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PLANTAR SURFACE CONTOUR ANALYSIS USING CLOSE RANGE PHOTOGRAMMETRY

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SUMMARY
The purpose of the research is to develop an approach that provides low-cost, high-quality 3D surface models which can be used to study the dynamics of the foot during gait. A three video camera mounting platform, glass-topped platform, and a set of photogrammetric targets were constructed and used for imaging and the captured images processed used PotoModeler® scanner. Results show an overall accuracy of the photogrammetric measurement technique of approximately 0.3mm for all surfaces generated.

INTRODUCTION
Automated 3D point cloud generation of an object surface from images using a Dense Surface Modeling (DSM) algorithm is a reliable technique. It has been applied in numerous mapping applications such as the human face, archaeological artefact recording, and forensic investigation. In this paper the technique is applied to mapping the plantar aspect of the foot during weight-bearing. The purpose of the research is to develop an approach that provides low-cost, high-quality 3D surface models which can be used to study the dynamics of the foot during gait.

METHODS
Three Sony HD video cameras were mounted under a glass-top platform to provide 100% three-image overlap of the plantar surface area. A photogrammetric control frame was installed under the plate to provide object-space control for camera station resection and scaling. The relative coordinates of the targets on the control frame were calculated by a photogrammetric bundle adjustment technique and the detail is provided in Al-Baghdadi et al. [1].

Image frames from the video clips were extracted using VirtualDub freeware and AVS4YOU proprietary software (Online Media Technologies Ltd, London, UK). Off-the-shelf multi-image bundle adjustment software, Australis (Photometrix, Australia), was utilised in the camcorder calibration, glass-top refraction distortion calculation, and photogrammetric control calibration. PhotoModeler proprietary software (Eos System Inc. Canada) using DSM technique was used to generate a point cloud of the foot while a MATLAB® protocol was developed to model the glass-top refraction distortion characteristics, detect outlier in measurements, and calculate the distortion correction parameters.

RESULTS AND DISCUSSION
The 3D surfaces generated from the captured images of the plantar surface (left) and the generated 3D surface using the three captured image (right) are presented in Figure 1. The generated 3D surface clearly showed the compressed overlaying fat pad at the heel. The total amount of gaps in the generated 3D surfaces was less than 0.1% and did not reduce the anthropometric mark positional measurement as these marks were clearly identifiable.

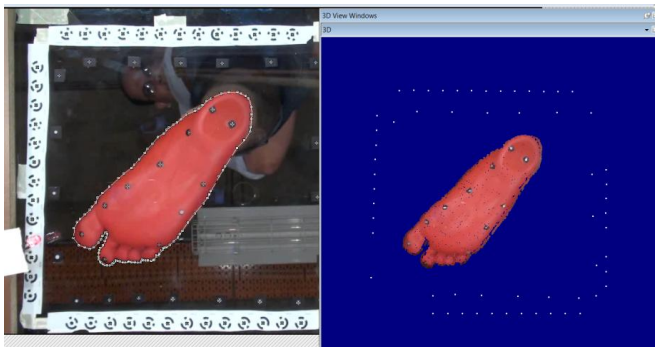

Figure 1: 3D plantar surface contours during heel strike

Based on the difference between the calibrated and measured 3D distance of the surface model, the technique achieved an accuracy of 0.25 mm, confirming the high-quality of the computed 3D surface model.

CONCLUSIONS
The results show that the developed technique using off-the-shelf HD video cameras is suitable for 3D surface mapping of the plantar surface of the foot. This information provides a unique insight into the dynamic characteristics of the foot during gait which can be incorporated into the design of footwear and orthotics.

REFERENCES
1. Al-Baghdadi, JAA et al *Proc Int Workshop Geoinfo Adv.* 2012.26-46.