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Development of a Hand Template Model for Ergonomic Grip Design

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SUMMATIVE STATEMENT

A posable, scalable, and deformable 3D hand template model which can be efficiently used for post-processing and feature extraction of 3D hand scan is developed for ergonomic grip design. The meshes of body surface and bones, joint centers, a link structure, skinning weights, segments, and landmarks are incorporated as the components of the hand template model.

KEYWORDS: Hand template model, Template registration, Hand scan data, Grip design

PROBLEM STATEMENT

A grip needs to be designed ergonomically for better usability during manual work. 3-D hand scan data can be applied to the design of the grip, but an efficient method of extracting hand features from a digital hand is needed for designing an ergonomic grip. Human body template models have been developed for the post-processing (e.g., hole filling and smoothing) of body scan data and the analysis of the postures and sizes of body segments with high efficiency. The development of a hand template model considering the anatomical and biomechanical characteristics of the hand is needed for efficient digital hand data processing.

RESEARCH OBJECTIVE

The present study is intended to develop a 3-D hand template model which is capable of (1) registration of hand scan image, (2) posture analysis of hand scan, (3) automatic measurement of hand dimensions, and (4) posture control and surface deformation of the hand scan image in the anatomical standard posture.

METHODOLOGY

Several components and techniques have been incorporated to the hand template model in the present study. First, a CT-scan based skeletal structure has been established for a posable hand model. Second, template registration techniques such as algorithms of correspondence pair generation and iterative closest point registration have been applied to the hand model. Third, the dual quaternion skinning method has been applied for nature skin deformation to the hand model. Lastly, a hand landmark-based automatic measurement of hand dimensions has been applied to extract the features of the hand model in a particular posture.

RESULTS

The hand template model consisting of 16 segments, 17 joint centers of rotation, and 19 links has been developed as shown in Figure 1. The root-mean squared error (RMSE) of registration between the deformable hand template model and the corresponding hand scan data was found 0.5 mm on average.

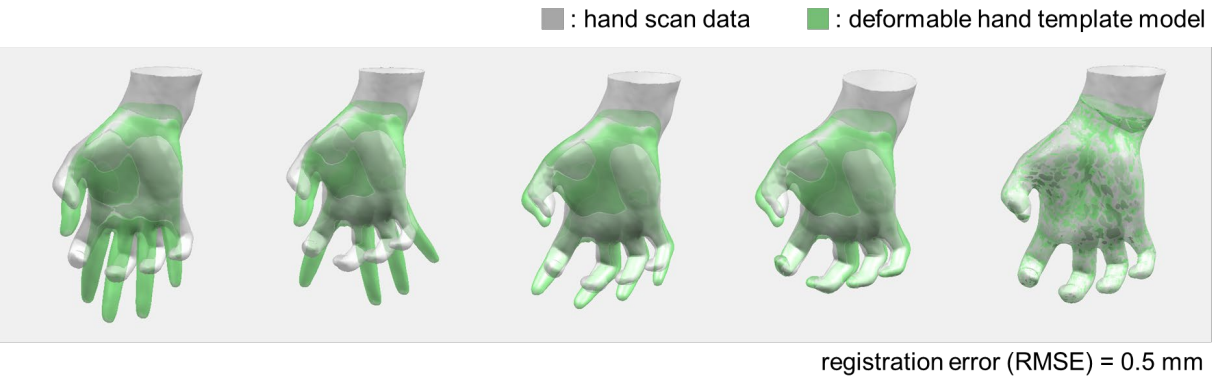

Figure 1. Registration of deformable hand template model to hand scan data (illustrated)

DISCUSSION

The present study developed a 3-D hand template model specialized for grip design based on the preliminary studies. The study proposed a process for aligning the hand template to a 3-D hand scan data with a particular hand size and in a particular grip posture. An automatic measurement of hand dimensions and a posture analysis was proposed as methods of applying a hand template model for ergonomic grip design. The developed hand template model can improve the utility of 3-D hand scan for grip design by changing the posture and shape of the static hand scan measured in the standard posture. Ergonomic analysis results using the developed hand template model needs to be verified.

CONCLUSIONS

The 3-D hand template model developed in the study can provide efficient post-processing results of hand scan in terms of size, shape, and posture for ergonomic grip design. The hand template model is expected to improve the usability of product as well as the applicability of 3-D hand scans to ergonomic grip design.

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