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Fiducial markers detection in anthropometric images

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1. Introduction

Anthropometry is the study of how the human body physical characteristics are correlated with its physiological processes, and their influences in the behavior and health. It involves the measurement of the physical parameters of the body, like geometric dimensions, body shape characterization, weighting, estimation of fat thickness, kinetics and dynamics of body motions, muscular tonus, etc. The body movement and equilibrium can be described by the instantaneous positions of some anatomical landmarks. It is of common practice to mark these points wiht adhesive markers over the body surface.

We are currently testing some sets of landmarks, in order to find the optimum configuration of markers, sufficient to completely characterize normal and pathologic situations of body equilibrium, solely by means of still snapshots taken at the four sides of a standing person (front, back, left and right poses). Figure 1(a) shows a boy's body suitably marked to evaluate his postural assymetries. Figure 1(b) displays a set of markers that could be correlated with the ones extracted from Figure 1(a). The snapshots are taken with digital photographic color cameras, following certain rules for illuminantion, background control, camera positioning and subject posing. The images are processed to first extract the markers coordinates and then correlate the set of found points with a standard model of landmark set topology. The remaning steps are procedures of statistical shape analysis, aiming to determine if the current subject has a normal or pathological resting posture. This work reports our results concerning the first steps of image processing, namely, the segmentation of the body and markers.

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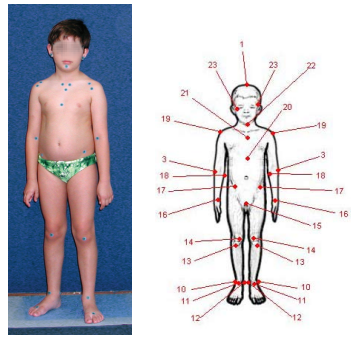

(a) (b)

Figure 1. Fiducial markers for anthropometry. (a) Tipical image acquired using the method described in the text (notice that the image was enhanced only for ilustrative purposes). (b) A possible set of landmarks used with the method (slightly different from the set used in (a).

2. Methodology

The diagnosis of normal or pathological situation implies on the existence of reference models of normality. These models must be created specifically for the population under study. In our case, what is needed is a so-called anatomical atlas of normality specific for the brazilian population. This atlas must be constructed before the use of the proposed method for diagnosis purposes. Its elaboration begins with the sampling of the population to obtain data from subjects considered normal by hypothesis. The gathered data is then classified on clusters indicating the several anthropometric biotypes presented on the sample. Each resulting cluster will be an indicative of a normality class of body geometry. The fidelity of the resulting atlas will thus depend on the quality of the segmentation of a high amount of images, coming from snapshots taken on a variety of places and with subjects dressed with swimsuits with colors of their own choice. The reasons for allowing such variety rely on the anthropometric hypotheses of the method [1]. To deal with all the potential differences in scene situations, we developed a set of rules that guarantees a good performance for the image segmentation step. These include the use of markers that are easy to find, despite the color of the subject's skin and with acceptable illumination variations, and the use of a stablished backgroud.

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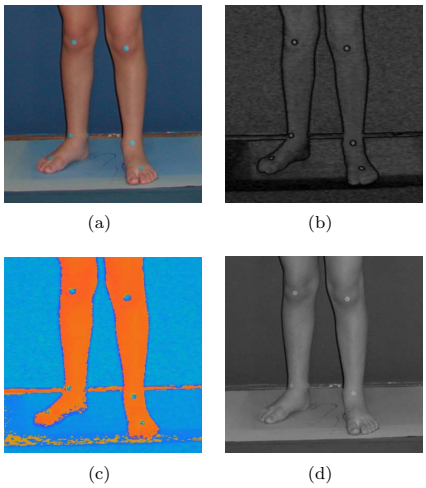
Reference [1] presents all the requirements and rules for illumination and camera set-up. These ought to be very simple and of easy application, in order to guarantee the widespredness of the method.

We thus selected markers with hue value greater than the corresponding to cyan. This interval of hue is not found in any variety of human skin color and thus it will provide a more secure marker segmentation in all cases. The same is valid for the background. Our rules prescribe the use of a specific background color. However, this condition could be difficult to reach for the floor [1], which corresponds to the background behind the subject's feet. Thus we allowed a differing background for the feet, provided it is reasonably homogeneous in the hue channel. Figure 2(a) depicts a tipical situation. In order to achieve a segmentation consistent with color perception, which is an essencial issue when considering the use of the method in clinical applications, we followed [2]. Figures 2(b)to 2(d)show the saturation, hue and luminance channels respectively. The hue and saturation channels provide all the necessary information to obtain a good segmentation, thus we don't use the luminance channel. The luminance channel will behave very differently depending on the subject's skin color, so it will be less useful in providing a uniform segmentation strategy.



(a) (b)

(c) (d)

Figure 2. Example of image channels calculated according to the method adopted in the text. (a) Detail of the RGB image presented in figure 1 (here with its original colors). (b) Saturation channel. (c) Hue channel displayed using a suitable colormap. (d) Luminance channel

The following steps are then taken using the hue and saturation channels:

1. Construct the self-complimentary top-hat of both the hue and the saturation channels, with a structuring element size suited to eliminate inhomogeneities and fluctuations at the image resolution.

2. Then find the maximum of these two top-hats at each pixel to enhance the separation of the several homogeneous regions consistent with both hue and saturation information.

3. Finally, find the maximum of the prior step and the original hue image, to separate the regions with differing hues.

The above procedure produces a segmented hue channel, consistent with the saturation. The luminance channel, as pointed before, doesn't bring information consistent with the hue and is very sensitive to the relative position of the iluminations source and the subject's body part. Notice that the predominant lighting source will always be the photographic flash, following the proposed protocol.

The final segmentation result is presented in Figure 3 below. The method was tested with a variety of situations of feet background, swimsuit colors and textures and skin colors, giving satisfactory results for the further steps of the application.

Figure 3. Resulting segmentation displayed in false colors. Compare with the hue channel.

References

[1] João E. Kogler Jr. and Paulo F.F. de Camargo, *Projeto de Avaliação Antropométrica de Postura Baseada em Análise Automática de Imagens Digitais*, NEIA - Núcleo de Estudos da Infância e Adolescência, São Paulo, 2005. Available from: <http://lsi.usp.br/~kogler/NEIA/publ/neia-TR-sem1-2005.pdf>.

[2] Jesús Angulo and Jean Serra, *Mathematical morphology in color spaces applied to the analysis of cartographic images*, GEOPRO'03 (IPN-Mexico, 2003), Proceedings of the International Workshop on Semantic Processing of Spatial Data, pp. 59–66.