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MANUFACTURING OF HAPTIC TEXTURES TRANSMITTING PREDETERMINED FEELINGS AND EMOTIONS

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Abstract: *Textures are widely present in our daily life. In the last years many researchers have focused their efforts on the study of tactile texture perception as a result of their expanding interest in the fields of psychophysics, neuroscience and computational modeling. This increasing interest is partly because of the many applications where tactile sense could play a crucial role as, for example, product design. Despite the wide use of haptic textures there is a lack of scientific studies on the emotional qualities and expectations associated with specific textures. In order to fill that gap, a project financially supported by the EC, aimed at providing methods and a theory to objectively measure, model, and predict psychological effects evoked by haptic textures.*
Key words: *Rapid prototyping, Emotional design, Customization*

1. INTRODUCTION

Textures are widely present in our daily life. For instance, they are used in industrial design, architecture, arts, computer hardware, etc. In the last years many researchers have focused their efforts on the study of tactile texture perception as a result of their expanding interest in the fields of psychophysics, neuroscience, and computational modelling (LaMotte & Srinivasan, 1991), (Connor & Johnson, 1992), (Lederman & Klatzky, 2006). This increasing interest is partly because of the many applications where tactile sense could play a crucial role as, for example, product design. Numerous consumer goods are likely to be touched by human skin, so it would greatly affect customer's final decision of whether they would purchase the product or not.

Despite the wide use of haptic textures there is a lack of scientific studies on the emotional qualities and expectations associated with specific textures. In order to fill that gap, a new project (SynTex) was supported by the European Commission through the Sixth Framework Programme. SynTex project aimed at providing methods and a theory to objectively measure, model, and predict psychological effects emerging from the touch of textures. A method to synthesize textures specified to evoke certain emotions was developed.

2. PROJECT DESCRIPTION

The project aimed specifically at developing:

- A computational model of human texture perception and interpretation based on neurophysiological and psychological experiments.
- A new investigative method on how to assess and model human interpretation of visual and haptic textures.
- A set of algorithms able to synthesize artificial textures that will be associated with a defined set of emotions.
- A set of artificially generated textures designed to bias the experience of 12 different emotions and the psychological evaluation of these textures

The project team included a wide variety of experts from many fields. It was coordinated by the machine vision group of the Austrian Technology Center PROFACTOR. Some of the experiments (Functional magnetic resonance imaging - fMRI) were performed at the Neuroimaging Centre of the University of Groningen, that participated through the Laboratory of Experimental Ophthalmology (LEO) and the Neuroimaging Centre of the School for Behavioural and Cognitive Neuroscience. Another set of experiments were performed by the ISIS group of the University of Amsterdam. The "affective engineering" scope (Nagamachi, 1995) was incorporated by the Affective Design Research Group of the University of Leeds. The mathematical part of the team was represented by the Department of Knowledge-Based Mathematical Systems of the Johannes Kepler University of Linz. The synthesis of the samples for the tests was performed by Fundacion PRODINTEC, which has equipment for rapid prototyping, micromilling, vacuum casting and laser sintering. These samples were then applied to standard laminates, manufactured by the Austrian company Fundermax.

The project was scheduled around three cycles of psychological and neurophysiological experiments combined with a concurrent development of a computational model. The modeling started from a model based on existing knowledge (on texture perception), and was focused on filling major mathematical gaps (rather than gaps in psychological understanding). Fuzzy logic was incorporated to account for the inherent fuzziness of emotions. From the results of the modeling process, a number of textures were synthesized and used for testing.

Synthesis of textures served two purposes in the project. It included on the one hand the production of samples that could be used in the experiments and on the other hand the development of synthesis algorithms able to create textures for certain feelings or expectations.

For sample production, rapid prototyping, mechanical micromilling and layer manufacturing (laser sintering and 3D printing) were used to create stamps for tactile textures.

- Mechanical micromilling processes are naturally downscaled versions of the macro-level processes. In these processes, the tools are usually in direct mechanical contact with the workpieces and, therefore, a good geometric correlation between the tool path and the machined surface can be obtained (Case et al, 2004) (Takács et al, 2003). An ultra-precision Computerized Numerical Control (CNC) machining centre (Kern-microtechnic GmbH) was used. This equipment is specially designed for applications requiring highest precision on the workpiece (deviation of position ± 0.5 μm), excellent surface quality (Ra < 0.1 μm), and high speed and feed rates.
- Layer manufacturing comprises a set of different technologies used to directly fabricate, layer-by-layer, physical models from 3-D computer aided design (CAD) solid models (Mansour & Hague, 2003). Since there is not any interference between tools and formed parts, these techniques are capable to create parts of any geometry and

complexity, which usually cannot be machined by traditional CNC technologies. Furthermore, they produce durable models with outstanding surface finish and fine details. Haptic textures needed for the project were synthesized by using LMT. Particularly, 3D printing (PolyjetTM-based system) and direct metal laser sintering (DMLS) techniques (Santos et al, 2006) were used. 3D printing equipment (Objet-Eden330) uses a UV light to cure a photosensitive liquid into a solid plastic part. The DMLS equipment (EOS GmbH) works in a similar way to 3D printing but, however, uses a powder rather than a liquid photopolymer as its build medium enabling the production of functional parts directly from a wide range of materials such as stainless steel, Titanium, metal alloys, etc.

These textures were used in an imprinting process to create laminate boards with a specific visual texture and a specific tactile texture. 576 different combinations of visual and tactile textures were produced.

Synthesis algorithms for textures were used to create visual and tactile textures that have specific properties. At the start of the project existing texture synthesis algorithms were used to generate textures. These methods were extended with the capability to mix two or more sample textures. Finally a feature-based synthesis algorithm that is able to create textures for specific perceived properties was developed and tested.

3. RESULTS AND DISCUSSION

After all experiments, a model was defined that is able to predict the rating of visual and tactile textures and their combination with respect to the following 12 properties (6 pairs of antonyms):

like – dislike
simple - complex
natural – artificial
elegant – not elegant
warm – cold
rough – smooth

The model consists of two parallel paths, one for the visual model and one for the tactile model. The inner structure of both paths is quite similar, starting from low-level feature with a multilayer structure up to high-level emotional properties such as "like" or "dislike". The evaluation of the model in the final round of experiments showed a correlation between the prediction and the experimental results of around 0.8, with "warm-cold" achieving the best results (>0.9) and "natural" the lowest (0.71).

Regarding the synthesis of haptic textures, 576 different samples were created (100x100 mm) by silicon moulding (vacuum casting) in combination with rapid prototyping. These samples were used by the manufacturer of the laminate boards for imprinting the tactile textures.

A general issue with tactile textures is the fact that there was a difference between the CAD files and the actual imprinted tactile texture. While this did cause some problems with controlling the actual physical properties of the textures, the major problem could be resolved by measuring the actual topography of the samples so that these data could be used as input to the model (instead of CAD data). Also, the characteristics of the materials of the samples used for manufacturing the boards were initially not appropriate, so much effort was needed to find suitable alternatives of materials and also to change and adapt the manufacturing process of the boards.

4. CONCLUSIONS AND NEXT STEPS

- For the set of features implemented in the samples, good correlations were achieved for some perceived properties and feature groups. This opens the path for manufacturing parts which will transmit predetermined feelings and emotions.
- A manufacturing process for putting these specific features on products that will be on the market was designed and tested, even though there is still much work to be done to generalize this process to many different types of products.
- Although much work is still needed, the results prove that it will be possible to design visual and haptic textures to transmit predetermined feelings, and that the manufacturing of products incorporating these textures will be possible.

5. ACKNOWLEDGMENTS

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