

# Anthropometric Proportions Estimation Using recCAL in Multi-camera Environment

O. Kainz, D. Cymbalák, and F. Jakab

**Abstract**—In this paper, a new technique for anthropometric proportions estimation using multi-camera environment is presented. We refer to this system as a recCAL. System is represented in a form of a 3D model and as well real-world physical model, both used as a reference model/object in the size estimation process. Further anthropometric proportions of human body and face are utilized to provide an estimate of real size from series of images as captured by multi-camera system. recCAL has potential applications in variety of areas where anthropometric proportions or size of other objects may be useful.

**Index Terms**—Anthropometry, human proportions, object size, multi-camera.

## I. INTRODUCTION

There are many cases when one has to determine the size of an object from the image, for example police investigators need to estimate the anthropometric features of offender directly from the image or estimate human body parameters in order to create proper 3D model. Such model may be later used for testing or in the field of clothing industry used as knowledge about body shapes tendencies of people from selected area. Estimation of size of the object in the image has been in focus of many researches. In this paper we will cover some of these and present our own approach.

We will focus primarily on estimation of selected anthropometrical features of human body. Once implemented in a real conditions as a tool in multiple camera environment, one may be able to obtain size parameters of scene relatively fast.

## II. ANTHROPOMETRIC FEATURES ESTIMATION

Most of the cases we cover are related to body height estimation. Related to our idea is study by [1], in this research authors tried to estimate the height of human body from single uncalibrated image, however no reference towards camera viewpoint and estimation of camera parameters were provided. Localization of body landmarks was done in semi-automatic way and estimation was in this case carried out only for height. No reference length was required for the height estimation. Another research focused on height

estimation is described in [2]. In this case authors used calibrated cameras (more specifically surveillance camera). Since this was the case of calibrated camera, intrinsic parameters of camera were known. For calculation of height were used top and bottom points of person as extracted from the image itself, no anthropometric features seems to be implemented. [3] is also dealing with the height estimation, author utilized a single image containing only human face. Extraction of eyes, lip and chin enabled this estimation using statistical measurement sets and facial golden proportion (see Fig. 1). Specific process of this extraction is based on [4] and further described in [3]. Another study carried out by [5] presents again estimation of height from single camera while only requiring height, pitch angle and vanishing point of camera. Results of the testing provide good accuracy. In [6] authors focused on calibrated camera as a part of research in field of demography, where authors aimed to estimate the height of the person. Their aim was to improve age and gender classification via height estimation. Testing was carried out on 127 subjects. Authors extensively worked with anthropometric data, e.g. distance between eye centers or distance between mouth and nasion (see Fig. 1), the first is for male and female estimated to be approx. from 50 to 60 mm and the latter, i.e. from nasion to mouth, (b) from 45 up to 75 mm.

Estimation of shape and pose from single image was object of the interest of research introduced in [7], authors aimed to extract 3D human model from archival images or paintings, i.e. image is uncalibrated. For initial pose estimation authors use manual selection of joints (vertices) on body. Body representation was not based directly on anthropometric model but model called SCAPE (Shape Completion and Animation of People). Body shape was derived from shading which provides strong constraints on surface shape.

## III. ANTHROPOMETRY

Anthropometry is rather unusual field of study. Oxford dictionary [8] defines anthropometry as "the scientific study of the measurements and proportions of the human body". Word anthropometry is actually combination of two Greek words *ἄνθρωπος* (man) and *μέτρον* (to measure). Based on [9] was anthropometry introduced in the middle of 17th century by physician named J.S. Elsholtz for description of system of measurements with aim to describe the intrinsic relationship between body proportions and various diseases. Later on this term gained broader meaning. P. Topinard in the dawn of 20th century refers to this field as system of measurements of the human body with the goal to determine its perspective proportions. More about beginning and history of anthropometry is covered in the book by above mentioned

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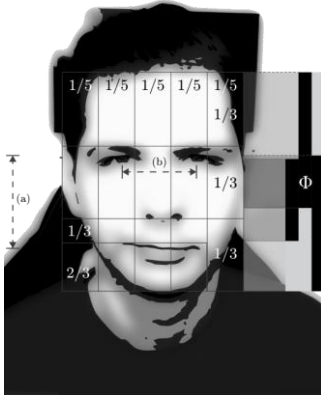


Fig. 1. Facial symmetry: a) nasion-to-mouth, b) eye-to-eye.

