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Non-Contact Human Body Measurement Based on 2D Imagery

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Abstract

Analysing human body shapes requires a substantial amount of anthropometric data. However, traditional manual measurement methods are often inefficient, while 3D scanning devices are expensive and inconvenient. To address these challenges, this study presents a method based on the U2-Net neural network model for extracting human body contours in complex backgrounds, feature point extraction, and circumference fitting analysis. Using data enhancement techniques, we utilized a dataset comprising 2 560 frontal and lateral images of individuals against various backgrounds, which was augmented to 42 800 images. Subsequently, a deep learning network model was trained to accurately fit chest, waist, and hip circumference measurements. Finally, 20 samples were selected for validation, and the predicted values were compared with manually measured values, showing that the errors fall within an acceptable range. The effectiveness and accuracy of this method have been validated, providing a practical solution for anthropometric data collection and body shape research in remote areas.

Keywords: 2D Picture; Deep Learning; Image Segmentation; Human Body Shape Studies

1 Introduction

As advancements in science and technology continue, our understanding of human body morphology becomes increasingly sophisticated [1]. Acquiring accurate human body data is essential; however, it remains a complex and resource-intensive endeavour. In China, there is a notable lack of investment in this research area, with only a limited number of academic institutions and companies actively pursuing studies on human body morphology. Collecting such data necessitates significant financial and labour resources. Traditional tactile measurement methods involving soft rulers are inefficient for gathering human body parameters. These methods require trained personnel to conduct the measurements and involve cumbersome procedures and extended measurement cycles [2]. Non-contact measurement techniques can be categorized into two-dimensional and three-dimensional methods [3]. The two-dimensional non-contact approach, which relies on human body photographs to extract contours, feature points, and girth fittings, is

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highly efficient and does not require specialized operation [4]. Conversely, three-dimensional non-contact measurement technologies, exemplified by 3D scanners, provide precise data; however, they face challenges such as high equipment costs, limited portability, and complex operational procedures, which hinder their widespread application in production environments [5-7]. Thus, the efficient and accurate acquisition of human body data cost-effectively presents an urgent challenge that necessitates innovative solutions.

Two-dimensional non-contact anthropometry enables the rapid extraction of human body outlines from photographs by utilizing the positions of feature points to accurately fit human body data. This method presents a highly efficient and cost-effective approach to human body data collection [8]. Traditional detection methods for extracting contours from human photographs in complex environments rely on edge operators. Feng et al. [9] examined the effectiveness of various edge operators—including Laplacian, Sobel, Roberts, and Canny operators—for human contour extraction. They noted that these methods often produce discontinuous edges and are highly noise-sensitive. Li Ke [10] employed an improved Canny algorithm with depth maps to extract human body contours; however, this approach still resulted in significant contour fragmentation. Deep learning techniques have gained traction in human contour extraction in recent years. DE et al. [11] collected subjects' frontal, lateral, and dorsal images, utilizing deep learning to semantically segment these images and accurately calculate the dimensions of the human body. Nonetheless, this approach necessitated that subjects wear only shorts, and the background had to be pure white, which imposes several constraints and limits the method's practicality.

To minimise the constraints on the photographic background, this paper presents a method for extracting human contours utilizing a U2-Net convolutional neural network. We employed the Bama chain algorithm for feature point detection by leveraging the extracted contours. Combined with the subject's height, these feature points determined proportional relationships between the photographic representation and the actual human form. Using these proportions, we calculated the dimensions of various body parts in length and width. Additionally, we computed the girth parameters of key anatomical regions, such as the chest, waist, and hips, through a fitting process. This approach offers a robust technical foundation for advancing non-contact two-dimensional anthropometric technologies.

2 Method

2.1 Raw Photo Collection

Given the scarcity of samples in existing datasets for specific postures, this paper presents the construction of a novel dataset tailored to these postures. The experimental team, predominantly male, required participants to wear form-fitting attire, necessitating manual data collection for some subjects. Considering various factors, including the composition of the experimental team and the practical requirements for data acquisition, the decision was to focus on creating a dataset for male subjects in specific postures. The location of the photo collection is the dormitory and teaching building; the shooting equipment is the Redmi K50 mobile phone, and the triangular bracket stabilises the shooting. Due to the inherent lens distortion present in photography, adjustments are made to the positioning of the subject, the backdrop, and the distance and elevation of the camera lens. These measures are implemented to minimise the distortion effects in the photographs, thereby enhancing the accuracy of the captured images. Through multiple exper-