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A digital garment simulation tool for fashion design linking consumer preference and objective fabric properties

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Executive summary

The project has proved the concept of connecting consumer’s sensory preferences for a garment’s drape and touchfeel to the fabric’s objective qualities in a computer simulation model.

1. Research Challenge

The aims of the project are to develop an intelligent digital tool for visualisation of the responsive garment deformations associated with fabric draping and tactile properties (for example, softness, sponginess, flexibility, crispiness and smoothness) based on measured fabric buckling properties; the consumer subjective feelings and objective tactile properties are associated using machine learning algorithms. Specifically, the objectives were:

1. Establishment of a fabric simulation models based on fabric buckling properties.

2. Build up fabric simulation models incorporating tactile comfort descriptors as input parameters.

3. To incorporate artificial intelligence (AI) into the fabric simulation model to enable the machine learning from human preference of tactile sensation of garments.

4. To objectively verify if the novel fabric simulation has a better performance by comparing static and dynamic fabric drape properties.

5. Develop sustainable relationships between ECRs and SMEs enabling high impact future funding.

2. Approach

The ultimate objective of the project is to study the feasibility of associating computing visualisation of fabric deformations with tactile properties (softness, sponginess, flexibility, crispiness and smoothness) based on measured fabric buckling properties. This is achieved by using objective tactile characteristics as input parameters for a new established simulation model. We devised a new methodology that the fabric elastic and plastic features extracted from measured fabric buckling property data were used as input parameters to optimise the buckling simulation model. This significantly reduced the complexity of the simulation model and enabled the model to be based on mechanical theories rather than vaguely using artificial intelligence (AI) training methods.

We also intended to link human preference of fabric touch sensation with objective fabric tactile properties, which could be achieved by using Artificial Intelligence (AI) as we did not know how well the objective fabric tactile properties and subjective touchfeel are linked. In parallel with the progress of this project, it was found from an industry funded study that the objective fabric tactile properties measured using LUFHES are highly linked with data collected from an expert panel on the subjective touch feel of fabrics. These results suggested that there is a simpler and possibly more robust way of incorporating AI to link objective tactile properties and subjective touch feel in simulation, thus the proof of the concept concerning whether artificial intelligence (AI) could be incorporated into the fabric simulation model in this feasibility study project would be excessive. Therefore, Objective 3, “To incorporate artificial intelligence (AI) into the fabric simulation model to enable the machine learning from human preference of tactile sensation of garments”, will be left as a major goal of a bigger project as a continuation of this feasibility study.

3. Results

Objectives 1 and 2: Establishment of a suitable fabric simulation model based on fabric buckling properties and incorporate objective tactile characteristics as input parameters

The existing garment simulation software available (Clo3D, Optitex, Lectra, Brozwear, Poser, Designer 7, etc) and the devices used to measure fabrics properties, the existing fabric analytical models used in fabric simulation with and without incorporating fabric buckling deformations were reviewed. It was concluded that Finite Element Analysis (FEA) software (e.g., Abaqus, DYLA, etc) is the best platform to prove the concept of fabric buckling properties based on mechanics theories. In this research, Abaqus is used for this purpose.

Fabric elastic-plastic models were established in Abaqus, fabric linear and non-linear buckling deformation models were established for pre-buckling and post-buckling deformations respectively. Buckling deformation behaviours of fabrics having various elastic-plastic properties were examined systematically, and the differences of their fabric dynamic deformations due to input elastic and plastic properties were compared and validated. A unique algorithm for optimising the simulation models using measured fabric buckling data were developed, and designated errors were found to be achieved within a reasonable number of iterations (20 – 30 iterations) of the simulation cycles for each input elastic and plastic parameters.

With this new approach, because both objective tactile indices and the visual simulation of the fabric buckling deformations are now produced from the same set of fabric buckling deformation data, the fabric tactile properties and fabric visual deformations are determined from one set of unified experimental data. Therefore, the fabric visual effect, tactile properties and subjective touch feels are thus inherently associated together.

Objective 3: To incorporate artificial intelligence (AI) into the fabric simulation model to enable the machine learning

As we have validated the significant linkage between fabric tactile properties and subjective touch feel of fabrics in a separate project, this conclusion suggests that there is a simpler and possibly more robust way of incorporating AI to link objective tactile properties and subjective touch feel in simulations. The 'proof of concept' of whether artificial intelligence (AI) could be incorporated into the fabric simulation model becomes excessive in this feasibility study project. This work package will be left as a major goal of a further research project as a continuation of this feasibility study.

Objective 4: Objective evaluation of the effect of the novel fabric simulation models

We have designed an appropriate validation method to quantify objectively the differences of the fabric simulation and the fabric deformations produced in experiment.

The buckling deformations of a fabric shell in experiment can be recorded by a digital video camera and digitalised as a set of small component elements. The distance of each element to the z-axis of the fabric shell in the simulation model obtained from FEA can be compared with that of the elements from the digitalised experimental model of the fabric shell. The minimum of the sum of the absolute differences of the two fabric shells are used to quantify the differences of the geometric shape of the two fabric shells in experiments and simulation.

4. Future funding

This research supported Leeds' successful bidding of AHRC Creative Industry Clusters programme in 2018, a funding of £5.4million for a Future Fashion Factory project to digitalise fashion/textile industries in the Leeds area, further research collaborations with Burberry, Royal College of Arts, and local textile industry partners are also in discussion.

5. Papers and Presentations

The outcomes of the research have been disseminated at the Conference Everything Conferences in Newcastle in 2018 and Nottingham in 2019. Conference and Journal papers regarding the relationship between fabric tactile properties and subject touch feel were published in Materials as well as presented at the Textile Institute World Conference 2018.

6. Feasibility study team members

The study was conducted by a team of researchers from the **University of Leeds**

Dr N Mao, Performance textiles
Dr N Morrison, Simulation of fluid dynamics
Dr H Wang, Computer graphics and animation
Dr Z Zhang, Wearable sensing and big data

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