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A Predictive Model Estimating Anthropometric Measurement Changes in Pregnant Women

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Introduction: Pregnant women are a special population where notable anthropometric changes occur between the periods of gestation and delivery. Measurements of the body, specifically, in the lower torso region change significantly, and these changes need to be considered while designing a user-centric product, especially maternity wear. It is predicted that by 2023, the global maternity apparel market will reach $7 billion (ReportBuyer, n.a). A previous study (Ho et al, 2009) suggested that maternity apparel should be functional, comfortable, safe, aesthetically pleasing and easy to don and doff. Since apparel is highly associated with self-image, pregnant women who are employed outside the home prefer apparel that offers a professional appearance alongside maintaining their self-image. It is apparent that the dynamics of size change in pregnant women had to be considered to attain an optimally fit garment. However, considering the existing maternity apparel market, reports (Ogle, Tyner and Tomschin, 2013) suggest that pregnant women were not able to find well-fitted garment, and have expressed dissatisfaction. The sizing chart and the grading rules followed for pregnant women are not reflecting the anthropometric changes of the pregnant women to a desired level of accuracy. One of the primary reasons for this deficit in the sizing chart is the lack of data on pregnant women anthropometry. Thus, the purpose of this study is (1) to document the anthropometrical changes in a sample population of pregnant women, starting from gestation to delivery and (2) to develop a statistical predictive model estimating the measurement changes that can be applied for product development.

Data Collection: 3D body scans of 12 subjects scanned at five different times throughout their gestation period were used in this study. The subjects were scanned using a Cyberware WB4 whole-body scanner. The first scan was completed before any surface anthropometrical changes had started due to pregnancy. From the scans, three key measurements (bust, waist and hip) were manually extracted using the Polyworks V14 tool. These measurements location was determined in accordance to the ASTM maternity sizing chart definition. In the data extraction process, scans from each subject were aligned with reference to the ground plane, and the measurement locations identified from the first scan were propagated through the subsequent scans of the individual. The extracted measurements were then used for developing the statistical predictive model.

Analysis and Results: The anthropometric changes in the three key locations are shown in Figure-1 estimated over the periods between 6th and 39th week for the 12 subjects. The shaded regions correspond to the variance of these changes at each time point, and the solid lines represent the mean change in the measurements. Predicting the mean change is straightforward
as it progresses linearly through time. However, the increase in the variance at each time point will contribute to a larger prediction error. So, the data was transformed using the Box-Cox function, separately for the three measurements. The transform used was, $data(\gamma) = \frac{data^{\gamma} - 1}{\gamma}$, where $\gamma$ is the transformation parameter determined from the original data. Figure-2 shows the transformed data, which shows a non-linear relationship between the measurements and time during pregnancy. The variance is approximately equal over the periods, and the mean serves as the non-linear predictive model to estimate how much change occurs after the 6th week in each of the key measurements. Out of the three measurements extracted, waist showed the maximum change, hip showed a moderate change and bust showed the least change.

**Conclusion:** Based on the developed model, the body measurement changes of pregnant women can be estimated with higher level of accuracy and minimum variance. Sizing chart and grading rules can be easily created using the estimated measurements. Additionally, the cross-sections extracted from the 3D scans can provide information related to orientation of shape changes, which could further support optimal product design. This study provides a non-linear model to estimate anthropometric changes in pregnant women and can serve to minimize the gap between the existing sizing charts for maternity wear and prevailing real-world data.
References:

