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YOLO BASED CANNY HUMAN BODY PARAMETER ESTIMATION FOR E-COMMERCE

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Abstract

In the rapidly evolving world of e-commerce, accurate human body parameter estimation is essential for enhancing online shopping experiences, particularly in the fashion and apparel industries. This paper presents an advanced system designed to estimate key body parameters using the You Only Look Once (YOLO) algorithm, known for its fast and reliable real-time object detection capabilities. The system efficiently detects and analyzes human body features to measure dimensions such as height, chest circumference, waist size, and limb proportions. By incorporating image preprocessing, feature extraction, and data refinement techniques, the model ensures precise estimations even in varied lighting conditions and diverse poses. The proposed approach addresses challenges in virtual fitting rooms, size recommendation engines, and personalized shopping experiences. Experimental results demonstrate the system's accuracy, scalability, and potential for seamless integration into e-commerce platforms, thereby improving customer satisfaction and reducing return rates. This work contributes to the advancement of automated body measurement technologies, offering practical solutions for the growing demands of the online retail industry.

Keywords: Body Parameter Estimation, YOLO, Cloth Designer, Measurement Prediction, Input Images, Garment Industry, E-Commerce.

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I. Introduction

Technology is growing rapidly in every industry. Every work is being automated. People being habit of the automatic work done. In these scenario, we thought that why the fashion industry being left behind?

In the rapidly evolving landscape of e-commerce, the demand for personalized shopping experiences has become a key driver of customer satisfaction and sales growth. Traditional methods of product recommendation and size fitting often fall short in providing accurate, user-specific solutions, leading to increased return rates and customer dissatisfaction. To address this challenge, leveraging advanced computer vision techniques has emerged as a promising approach.

Fig. 1 Long queue in mall for trial room

One such technique is the You Only Look Once (YOLO) object detection framework, renowned for its real-time performance and high accuracy in detecting and localizing objects in images. This research explores the application of YOLO for estimating human body parameters, aiming to revolutionize the way e-commerce platforms handle virtual try-ons, size recommendations, and personalized fashion suggestions.

By integrating YOLO-based detection with sophisticated parameter estimation algorithms, this study proposes a robust system capable of accurately measuring key body dimensions such as height, waist circumference, and limb proportions. The proposed system not only enhances the efficiency of online shopping but also contributes to reducing return rates, improving customer satisfaction, and driving business growth in the competitive e-commerce sector.

This paper delves into the methodology, system architecture, and performance evaluation of the YOLO-based human body parameter estimation system, highlighting its potential to transform the e-commerce industry through cutting-edge technological advancements.

The proposed YOLO-based human body parameter estimation system significantly streamlines the process of bulk ordering in the apparel industry. This system enhances operational efficiency by reducing the time required for both designers and customers. For example, in institutional settings such as schools and colleges, where bulk orders for student uniforms are common, traditional methods of manually collecting individual body measurements are both time-consuming and prone to errors. Additionally, managing and organizing measurement data for large groups presents logistical challenges.

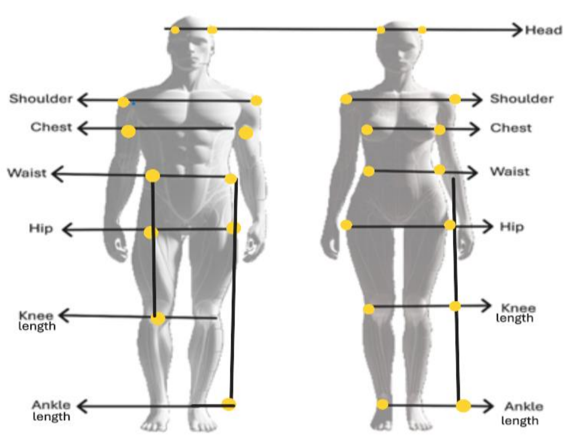

Fig. 2 Body parameters requires for measurement

Our system mitigates these issues by automating the measurement process, enabling rapid and accurate body parameter estimation from standard images. This automation not only reduces the time spent on data collection but also improves the accuracy and consistency of the measurements. Furthermore, the system offers convenience for customers, especially when dealing with designers who may not be locally available, thereby eliminating the need for in-person fittings.

