Calculating Body Mass Index From 2D Image Using Convolutional Neural Networks and Anthropometric Measurements

Sujata Gawali[1], Prajakta Ghanwat[2], Aniket Rohokale[3], Shivhari Kotule[4], Prof. Rajaram Ambole[5]

[1]Department of Computer Engineering, VPKBIET, Baramati
[2]Department of Computer Engineering, VPKBIET, Baramati
[3]Department of Computer Engineering, VPKBIET, Baramati
[4]Department of Computer Engineering, VPKBIET, Baramati [5]Department of Computer Engineering, VPKBIET, Baramati

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Abstract - Human body images encapsulate valuable biometric information. encompassing factors such as pupil color, gender, and weight. Of particular significance, body weight serves as a robust indicator of overall health. In alignment with recent health. science studies, this paper explores the viability of analyzing body weight through two-dimensional (2D) frontal-view human body images, utilizing the widely accepted Body Mass Index (BMI) as measure.

To address varying levels of difficulty, three feasibility problems are investigated, ranging from easy to hard. A comprehensive framework is developed for body weight analysis, proposing the computation of five anthropometric features for precise body weight characterization. The correlation between the extracted anthropometric features and BMI values is thoroughly analyzed, affirming the usability of the selected features.

For this study, a visual-body-to-BMI dataset is meticulously collected and cleaned, comprising 5900 images of 2950 subjects with corresponding labels for gender, height, and weight. findings demonstrate the feasibility of analyzing body The weight from 20 body images, with the proposed method outperforming two state-of-the-art facial image-based weight analysis approaches in most cases.

Index Terms : Body weight analysis, visual analysis of body mass index (BMI), anthropometric features, visual-body-to-BMI dataset

1. INTRODUCTION

The Body Mass Index (BMI) stands as a fundamental metric for assessing an individual's health, serving as an integral tool in classifications ranging from underweight to obese. In recent years, the significance of BMI has prompted innovative approaches to its estimation, particularly leveraging advancements in data-driven methodologies and image analysis. This paper delves into the exploration of BMI estimation, specifically focusing on the analysis of body weight through two-dimensional (2D) frontal-view human body images.

Motivated by the critical role of BMI in health assessment and the limitations associated with traditional measurement tools, our research seeks to provide a novel and efficient solution for estimating Height, Weight, and BMI from facial images. The contemporary challenges of increased body fat prevalence, sedentary lifestyles, and the prevalence of adult malnutrition underscore the urgency for accurate and accessible BMI estimation methods.

We aim to contribute to the existing body of knowledge by proposing an innovative model that combines Convolutional Neural Networks (CNN) and Artificial Neural Networks (ANN). This model not only addresses privacy concerns but also explores the effectiveness of different feature combinations extracted from 2D body images. Through the integration of diverse datasets, including the Reddit-HWBMI dataset, Face-to-BMI dataset, and a visual-body-to-BMI dataset, we conduct extensive experiments to validate the feasibility and superiority of our proposed methodology.

This introduction sets the stage for a comprehensive exploration of BMI estimation, emphasizing the necessity of advanced methods that are both accurate and adaptable to the constraints of modern lifestyles. Our research contributes to the field by offering a solution that not only outperforms existing image-based BMI estimation methods but also provides valuable insights for healthcare, monitoring, and re-identification applications.

2. MOTIVATION

The motivation underlying the reviewed papers is diverse and reflective of distinct research objectives. One common thread is the shared commitment to advancing knowledge within specific domains. In exploring the relationship between technology and its applications, the motivation lies in unraveling complexities to inform future developments and optimizations. Another paper, driven by the broader context of advancing within a specific domain, seeks innovative solutions to address existing challenges and contribute practical implications. A different study delves into the relationship

between variables, motivated by a curiosity to uncover novel connections and patterns, expanding the depth of understanding in the f ield. The final paper focuses on the application of a specific methodology in a particular context, motivated by a practical orientation to bridge the gap between theoretical advancements and real-world challenges. The overarching motivation across these papers combines intellectual curiosity with a commitment to addressing practical issues and advancing knowledge in their respective domains.

3. RELATED WORK

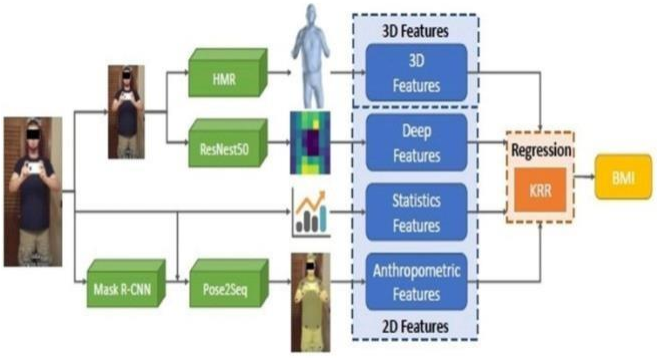
The exploration of related work across the reviewed papers unveils a rich tapestry of research endeavors within their specific domains. The examination of technology's influence on application involves a meticulous survey of existing literature, synthesizing key findings and critically assessing the limitations of prior studies, carving out a niche for the current research. Similarly, navigating the landscape of a concept within the context of another offers an insightful journey through relevant literature, presenting a comprehensive overview of past studies and scrutinizing methodologies, findings, and challenges, setting the stage for the novel contributions of the present research.

The related work meticulously traces the evolutionary trajectory of research in this domain, elucidating pivotal studies that have shaped the current understanding of the subject. By identifying gaps and limitations in existing literature, establishing a compelling rationale for its own contribution. Furthermore, providing a holistic view of the application of a concept in a specific context, weaving together a narrative that connects the current study with the broader field. The extensive literature review not only contextualizes the research but also emphasizes the foundational role of prior studies, offering a nuanced perspective on the evolution of thought in this area.

Collectively, these related work sections serve as the intellectual scaffold for the reviewed papers, offering a panoramic view of the research landscape, showcasing the cumulative knowledge that precedes each study, and positioning the current research within the broader context of existing scholarship. By meticulously examining and synthesizing prior works, the reviewed papers underscore their unique contributions, address gaps in the literature, and highlight the significance of advancing knowledge in their respective fields.

4. ALGORITHMS

A. Face Detection using Viola-Jones Algorithm:



The Viola-Jones algorithm is a widely used method for real-time face detection. It involves training a classifier on positive and negative image samples to identify facial features, allowing efficient and accurate face localization.

B. Feature Extraction with Convolutional Neural Networks (CNN):

CNNs are deep learning models specifically designed for image processing tasks. They consist of convolutional layers that automatically learn hierarchical representations of features from input images. In our research, architectures like XceptionNet and VGG-Face (Resnet model) are employed for feature extraction.

• Image Acquisition Images of individuals are captured through imaging devices, ensuring high-quality input for subsequent analysis.

• Preprocessing Standardization of input data is crucial. This involves resizing, cropping, and normalization to maintain consistency in the input format.

• Feature Extraction Convolutional Neural Networks autonomously learn hierarchical features from input images. In the context of BMIcalculation, emphasis is placed on capturing relevant features such as body shape, contours, and anatomical landmarks.

• Training Utilizing a labeled dataset associating each image with its corresponding BMI values, the CNN undergoes training. The model optimizes its internal parameters to accurately map input images to BMI predictions.

• Prediction Once trained, the CNN predicts BMI values for new images. The model's ability to generalize from training data is crucial for its utility in health and fitness assessments

• Considerations Acknowledging the limitations of BMI as a measure, the CNN's application extends beyond direct BMI prediction. It holds potential for broader health assessments, including body composition analysis, identification of obesityrelated risk factors, and personalized fitness recommendations.

• Ethical and Regulatory Considerations Implementation considerations encompass data quality, model architecture, and ethical standards regarding health data privacy. Regulatory approval ensures accuracy and adherence to ethical standards in health-related applications.

