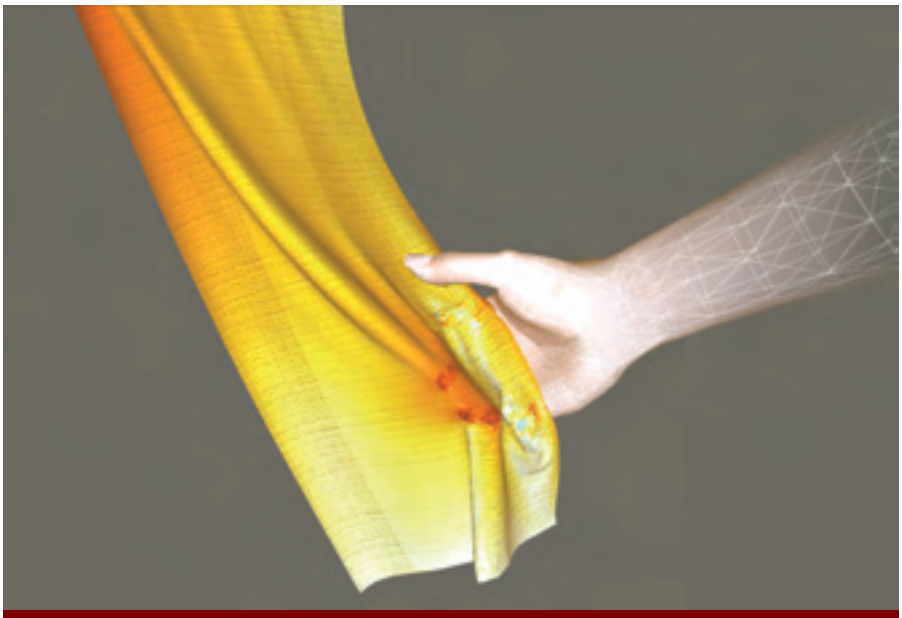

The corners, edges and surface texture of a virtual object can be felt with the device

drive signals, specified on the basis of a software model of the finger/object interaction.

The resulting touch stimuli provide information about finger/object contact area and about edges, corners and surface texture of the virtual object.

Force-feedback component: The force-feedback device returns to the user the forces acting on the manipulated piece of textile. A force-feedback renderer takes care of the computation of forces to be returned on the basis of the mechanical model of the cloth simulation.

The force-feedback device also hosts the tactile component. Different configurations of the force-feedback component have been realised in the context of the HAPTEX Project to study the compromise between feasible and optimal configurations.

An integration of force-feedback device and tactile arrays has been successfully achieved. The resulting interface is capable of rendering forces and tactile stimuli at the same time.

All components of the HAPTEX System represent a significant advance with respect to the current state of the art. Surely, before actually developing a final product for the market, further research and testing is needed? However, encouraging preliminary results have been obtained from a comparison of real and virtual fabrics, in terms of their tactile aspects.

In this case the experimental scenario involved exploration of real and virtual samples stretched on a horizontal table, using only the index finger of one hand. An evaluation of the visual system has also provided good results. Evaluation of the full functionality of the whole HAPTEX system is planned for the coming months.

As a truly interdisciplinary research effort, the partners involved in the HAPTEX are coming from different research areas, including textile engineering, computer graphics/3D simulation, fashion design, perceptual robotics, and biomedical physics.

The integration of components of different nature into one single system using real parameters to simulate a highly complex deformable material such as textile in a physically based way at different sensorial levels simultaneously make the HAPTEX System a truly unique platform for experts and the general public with which to experiment and experience novel communication modalities.★

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At a Glance

HAPTEX
HAPtic sensing of virtual TEXtiles

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