#1 深度相机方案

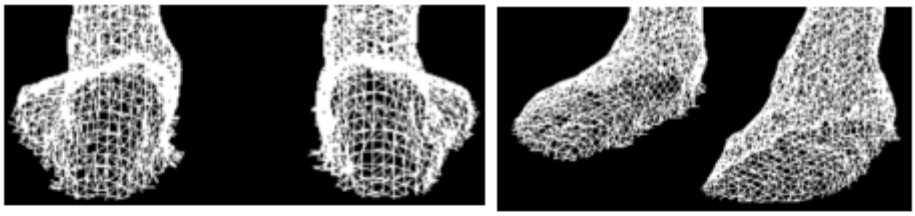
移动设备深度相机

（注：仅需要一台移动设备（可能需要激光雷达支持，参照iPadPro 3D点云扫描），阐述扁平足和外翻的联系很清楚，无足部骨骼分析，仅形态，有算法无代码实现）

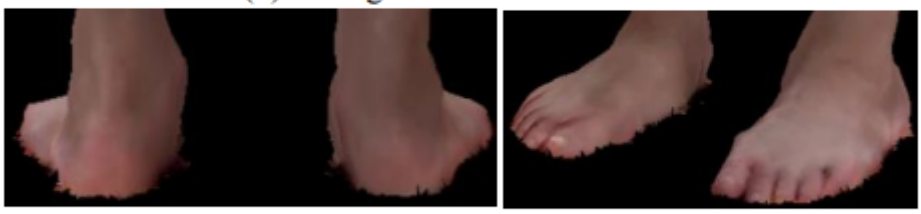
> K. Yamashita, T. Yamashita, M. Sato, M. Kawasumi and Y. Takase, "Development of a quantitative measurement system for three-dimensional analysis of foot morphology using a smartphone," 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 3171-3174, doi: 10.1109/EMBC.2019.8857209.

https://doi.org/10.1109/EMBC.2019.8857209
Development of a quantitative measurement system for three-dimensional analysis of foot morphology using a smartphone | IEEE Conference Publication | IEEE Xplore

(a) Video data



(b) Configured wire frame data



(c) Rendered wire frame data

Figure 1. Results obtained from 3D foot measurement system

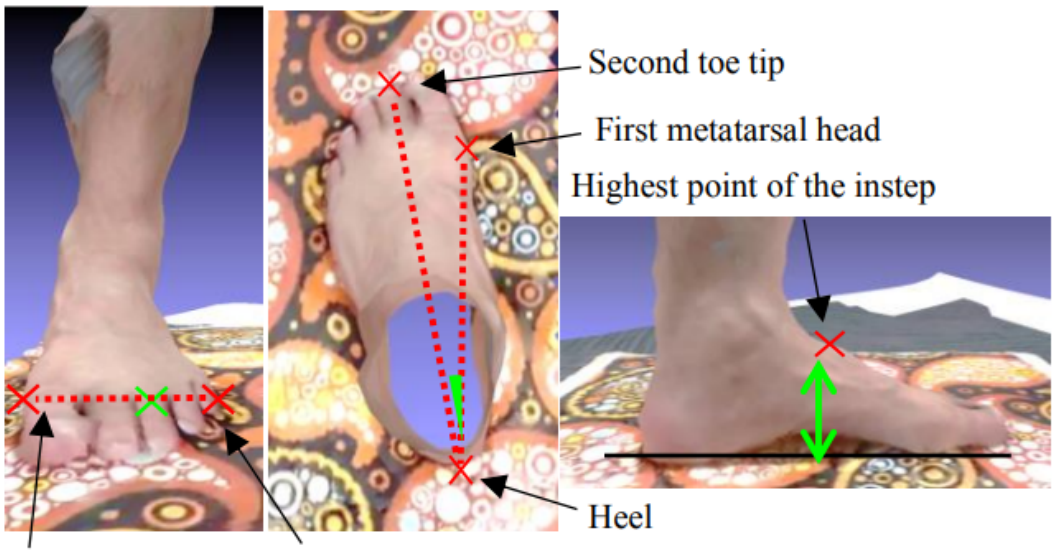


Figure 2. Analytical parameters of the 3D foot measurement system

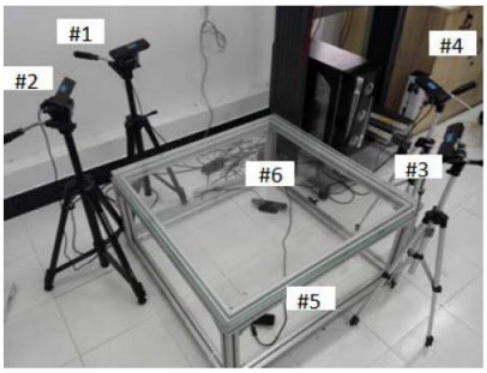
by foot size because the height of the instep and metatarsal bones has a significant correlation with foot size. In addition, the presence of hallux valgus was visually checked. Hallux valgus is defined as a lateral deviation exceeding 15°.

