Human Weight Derivation Through Mosteller's Body Surface Area Applied to Web Camera Images

Desirie A. Meriales, Charmaine Anne A. Las Pinas, Adomar L. Ilao
Malayan Colleges Laguna, Cabuyao City, Laguna 4025 Philippines.
alilao@mcl.edu.ph

***Abstract*—This study implemented computer vision techniques to derive human weight using Mosteller's body surface area formula to web camera images. It has several stages of image processing and analysis to identify human weight from collected web camera images taken in a controlled environment to lessen computer vision constraints. Using Novel Edge Detection and Otsu Thresholding Algorithm, a human body contour for both front-view and side-view were constructed; and an analysis was done using Mosteller's body surface area formula in deriving human weight.**

***Index Terms*—Human Weight; Body Surface Area; Novel Edge Detection; Image Analysis; Mathlab.**

I. Introduction

Through the years of improving people's lives, technology plays an important role in ways we cannot imagine. Driving forces behind such actions are preserving human life. It might be in the form of accessing information, analyzing data or simplifying workloads. Evidently, technology lingers on the field of education, industry and medicine. Several researches were done in weight management [1], posture recognition [2], automatic health screening [3], primary healthcare [4][5] and work related fatigue [6] to lessen the probability of facing future health diseases.

Currently, the Department of Education in the Philippines is a mover of healthcare. It implemented a mandatory monitoring of the malnutrition status of students in public schools. Studies on malnutrition show that it has a direct relationship to person's learning capabilities [7]. Common method to identify malnutrition status is by getting the body mass index (BMI) [8], which involves height and weight. The method used by nurses or teachers was still the traditional way of manually measuring the anthropometric data of the students all around the archipelago. Collected information from different schools was summarized for analysis by the Department of Education to provide better solution for the improvement of the health of the students.

Several researches drawn information from the field of computer science which is computer vision [9][10]. It is an alternative way to automatically derive anthropometric data of the subject where a captured image will be analyzed through image processing [10] and image analysis [10][11]. This said approach lessens the manual labor needed to perform intensive activities of collecting student's data to improve government's implementation plan on the issue of malnutrition. However, malnutrition is analogous to weight. Past works on weight estimation of human [12] and animals [13][14][15][16][17][18] yield acceptable results.

This study performed experiment on the possibility of utilizing computer vision in deriving human weight based on body surface area. A prototype was constructed in MatLab 2012 and low-cost web camera was used as a source of real-time student image in different points of reference.

II. Experimental

A. Research Design

Initially, web camera configuration [11] was manually setup to determine the ideal settings in accommodating the largest number of students that can capture front-view and side-view position in an image. This will allow the prototype to segment each student's image properly for the derivation of their individual weight.

The study involved several stages as shown in Table 1. In the first stage, average filter was applied to each image to lessen any unwanted noise brought about by uncontrollable constraints. For the second stage, Otsu thresholding algorithm and novel edge detection was used to construct front-view and side-view perspective of a human contour. In the third stage, each segmented images was separated from one another. And lastly, individual height of each student was encoded and applied to the collected data to body surface area formula (BSA) of Mosteller's to derive human weight.

$$BSA(m^2) = \sqrt{\frac{weight(kg) \times height(cm)}{3600}} \tag{1}$$

Table 1
Input-Process-Output Framework

Input	Process	Output
Front-View Images Side-View Images	Average Filter Algorithm Otsu Thresholding Technique Novel Edge Detection Algorithm Body Surface Area Algorithm	Weight Derivation

B. Methodology

This study applied a quantitative experimental research design using Posttest Only Control Group design in determining the validity of the weight derived by the prototype (experimental group) against the traditional method (control group).

Control group data were collected from the traditional method of using weighing scale taken by a medical practitioner or elementary school teacher.

A sample size of 30 [19] students from 1,288 students was identified through convenient sampling. Five students each from Kinder and Grade 1, and 4 students each from Grade 2 to Grade 6 were taken as samples. Each student was subjected to 4 test sets as stated in Table 2. The derived weight of the respondent corresponds to the mean of 4 derived weights from each data set.

During the experiment, students stepped on a green cloth to control image segmentation issues on extracting image and were arranged randomly as shown in Figure 1 to test the prototype's weight derivation consistency.

Table 2
Number of Respondents in an Image

Data Sets	Number of Respondents
Data Set 1	1
Data Set 2	2
Data Set 3	3
Data Set 4	4

(a) (b)

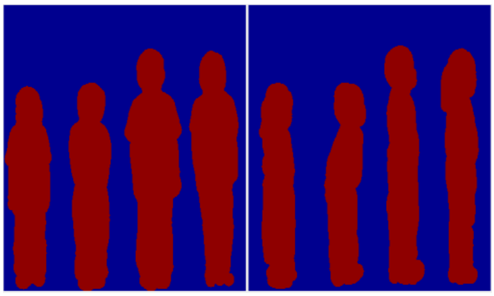
Figure 1: Different Images Perspective (a) Front-view (b) Side-view

Table 3
Web Camera Technical Specification

Parameters	Value/Description
Resolution	1300K Pixels in hardware
FPS	30fps/sec
Lens	2-layer glass lens, shimmering inducing
Maximum Supported Video Resolution	1280x960
Video Format	Microsoft AVI
Video Stream Rate	30fps (CIF) and 30Fps (VGA)
Color Depth	24Bit True color
Operating System	Vista/XP/2000/Windows 7/8
Interface Plug Type	USB

Initially, web camera was configured manually in terms of the angle and distance to ideally determine the largest number of students who can fit perfectly on a single image. A Web camera with technical specifications stated in Table 3 was connected to personal computer.