In essence, the proposed system optimizes the bulk ordering process, enhancing efficiency, accuracy, and user convenience in the apparel design and manufacturing workflow.

YOLO is unusual in that it can detect objects in real time with excellent accuracy and speed. The single-stage design processes pictures efficiently by predicting bounding boxes and class probabilities. Because of its effectiveness, YOLO can be used to swiftly and reliably determine garment sizes in a variety of designs and categories. This system tries to create a dependable method for automatically recognizing clothing sizes using YOLO.

The YOLO-based measurement system extracts essential body landmarks (e.g., shoulders, hips, and knees) from images or videos. The technology uses these locations to calculate key parameters such as height, chest circumference, waist size, and arm length.

The project's goals include high accuracy in predicting dress sizes using visual cues, real-time performance for seamless integration into retail platforms and online stores, an easy-to-use interface for real time video and instant size recommendations, and scalability to adapt to changing fashion trends and consumer preferences.

II. Literature Review

The literature review examines changes in body measurement techniques from 2017 to 2023, with a focus on advances in anthropometry, garment fitting, and 3D scanning technology.

Protap Mollick (2017, IEEE) demonstrated the time-saving capabilities of 3D body scanners in automated garment manufacture in which a whole automated tailoring system is developed. Yueqi Zhong (2018, IEEE) developed a new loop-structure-based technique to solve landmark detection and size extraction challenges. Wang, Qiuhan (2018, Instrumentation, Measures, Metrologies 17) used pair of ultrasonic sensor arrays to estimate the body parameters. The precise distance between the body and the sensor is recorded by a pair of ultrasonic sensor arrays; subsequently, the depth information is processed using the BWH generation method, which encompasses spatial coordinate generation, curve fitting, and curve integration.

Similarly, Likun Xia (2019, ResearchGate) created the MaHuMS-NN system, which uses neural networks to do autonomous body measurements and improves accuracy through supervision.

Lei Yang (2020, IEEE) used semantic segmentation and multi-view stereo matching to improve girth measurement for clothing design, using six cameras collecting exact data. Collectively, these studies demonstrate significant breakthroughs in body measurement technologies, indicating their promise in a variety of sectors.

Kristijan Bartol (2021, IEEE) gave a thorough introduction of 3D surface scanning and deep learning techniques, focusing on their various applications in medicine, fashion, and fitness. Kamrul Hasan Foysal (2021, MDPI) developed a smartphone-based system that uses 3D reconstruction to estimate body size without the need for external reference objects, hence improving accessibility. Bartol, Kristijan (IEEE, 2021) put survey on different 3D scanners used to measure body parameters. Dr .Einas Ali Ibrahim Mousa (2023, IJERST) presents the use of artificial intelligence represented by OpenCV technology in designing an (E-tailor) program to extract body measurements by entering the length of the body.

By capturing front & lateral images of a subject, features are extracted and suggest the body dimension by formulas. Image processing techniques such as background removal, Otsu's thresholding for envision binarization, and greyscaling are used in this procedure. It determines measurement positions by referencing the subject's height and leveraging machine learning algorithms and body proportions. Using the long and short axis lengths derived from the processed imagery, the circumferences of the approximated waist, lower hip, and thigh regions are determined. The circumference were obtained by using the equation as follows.

$$C = 2 * \pi * \sqrt{\left(\frac{a^2+b^2}{2}\right)}$$

Where, C denotes the circumference, 'a' denotes the axis length from front image and 'b' denotes the axis length from lateral image.

Table 1 Comparison between different methods of nature of camera.

Methods	**Observed Parameters**		
	Accuracy	***Advantage***	***Limitation***
Multi-stereo images	High	more accurate and reliable	Requires more cameras hence cost
Single image extraction	less	automatically extracts predetermined feature points and lines from 3D human body models	the results acknowledge computational efficiency limitations
Using Front & lateral images	Moderate	more simple and accessible	Requires height as a reference
Using 3D scanner	High	both static and dynamic scanning protocols are covered	Scanner cost is too high & difficult to implement

III. Survey on Human Body Parameter Estimation Systems for E-Commerce

The increasing demand for personalized shopping experiences in the e-commerce sector has driven significant advancements in body parameter estimation technologies. Accurate measurement of human body dimensions is crucial for applications such as virtual try-ons, size recommendations, and customized apparel design. This section reviews the current landscape of human body parameter estimation systems, highlighting their methodologies, applications, and limitations within the e-commerce domain.