多机位深度相机

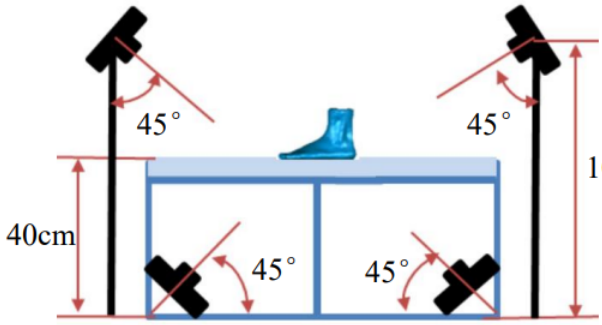
（注：需要六台深度相机，阐述较详细，3D点云模型分析，无足部骨骼分析，仅形态，有算法无代码实现）

> 毋戈. 基于多个深度相机的足部三维重建及形态分析[D].东华大学,2017.

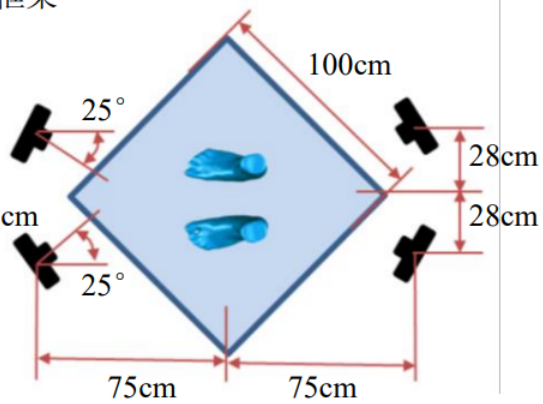
[基于多个深度相机的足部三维重建及形态分析 - 中国知网 (cnki.net)](https://)



