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3D geometric and haptic modeling of hand-woven textile artifacts

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3D Geometric and Haptic Modeling of Hand-Woven Textile Artifacts

by

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" Man is the supreme Talisman. Lack of a proper education hath, however, deprived him of that which he doth inherently possess. Through a word proceeding out of the mouth of God he was called into being; by one word more he was guided to recognize the Source of his education; by yet another word his station and destiny were safeguarded. The Great Being saith: Regard man as a mine rich in gems of inestimable value. Education can, alone, cause it to reveal its treasures, and enable mankind to benefit therefrom."

Baha'u'llah

To my Mum

CERTIFICATION

I, Hooman Shidanshidi, declare that this thesis, submitted in fulfillment of the requirements for the award of Master of Engineering by Research, in the School of Electrical, Computer and Telecommunications Engineering, Faculty of Informatics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Hooman Shidanshidi

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Abstract

Haptic Modeling of textile has attracted significant interest over the last decade. In spite of extensive research, no generic system has yet been proposed. The majority of the haptic models developed in the previous work assume a 2D mesh model for the textile which does not represent the real geometric configuration of the textile. In addition, they are based on empirical parameters obtained from textile samples using specialized instruments. The process is often time consuming and elaborate, consisting of manual measurement of physical and mechanical properties of the artifacts. The development of a generic approach for 3D haptic modeling of hand-woven textile artifacts is pursued in this work.

In the proposed approach, the textile pattern and structure are recognized by digital processing of the artifact still image. A fuzzy-rule based expert system is developed to perform the recognition process. The data obtained in this process is employed to automatically generate the 3D geometric model of the artifact in VRML. The mechanical properties of the artifact are estimated by processing the textile geometric characteristics and yarn properties in a neural network system. These mechanical properties are then deployed in the construction of the textile mechanical model. The mechanical model is superimposed over the 3D geometric model to construct the haptic model. The proposed system is validated through both subjective and objective methods using a number of artifact samples.

An extensive review of the published literature on the haptic modeling of textile is provided in the thesis. The benefits of textile haptic modeling are identified. Applications of existing models are reviewed and the significance and unique contribution of the work is presented.

The image processing method and the fuzzy rule based expert system deployed in the construction of the geometric model are described in detail. The outcome is a 3D geometric model of the artifact in VRML which could be explored in a virtual reality world viewer. Similarly, the neural network model designed to estimate the mechanical characteristics of an artifact is presented the results of the training and validation of the model are provided.

Finally, two methods developed for the haptic model based on geometric and mechanical models in the Reachin are explained. The accuracy and effectiveness of the overall approach are validated through a series of experiments.

Overall, the work conduced in this study offers a novel 3D generic haptic modeling for textile artifacts. It can be deployed in museums providing an opportunity for the visitors to touch unique samples of hand-woven textile artifacts. The approach is cost-effective, reliable and reproducible as the haptic modeling of these samples does not need time-consuming and costly laboratory conditions.

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