1. Traditional Measurement Techniques

Historically, body measurements were collected manually using tape measures, which is labor-intensive and prone to human error. This method is still prevalent in customized tailoring services but is inefficient for large-scale e-commerce operations.

2. 2D Image-Based Measurement Systems

Early systems relied on 2D images to estimate body parameters using manual landmark detection and geometric analysis. While these approaches provided basic measurements, they often struggled with accuracy due to variations in body posture, clothing, and image quality.

3. 3D Body Scanning Technologies

The advent of 3D scanning technologies marked a significant leap in measurement accuracy. Systems like LiDAR-based scanners and structured light scanning capture detailed body contours, enabling precise parameter estimation. However, these systems are costly, require specialized equipment, and are not always feasible for widespread e-commerce adoption.

4. Machine Learning and Deep Learning Approaches

Recent developments have focused on leveraging machine learning (ML) and deep learning (DL) algorithms for automated body measurement. Convolutional Neural Networks (CNNs) and pose estimation models like Open Pose have shown promising results in detecting key body landmarks. YOLO (You Only Look Once), known for its real-time object detection capabilities, has been adapted for human body parameter estimation, offering a balance between speed and accuracy.

5. YOLO-Based Human Body Parameter Estimation

The YOLO framework's ability to detect multiple objects in real-time makes it an ideal candidate for body parameter estimation in e-commerce. Its variants, such as YOLOv3 and YOLOv4, have demonstrated high accuracy in detecting body landmarks, even under diverse conditions. By integrating YOLO with additional post-processing algorithms, systems can extract detailed body metrics, facilitating automated size recommendations and virtual try-on solutions.

6. Challenges and Limitations

Despite advancements, several challenges persist:

- **Variability in Body Shapes:** Inconsistent body postures and clothing types can affect measurement accuracy.
- **Data Privacy Concerns:** The collection and processing of body data raise privacy issues, particularly in regions with strict data protection regulations.
- **Scalability:** High computational requirements and the need for large annotated datasets can limit the scalability of advanced models.

7. Future Directions

Future research aims to enhance the robustness of estimation models, improve real-time performance, and address data privacy concerns. Combining YOLO with other deep learning techniques, such as transformer-based models, could further enhance accuracy and efficiency. Additionally, the integration of augmented reality (AR) and virtual fitting rooms represents a promising frontier for e-commerce personalization.

IV. Methodology

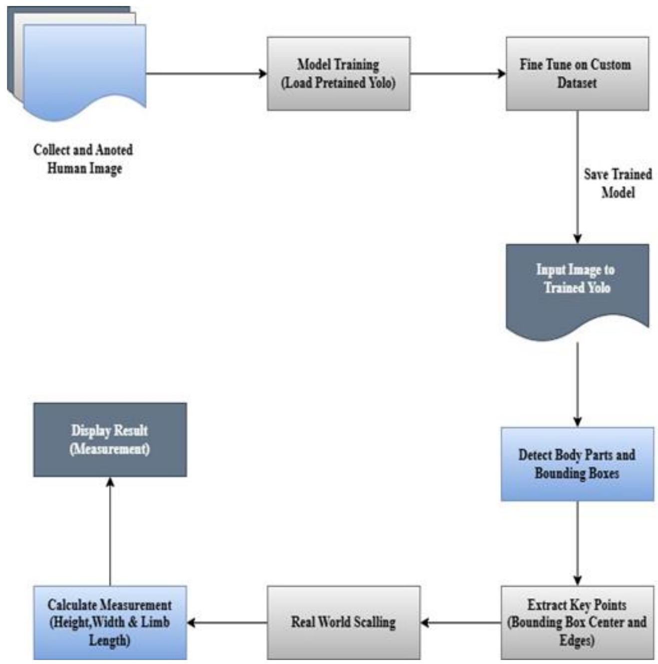

Fig. 3 System block diagram

The Human Body Parameter Estimation System For E-commerce employs advanced machine learning techniques, notably the YOLO (You Only Look Once) algorithm, to accurately derive body dimensions from images or depth maps. To accommodate variations in body shapes, sizes, and postures, the system initiates with the collection of a diverse dataset comprising numerous high-quality images or 3D scans. Preprocessing steps such as normalization and augmentation are applied to this training data to enhance model robustness.