Nowadays anthropometry or better say its output provide utilization in many areas of life, primarily it is being used as a one of the dominant methods utilized in physical anthropology and palaeoanthropology, another use is for example in ergonomics for design of products or interiors/exterior. There are basically two types of anthropometry presented by [10]:

- Structural (static) measurement of features in standardized (rigid) positions, movement of human body is not major concern in this type of measurement; examples are height, weight, height when sitting, body depth, elbow height *et al.* For measurements to be replicable on various subjects the standardized posture has to be maintained.
- Functional (dynamic) measurement of features in motion or physical activities in general, i.e. body is in various postures, e.g. arm reach, kneeling height, bent torso height *et al.*

Another third type of measurement introduced by [11] is:

- Newtonian measurement where the mechanical principles are applied on a human body, output of this describes segmental parameters used further in biomechanical analysis, e.g. centre of mass.

#### IV. BODY REPRESENTATION

In this part we put our focus on body representation. In [12] is body represented as connection of edges joined by vertices (axes of rotation). These links are merely abstractions of constant length that allow angular displacement, none of which is truly edge-centered. More about link body system and its dynamic properties is described in publication by just mentioned authors. [13] used model of human body consisted from vertices, edges and faces as a foundation for human model. Same authors also developed a system called SASS (Spreadsheet Anthropometry Scaling System) for generating the human figure based on population data as an input.

Vertex in our case is connection between bones, i.e. synovial type of joints and diarthrosis, well known of these is e.g. knee or elbow (in Fig. 2 see rk, lk and re, le, respectively). All the joints that are synovial are freely moveable, however each type has some level of movability. Most of the vertices are of type diarthrosis. In Fig. 2 is depicted human body model consisted of edges end vertices.

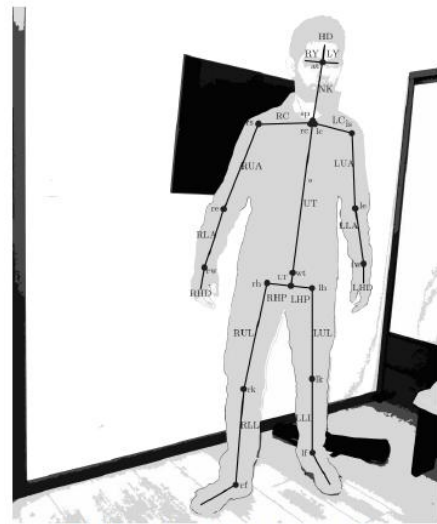


Fig. 2. Skeleton human body model: vertices and edges.

TABLE I: DESCRIPTION OF EDGES FOR FIG. 2 [14]

Edge	Name	Edge	Name
HD	HeaD	RHD	Right HanD
RY	Right eYe	LHD	Left HanD
LY	Left eYe	LT	Lower Torso
NK	NecK	RHP	Right HiP
UT	Upper Torso	LHP	Left HiP
RC	Right Clavicle	RUL	Right Upper Leg
LC	Left Clavicle	LUL	Left Upper Leg
RUA	Right Upper Arm	RLL	Right Lower Leg
LUA	Left Upper Arm	LLL	Left Lower Leg
RLA	Right Lower Arm	RF	Right Foot
LLA	Left Lower Arm	LF	Left Foot

TABLE II: DESCRIPTION OF VERTICES FOR FIG. 2 [14]

Vertex	Name	Vertex	Name
at	atlanto occipital	ra	right ankle
sp	solar plexus	rc	right clavicle
la	left ankle	re	right elbow
lc	left clavicle	rh	right hip
le	left elbow	rk	right knee
lh	left hip	rs	right shoulder
lk	left knee	rw	right wrist
ls	left shoulder	wt	waist
lw	left wrist		

#### V. RECCAL DESIGN

recCAL is basically rectangular cuboid for calibration of camera with the aim to estimate the unknown size of objects in the image. Basis presumption is that this device is present in the image. Further we utilize the facial anthropometric measures and also anthropometric measures of human body. Illustration of recCAL is depicted in Fig. 3. recCAL is 3D model that is loaded into the image based on extraction of feature points from the real world device, once located mapping is of 3D model into the image is carried out. When located, parameters of image and estimation of camera parameters are enabled. Carried out next is detection of human face based on feature extraction presented in [15].

Then vertices are located following the skeleton model of human body, this is based on extreme point detection, see analogous approach in [2]. Final result is the estimation of anthropometric proportions and partial pose estimation. These data may then serve as an input for metric calculation of multiple camera sources.