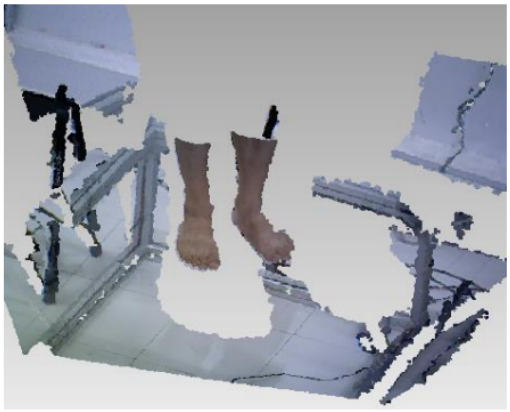
（a）系统框架



（b）侧视图

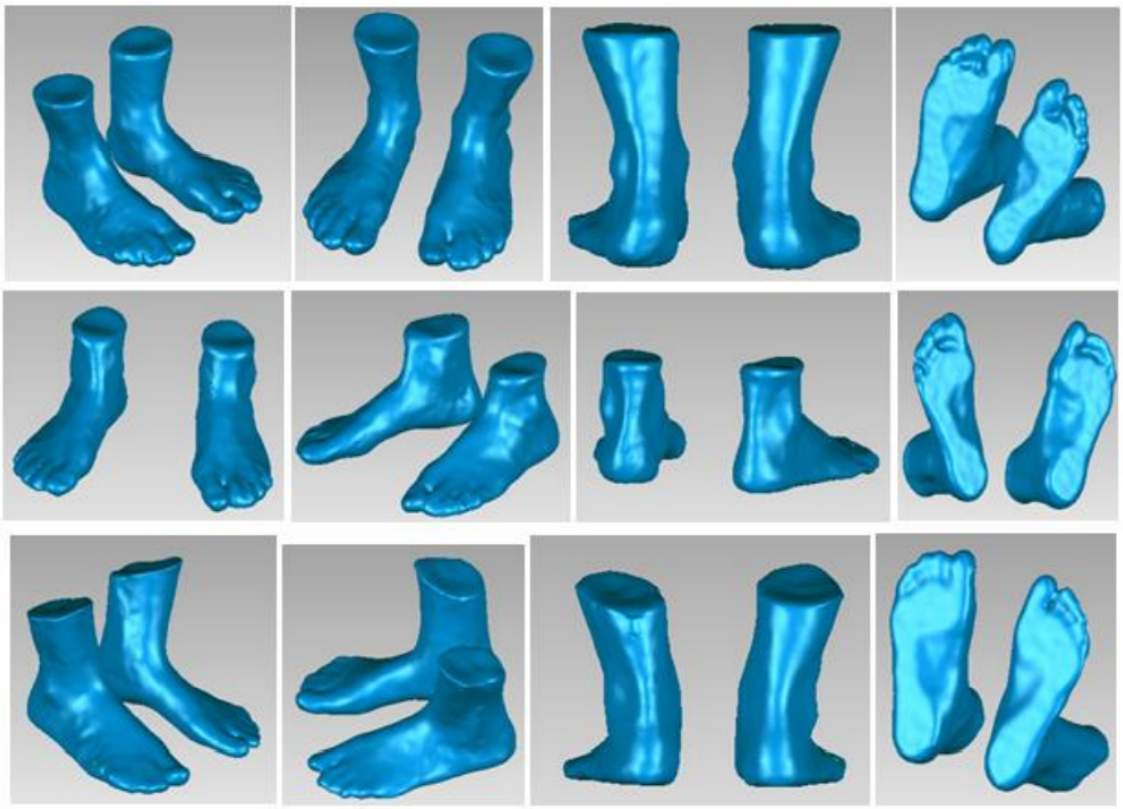


（c）俯视图



（a）原始点云

（b）去除背景后点云



RGBD深度相机

> Chun S, Kong S, Mun KR, Kim J. A Foot-Arch Parameter Measurement System Using a RGB-D Camera. Sensors (Basel). 2017 Aug 4;17(8):1796. doi: 10.3390/s17081796. PMID: 28777349; PMCID: PMC5579737.

A Foot-Arch Parameter Measurement System Using a RGB-D Camera - PMC (nih.gov)

Figure 3. System installation: (**a**) scanning stage of the proposed system, (**b**) RGB-D camera beneath the transparent acrylic board, (**c**) sole of foot measurement using our system.