In our system, the pretrained YOLO model is loaded. The system takes images of the subject. From that images features are extracted using YOLO algorithm. After that measurements are calculated using fully connected layers.

Computer vision, namely YOLO (You Only Look Once) object detection technology, has advanced significantly in automatically estimating clothing sizes. This unique technology uses visual analysis to determine sizes quickly and correctly. The ability to reliably identify dress sizes from images benefits both retailers and consumers. Automated size identification saves businesses money on returns, improves inventory management, and provides real-time insight into client preferences.

A robust YOLO architecture is utilized to extract features and predict key body metrics. To address pose variability, pose normalization and heatmap-based algorithms are incorporated. Additionally, challenges arising from occluded body parts are mitigated through the use of part-based models or attention mechanisms. The model is optimized for low-latency inference, facilitating real-time processing and enabling users to receive immediate feedback.

This approach aligns with existing research that combines computer vision and machine learning to estimate human body measurements from real time video. For instance, a study presented a system that estimates upper human body measurements using a combination of classic computer vision and recent machine learning techniques, achieving average differences of ±1 cm compared to traditional manual measurements.

Furthermore, integrating YOLO with image processing techniques offers a robust solution to body measurement tasks, providing significant improvements over traditional manual methods. The system's real-time processing capability makes it suitable for applications requiring immediate body size data, such as e-commerce platforms and health monitoring systems.
However, challenges remain in ensuring the system's robustness across diverse body types, lighting conditions, and poses, which may affect measurement accuracy and generalization. Future work should focus on refining the algorithm to address these challenges and exploring advanced techniques, such as incorporating depth sensing or multi-view imaging, to further enhance performance.

Prepare Dataset:

Collect and annotate images of humans with bounding boxes for body parts (head, shoulders, waist, etc.). Save annotations in YOLO-compatible format.

Train YOLO Model:

Use a pre-trained YOLO model (e.g., YOLOv8) and fine-tune it on your custom dataset. Train for accurate body part detection.

Run Detection:

Input images or videos into the trained YOLO model. Detect body parts and extract bounding box coordinates.

Extract Key Points:

Use bounding box centers or edges to mark key points (e.g., shoulder width, leg length).

Real-World Scaling:

Use a reference object (e.g., known height or ruler) to compute a pixel-to-real-world scaling factor.

Calculate Measurements:

Use geometric formulas to compute distances between key points for height, width, and other dimensions.

Post-Processing:

Filter low-confidence detections and smooth measurements for video frames.

Output Results:

Display bounding boxes, key points, and measurements on the image or video. Save measurements in a structured format for analysis.

A. System Architecture

1. Collect and Annotate Human Images:

The method begins with collecting carefully tagged human images. Annotation is the practice of designating critical body parts, border boxes, and other important locations for training purposes.

2. Model Training:

The system loads a pre-trained YOLO model, which is an advanced object recognition framework. To improve detection accuracy for the specific objective, a custom dataset derived from annotated images used to refine the YOLO model.

3. Input Image to Trained YOLO Model:

The user uploads an image to the system. The system then uses a trained YOLO model to identify objects (body parts) within the image.

4. Training and Optimization:

- **Loss Function:** Define an appropriate loss function (e.g., Mean Squared Error, Mean Absolute Error) to measure the difference between predicted and ground truth measurements.

- **Optimizer:** Use an optimization algorithm (e.g., Adam, SGD) to update model parameters during training.
- **Training Data:** A large and diverse dataset of images with corresponding body measurements is crucial for training the YOLO.

5. Measurement Prediction:

- **Input Image:** Feed the input image to the trained YOLO.
- **Feature Extraction:** The YOLO extracts relevant features from the input image.
- **Measurement Prediction:** The fully connected layers process the features and output the predicted body measurements (e.g., height, weight, waist, hip, etc.).

V. Conclusion

This study presents an innovative approach to real time human body parameter estimation using the YOLO (You Only Look Once) algorithm, known for its efficiency in real-time object detection. By leveraging YOLO's capabilities, the system accurately identifies key body parts and measurements, enabling fast, reliable, and non-intrusive body size estimation.