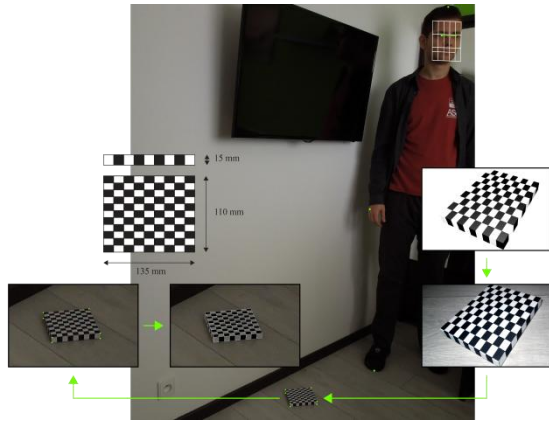


Fig. 3. recCAL model.

### VI. BUILDING OF SKELETON BODY MODEL FROM MULTIPLE CAMERAS AND RECCAL

Previous approaches consider primarily usage of static photos for calculation of the proportions of vertices. Our revolutionary approach bring the advantages of using video for calculating the vertices by dividing the computing capacity to multiple camera sources via searching the diffractive points of human body. These points are evaluated by optical flow algorithm during the observation of walking or moving habits using computer visions techniques (Fig. 4).

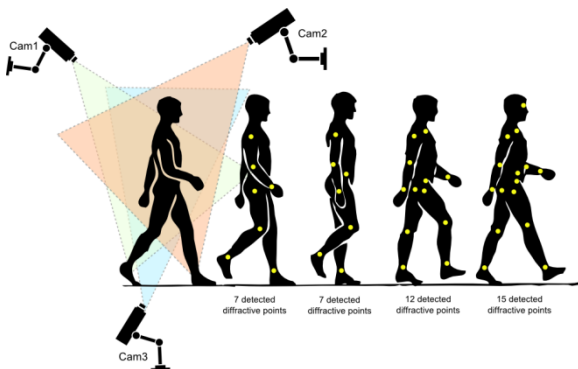


Fig. 4. Detecting the diffractive points from multiple angles.

Once diffractive points are detected, the process of calculation the distance between these points is carried out, this is done in order to get value of chosen vertices in skeleton model. These values are initially set from the first camera view and also updated by next cameras view to the final model related to the reference recCAL (Fig. 5).

The result of overall calculations is creation of vector of chosen vertices values:

$$H'_n = [HD_n, RY_n, LY_n, UT_n, LUA_n, RLA_n, LUL_n, RLL_n] \quad (1)$$

This vector is used in real time for track and prediction of movement of specific human. This solution was tested in experimental laboratory environment by using the software vMix system and also the cloned HDMI input cards and

scripts for evaluation of the skeleton model vector (Fig. 6).

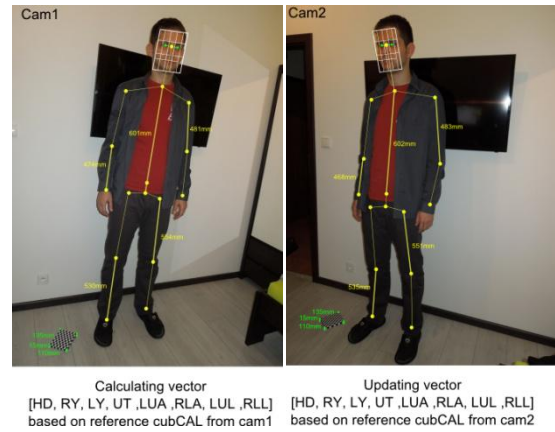


Fig. 5. Calculating vertices and updating skeleton model from multiple angles.

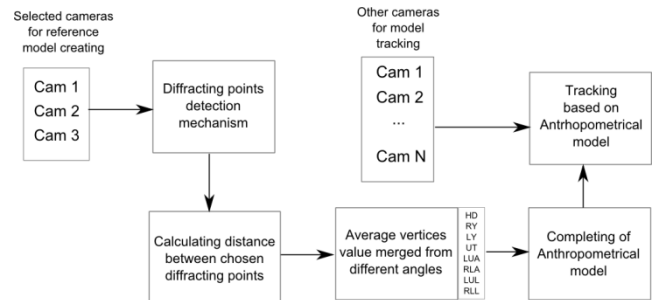


Fig. 6. Process of creation of skeleton model with reusing model for tracking the human through different video sources.

### VII. CONCLUSION

recCAL prototype system consists from device and 3D model, both of them are introduced as an aid in for measurement the object size in the scene using multi-camera approach. Proposed solution is able to estimate anthropometric proportions due to homogeneous proportions of human body. In this study we were able to partially estimate certain of these anthropometric proportions following skeleton model of human body and facial proportions. Knowing recCAL parameters enabled us to estimate parameters from the image and map its 3D model to scene itself. In future we plan to extend the number of vertices in skeleton model and thus enhance the accuracy of body parameters estimation, potential is to utilize system for calculating the parameters of the whole scene.

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