School of Mechanical & Control Engineering
MIP 24-2

Body Measurement using a 2D Camera for Home Fitness

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Introduction

Problem Statement:
3D body measurement systems are costly and impractical for home use.

Objective:
Develop affordable and accessible alternative to traditional 3D systems.

Goal:
Design and prototype a 2D-based human body measurement system.

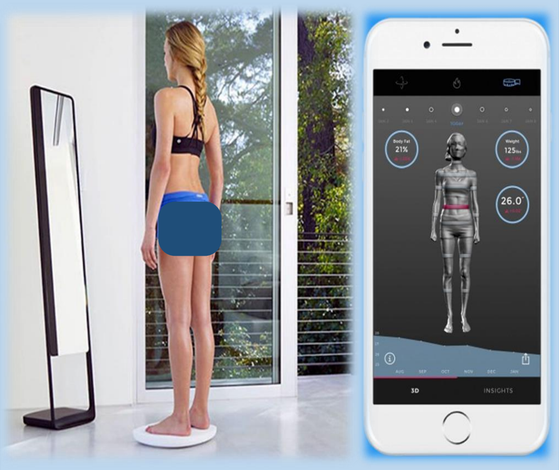


Fig 1. Aimed System Feature

Proposed System

Proposed System Process:

Single Image Capture → Body Segmentation Model → Body Size Estimation Model → Visualize Result

1. Single Image Capture:

Fig 2. Captureing Image

LCD panel visualizes the user's current pose and instructions.

Background set with green chroma key for better image capture.

2. Body Segmentation Model:

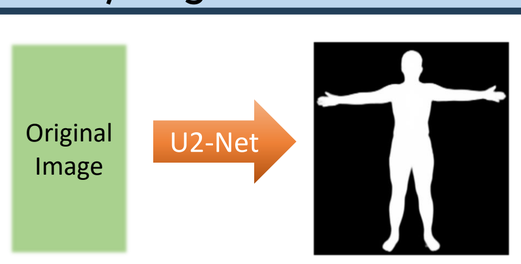


Fig 3. U2-Net

"U2-Net" highly accurate background segmentation model used for image processing.

Pretrained model: u2net_human_seg.pth

3. Body Size Estimation Model:

Model

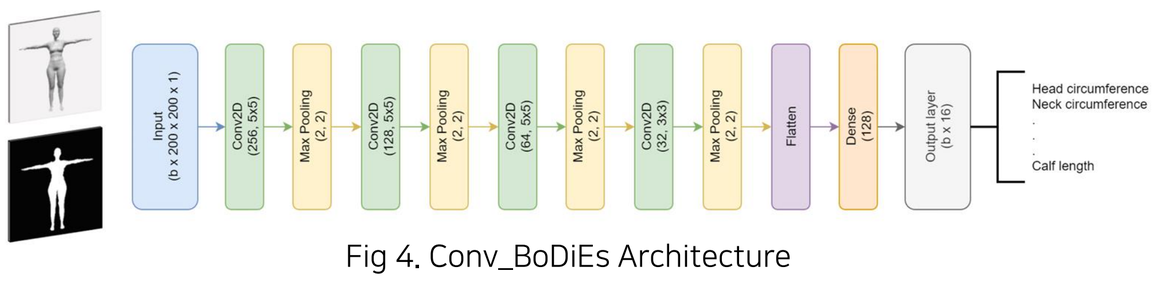


Fig 4. Conv_BoDiEs Architecture

Model	Conv_BoDiEs
Input	Front T pose image
Output	Size of 16 body parts

The model relies on a single 2D image for estimation, simplifies implementation

Dataset & Test Evaluation

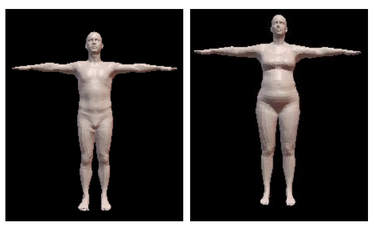


Fig 5. Sample Dataset

Body part	Test Data
chest circ	9.3
waist circ	8.8
pelvis circ	9.2
neck circ	5.8
⋮	⋮
MAE(total)	5.537[mm]

Table 1. Test Data Result

Dataset :
50,000 *SMPL captured images are used for train and test.
Evaluation :
The model achieved a 5.537[mm] MAE.

4. Visualization Result:

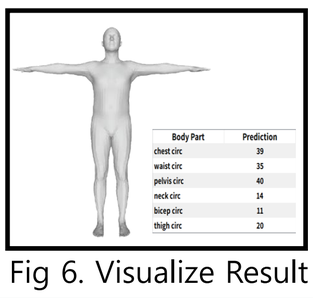


Fig 6. Visualize Result

The result is shown through the LCD placed back of the mirror.