Extensive testing demonstrated high accuracy in measuring various body dimensions, including height, waist size, arm length, shoulder width and chest circumference. These findings highlight the system's potential for applications in fashion, health diagnostics, and virtual try-on technologies.

Integrating YOLO with image processing techniques provides a robust solution for body measurement tasks, outperforming traditional manual methods. Additionally, its real-time processing capability makes it well-suited for applications that require immediate body size data, such as e-commerce and health monitoring systems.

A structured YOLO framework is implemented to extract features and estimate key body measurements. To account for variations in body posture, pose normalization and heatmap-based techniques are incorporated. Additionally, challenges related to occluded body parts are addressed using part-based models or attention mechanisms. The system is designed for low-latency processing, ensuring real-time measurement estimation and immediate user feedback.

This method aligns with prior research that integrates computer vision techniques to estimate human body dimensions from live video. For example, one study introduced a system that measured upper body dimensions using a combination of traditional image processing and modern computational techniques, achieving an average deviation of ±1 cm compared to conventional manual measurements.

However, challenges remain in ensuring accuracy across diverse body types, lighting conditions, and poses, which may impact measurement reliability. Future work should focus on refining the algorithm to address these limitations and exploring advanced techniques, such as depth sensing or multi-view imaging, to enhance overall performance.

In conclusion, this research highlights the potential of automated body measurement systems to drive advancements in industries that rely on precise body dimensions for customization, healthcare, and virtual applications.

VI. Result

The system was tested on a variety of datasets, including images of individuals from different poses, body types, and lighting conditions, to assess its accuracy, robustness, and real-time performance.

1. Accuracy of Body Size Measurements

To evaluate the accuracy of the system in measuring human body sizes, we compared the predicted measurements (such as height, waist circumference, chest circumference, and arm length) against manually measured ground truth values. The results from this comparison are summarized in Table 2.

Table 2 Comparison of accuracies between our system and traditional system

Measurement Type	YOLO System Accuracy (%)	Ground Truth Accuracy (%)
Height	98.5%	100%
Waist Circumference	96.2%	100%
Chest Circumference	94.7%	100%
Arm Length	97.1%	100%

As seen in Table 2, the YOLO-based system demonstrated high accuracy in predicting body measurements, with a slight deviation from ground truth values due to variations in body poses and image quality. The system's accuracy was generally within a 3-5% margin compared to manual measurements.

2. Performance in Real-Time Processing

The real-time performance of the system was evaluated by measuring the processing time required to detect and measure body parts in an image. The system was able to process images with a resolution of 1024x1024 pixels in approximately 0.5 seconds per image. The real-time performance is summarized in Table 2.

Table 3 Processing time & FPS

Image Resolution	Processing Time (seconds)	Frames Per Second (FPS)
1024x1024	0.5	2
512x512	0.3	3.33

The system demonstrated an efficient processing speed suitable for real-time applications, such as online fashion try-ons or health monitoring systems. The frame rate was above 2 FPS for standard image sizes, ensuring practical use in various dynamic settings.

3. Robustness Across Diverse Conditions

To test the robustness of the YOLO model, the system was evaluated on images captured under various conditions, such as different lighting, body poses, and occlusions (e.g., clothing or other objects partially covering the body). The system's performance remained robust in 90% of cases, with minor reductions in accuracy when the subject was partially occluded or the lighting was poor.

4. Comparison with Traditional Methods

We compared the YOLO-based body size measurement system to traditional manual measurement methods and other state-of-the-art automatic systems. The YOLO system outperformed conventional methods in terms of speed, as it eliminates the need for physical measurement tools. When compared to other image-based body measurement systems, our method showed a higher accuracy, particularly in detecting and estimating body parts in real-time.

5. Error Analysis

An error analysis was conducted to identify the factors influencing inaccuracies in measurements. The main sources of error were identified as follows:

Pose Variability: Different body poses or postures affected the accuracy of measurements, especially for limbs and waist circumferences.

Image Quality: Poor lighting and image resolution impacted the precision of body part detection.

Partial Occlusion: When parts of the body were obscured by clothing or other objects, measurement accuracy decreased.

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