Before image segmentation, average noise filter was applied to front-view and side-view images and the acquired RBG images were converted to grayscale in constructing body contour by Otsu Thresholding and Novel Edge Detection as shown in Figure 2. These segmented body contours' areas are the vital component for human weight derivation.



(a) (b)

Figure 2: Body Contour (a) Front-view (b) Side-view

Weight derivation begins with identifying the number of available pixels from both images. Each computed value will then be multiplied to the estimated pixel weight [20]. Finally, derivation ends by getting the sum of computed body surface areas derived from Mosteller's formula.

$$\text{Total Number of Pixel} = \text{Body Contour Area} \times \text{Pixel Weight (Kg)} \quad (2)$$

$$\text{Body Surface Area} = \sqrt{\frac{weight(kg) \times height(cm)}{3600}} \quad (3)$$

$$\text{Human Weight Derivation} = \text{Front-View Body Surface Area} + \text{Side-View Body Surface Area} \quad (4)$$

III. RESULTS AND DISCUSSION

Prototype was designed to load captured image ranging from Data Set 1 up to Data Set 4 and key-in the number of students available from the image just like what is shown in Figure 3. Afterwards, individual weights will be derived automatically based on body-surface area.

Figure 3: Prototype Graphical User Interface

During experimentation, image segmentation using novel edge detection failed to segment the objects properly due to students' clothes or marks on the background cloth as shown in Figure 4. These issues were resolved by manually enhancing the background color and changing student's cloth color to dark color using a photo editing tool as shown in Figure 5.

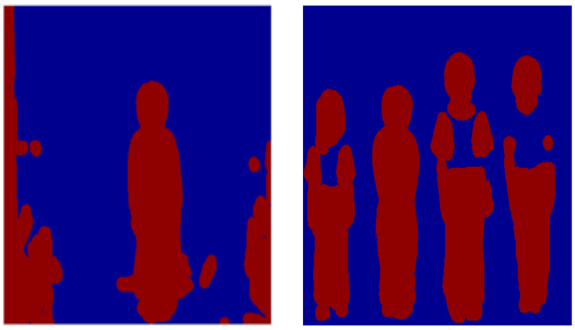
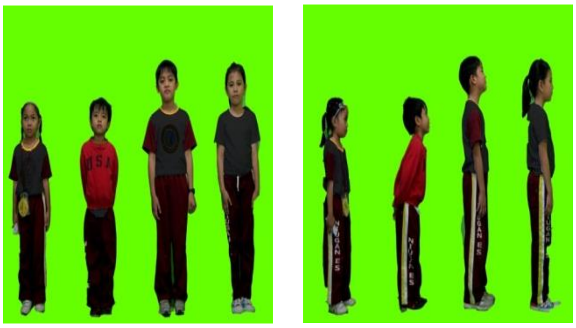


Figure 4: Segmentation Issues on student's cloth or marks on the background cloth



(a) (b)

Figure 5: Enhanced Images (a) Front-View (b) Side-View

Figure 6 shows 86% of students' derived weights have an average difference of 30% from their respective actual weights and yielding an accuracy rate of 14%.

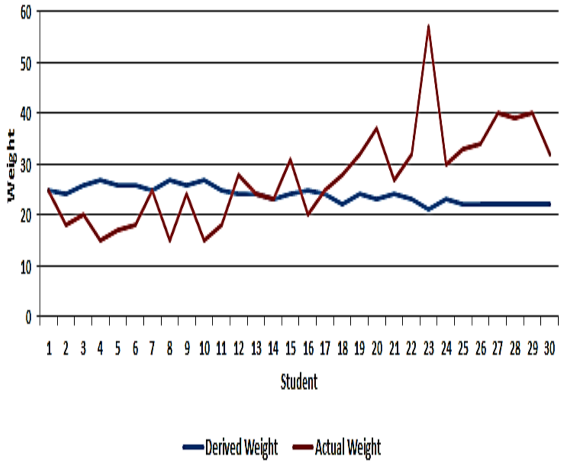


Figure 6: Comparison Between Actual and Derived Weight

One-way ANOVA was used to determine whether the difference of the derived weights of student from 4 data sets is significant. Table 4 shows the difference that resulted from the 4 data sets are not significant since the p-value is greater than 0.05.

Table 4
ANOVA Results of 4 Data Sets Reading

F-value	p-value	Interpretation
0.592	0.621	Not Significant

T-test was used to determine if there is a significant difference between the actual and derived weights of the 30 students. Table 5 shows that the mean difference of post-test (actual weight) and pre-test (derived weight) yields 3.36352 is not significant based on the p-value greater than 0.05.

Table 5
T-Test Result of Human Weight Derivation

	Mean	N	Mean Difference	t-value	p-value	Interpretation
Actual Weight	30	27.3667	3.36352	1.691	0.102	Not Significant
Derived Weight Average	30	24.0031				

IV. Conclusion

The prototype of this study can derive individual student's weight from an image of 4 students. But some of the student's weights are affected by clothing thickness, hair volume, cloth's color, cloth's folding or any markings on the students since it becomes part of the surface area resulted from image segmentation.

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