For visualization, human feature and result table are shown.

Hardware

Hardware designed like a mirror for "Home Fitness"

Fig 7. Smart Mirror & LCD Display

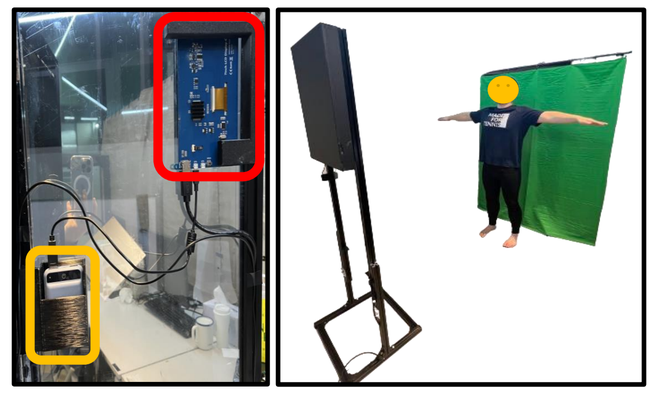


Fig 8. Inner Part & Overall Layout

Hardware Specification:
Height: 175cm
Width: 54cm
LCD panel: 7inch (600x1024)
Camera: 1090P web cam

Red Box:
LCD pannel with 3D printed holder

Orange Box:
Barttery with 3D printed holder

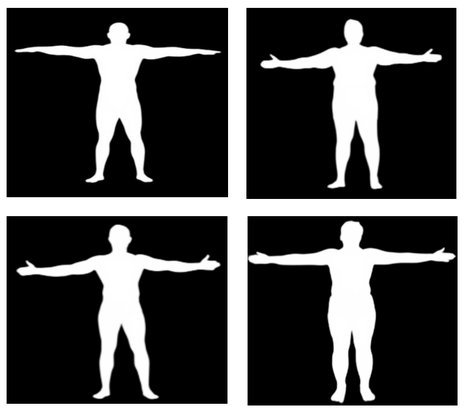
GUI

GUI framework - Tkinter

Fig 9. GUI Sequence

1. Type name for user result storage
2. Select gender for appropriate "trained model"
3. Results visualized in segmented image with table

Test



Test participants:
10 male
Distance between camera and subject:
190[cm]
Overall space layout:
width – 3.1[m]
length – 2.2[m]
height – 2.5[m]

Fig 10. 4 Sample of Test Participant

Result

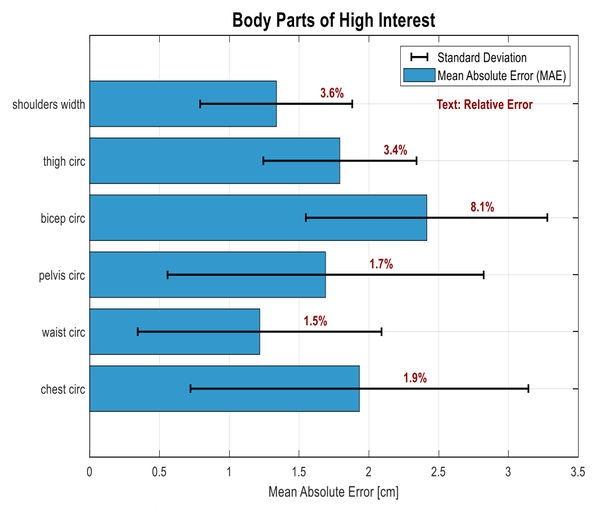


Fig 11. Result of Interest Body Parts

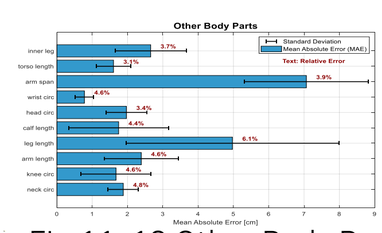


Fig 11. 10 Other Body Parts

Result:
Overall MAE: 2.3[cm]

Directions for Future Research:
Enhancement of Accuracy
Visualizing in 3D model

Reference

[1] Škorvánková, Dana, Adam Riečický, and Martin Madaras. "Automatic estimation of anthropometric human body measurements." arXiv preprint arXiv:2112.11992 (2021).
[2] Loper, Matthew, et al. "SMPL: A skinned multi-person linear model." Seminal Graphics Papers: Pushing the Boundaries, Volume 2. 2023. 851-866.
[3] Qin, Xuebin, et al. "U2-Net: Going deeper with nested U-structure for salient object detection." Pattern recognition 106 (2020): 107404.