A Novel Approach for Determining Glove Area Factors Based on the 3D Scanning Technology

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Abstract

The clothing area factor (f_{cl}), which is the ratio of the clothing surface area to the body surface area, is an important parameter in the analysis of heat transfer between clothing and thermal environments and measurement of clothing thermal properties. Traditionally, f_{cl} was measured by a photographing method, which potentially underestimates it due to the loss of information converting three-dimensional (3D) objects into two-dimensional images. Recent advancement in 3D scanning techniques has made it possible to quantify the 3D geometry of the nude and clothed human body and the developed air gap of the clothing microclimates. However, so far, there exists no essential data related to the glove area factor (f_{gl}). Actually, the hand has a significantly large surface area to volume ratio, making it especially susceptible to heat loss, specifically under different environmental conditions. Without accurate f_{cl}, it is impossible to determine the thermal properties provided by the glove properly. Consequently, better protection and enhanced work performance, health, and safety of human beings are hindered.

This study aimed to determine the area factor of gloves used by a wide range of occupations by a 3D body scanning approach. A hand-held 3D laser scanner (HandySCAN 3D™ Black, Creaform, Québec, Canada) was used to obtain the 3D geometry of the nude and gloved hand manikin. The hand manikin applied has a 50th percentile western male hand size. Total 53 gloves (right hand) were investigated, including firefighters' protective gloves, light-duty work gloves, anti-vibration gloves, cold weather protective gloves, and chemical protective gloves. Geomagic Studio 12 software (Geomagic, USA) was used to smooth, overlap, and align the nude and gloved hand model, as shown in Figure 1. After alignment, the surface area of the nude and gloved hand manikin was identified, and the corresponding f_{gl} was calculated.

It was found that f_{gl} ranged from 1.02 to 1.67 and varied significantly by glove types. The f_{gl} averaged 1.39, 1.07, 1.28, 1.60, and 1.28 for firefighters' protective gloves, light-duty work gloves, anti-vibration gloves, cold weather protective gloves, and chemical protective gloves, respectively, indicating a significant occupational difference. Typically, The calculated f_{gl} for firefighters and cold weather protective clothing is greater than the corresponding f_{gl} suggested by ASTM F 1291-16 standard. These results obtained contribute to the accurate measurement of thermal properties of gloves and the development of comfort models, which ultimately contribute to the engineering of high-performance gloves. Future studies include applying the developed approach to investigate and study glove design, material application, and performance analysis for next-generation glove development.

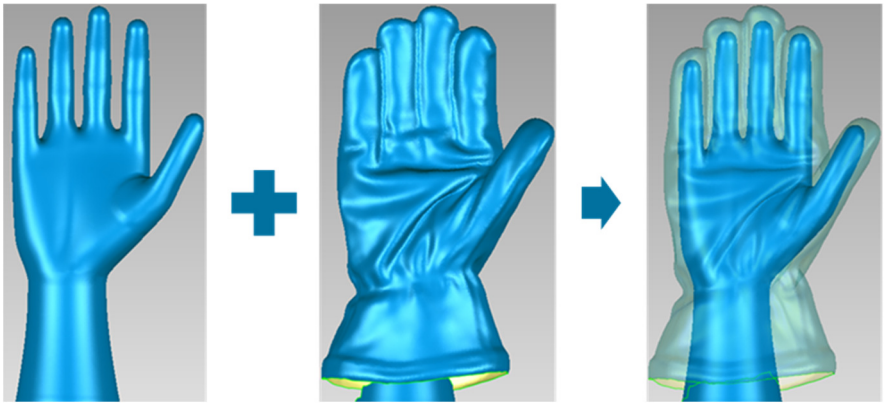

Figure 1. Alignment of the nude and gloves hand manikin.

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