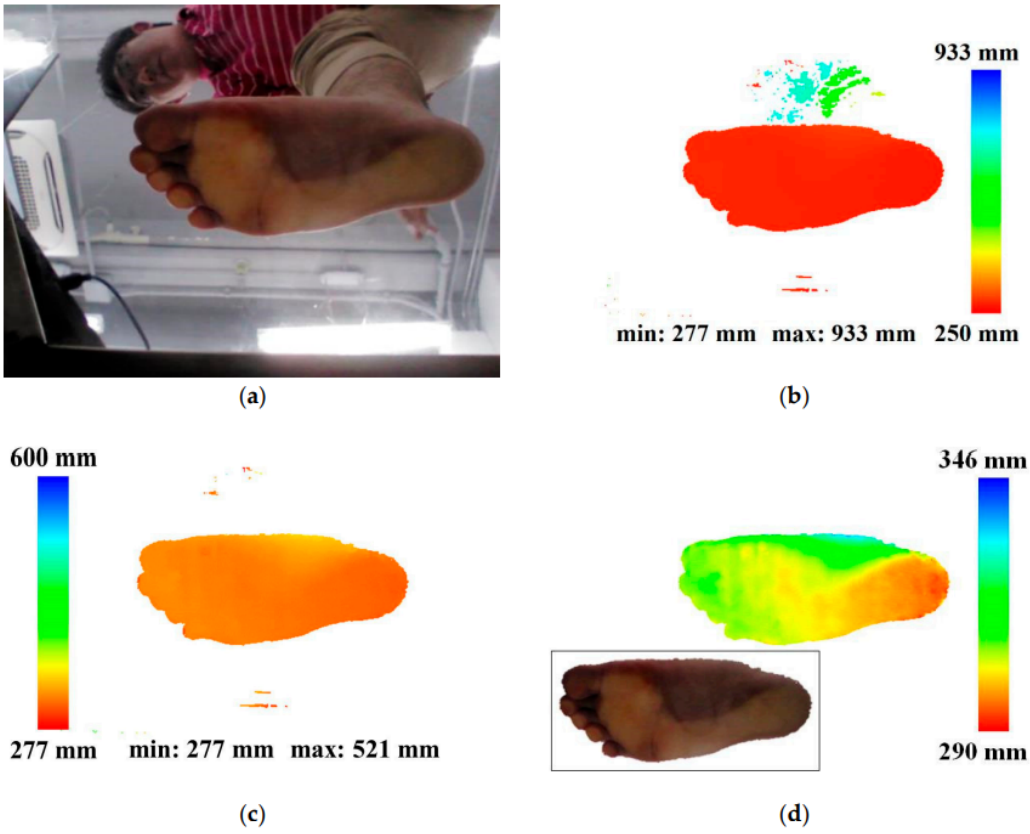


Figure 4. Results of preprocessing module: (**a**) input color image, (**b**) input depth image color-coded by depth value, (**c**) depth image filtered by depth thresholding, (**d**) foot point image filtered by the connected component labeling and color mapped image (left bottom).

#2 足印方案

压力垫步态足印+深度学习方案

（注：依靠步态周期内在压力垫上的足部各部分压力来判断足部形态，扁平足等，仅形态，有算法无代码实现）

> Yue Ma, Zhuangzhi Zhi, "Extraction and Analysis of Foot Bone Shape Features Based on Deep Learning", Computational and Mathematical Methods in Medicine, vol. 2022, Article ID 2372160, 11 pages, 2022.

https://doi.org/10.1155/2022/2372160
Extraction and Analysis of Foot Bone Shape Features Based on Deep Learning (hindawi.com)

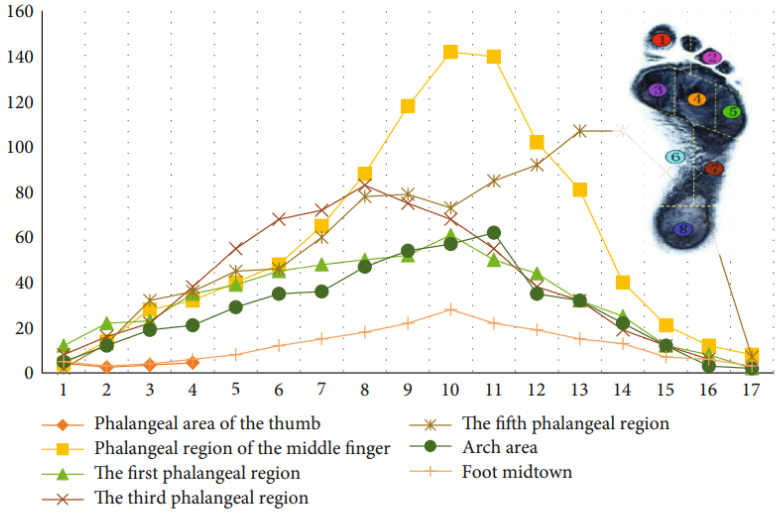


FIGURE 4: Multisensor foot bone pressure acquisition signal.

扫描仪扫描足印

（注：该论文实现较基础，仅足印形态简单分析，利用扫描仪扫描足部图像然后灰度二值法控制阈值判定，有算法无代码实现）

> 高强. 个人足部分析系统的设计与实现[D].湖北工业大学,2017.

个人足部分析系统的设计与实现 - 中国知网 (cnki.net)

(a) 源图像 (b) 阈值=10 (c) 阈值=60 (d) 阈值=100 (e) 阈值=120

图3.10 由不同阈值生成的二值图

#3 额外发现

MATLAB项目代码（仅跖骨骨骼） 给定用户脚的照片，将绘制跖骨（脚骨）的位置并找到其他兴趣点。该程序确定了Jones Fracture（沿着足底的第五跖骨骨折）可能发生的位置。

ryanskeller48/Jones-Fracture-Scanner: A rudimentary MATLAB program that, given a photo of a user's foot, will plot the location of metatarsals (foot bones) and find other points of interest. The program identifies the location in which a Jones Fracture (fracture of the fifth metatarsal along the base of the foot) would occur. This can be a helpful visualization for a patient applying at-home therapy who doesn't have a strong basis in anatomy. This program is a demonstration of

how a more robust computer vision software could provide comprehensive at-home assistance to patients based on user-taken photos. (github.com)

#4 关于足部骨骼识别

CV方面国内外均未找到足部骨骼类似于手部姿势的机器视觉研究论文、项目以及代码；足部骨骼X光片关键区域分割倒是有一些，倒是都未对骨骼关键点做提取