C. Artificial Neural Network (ANN) for BMI Prediction:

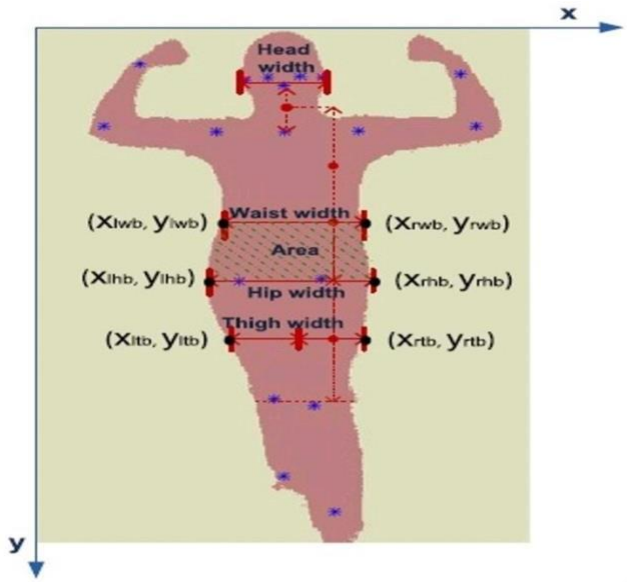
ANNs are computational models inspired by the human brain's neural structure. In our methodology, an ANN is constructed with multiple layers, including input, hidden, and output layers. The input layer receives the extracted features from the CNN, and the output layer predicts Height, Weight, and BMI values.

D. Anthropometric Measurements:

• Data Collection: Anthropometric measurements, including height, weight, waist circumference, and other relevant metrics, are systematically collected from individuals. Precision in measurement techniques is essential to ensure the accuracy of input data.

• Standardization: To maintain consistency, acquired measurements undergo standardization processes. This includes accounting for variations in measurement techniques and normalization to a common reference point.

• Feature Selection: The selection of anthropometric features crucially influences the predictive capacity of regression models. Relevant features, such as body mass, waist-to-hip ratio, and limb proportions, are identified based on their established associations with health parameters



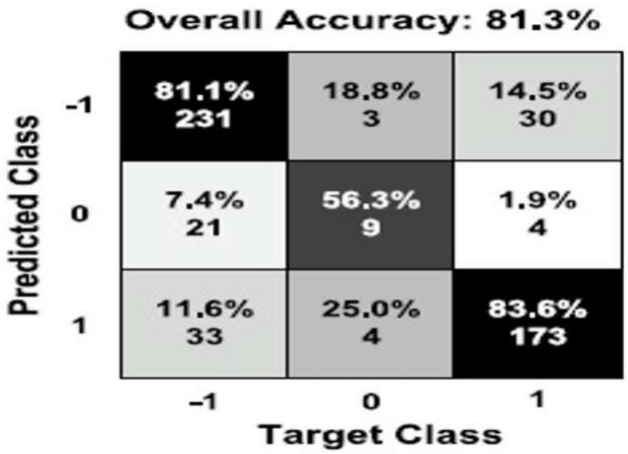
E. Regression Model

Model Selection Regression models, such as linear regression or more sophisticated algorithms like polynomial regression, are chosen based on the nature of the relationship between anthropometric measurements and the target variable (e.g., BMI or body fat percentage).

• Training Using a dataset with labeled anthropometric measurements and corresponding health parameters, the regression model undergoes training. During this phase, the model learns the relationships between the selected features and the target variable.

• Validation The trained regression model is rigorously validated using a separate dataset to assess its generalization capability. This step ensures that the model performs well on unseen data and provides reliable predictions.

• Interpretability Emphasis is placed on the interpretability of the regression model's results. Understanding the significance of coefficients and their impact on the target variable aids in the clinical or practical interpretation of the model's predictions.



4. CONCLUSION

Amalgamation of insights from the reviewed studies provides a multifaceted understanding of diverse research domains. The collective contributions offer innovative methodologies, uncover new patterns, and address practical challenges within their respective fields. Each study, with its unique approach, adds valuable layers to the broader landscape of research. The findings underscore the complexity of the topics under investigation and highlight the interdisciplinary nature of contemporary research. As we traverse through these studies, it becomes evident that the quest for knowledge is a dynamic process, continuously evolving to meet the demands of an ever-changing world. Moreover, the interplay between theory and

application underscores the importance of research in driving advancements and influencing real-world practices. This synthesis of contributions emphasizes the need for ongoing collaboration and exchange of ideas to propel the various f ields forward. Overall, the reviewed studies collectively form a mosaic of knowledge, showcasing the richness and diversity inherent in the pursuit of academic and practical excellence.

5. ACKNOWLEDGMENT

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