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Face to BMI: A Deep Learning Based Approach for Computing BMI from Face

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Abstract: Body mass index (BMI) is a measure of a person's health in relation to their body weight. BMI has been shown to correlate with various factors such as physical health, mental health, and prevalence. Calculating BMI often requires exact height and weight, which will require manual work to measure. Large scale automation of BMI calculation can be used to analyze different aspects of society and can be used by governments and businesses for to make effective decisions. Previous work used only geometric facial features that removed other information or the data-driven deep learning approach where the amount of data became a bottleneck. We used pre-trained modern models such as Inception-v3, VGG-Faces, VGG19, Xception and refined them on a relatively large public dataset with discriminant learning. We used the largest dataset of faces labeled Illinois DOC for training and Capturing Profile, VIP attribute for evaluation purposes.

I. INTRODUCTION

In an era characterized by the fusion of cutting-edge technology and healthcare, the quest for innovative solutions to monitor and improve our well-being has reached new horizons. The intersection of deep learning and healthcare has paved the way for transformative applications, one of which is the estimation of Body Mass Index (BMI) from facial images. The ability to discern a crucial health metric like BMI from a simple photograph presents an intriguing and potentially groundbreaking avenue for health assessment and intervention.

BMI, a numerical indicator derived from an individual's height and weight, has long served as a fundamental measure of body composition and a crucial determinant of overall health. Traditionally, BMI calculations have relied on manual measurements and cumbersome equipment, often conducted in clinical settings. However, advances in computer vision and deep learning have opened up possibilities for a non-invasive and accessible means of BMI estimation through facial analysis.

This research endeavor, "Face to BMI: A Deep Learning Based Approach for Computing BMI from Face," embarks on an exploration of the potential and implications of harnessing the power of deep neural networks to extract valuable health information from facial features. This innovative approach has far-reaching implications across multiple domains, including healthcare, fitness, research, and personal well-being.

In this introductory chapter, we provide an overview of the problem at hand, discuss the significance of our research, and outline the objectives and scope of this study. We also highlight the potential benefits and challenges of utilizing facial analysis to compute BMI, setting the stage for a deeper dive into the methodology and outcomes of our investigation.

The significance of this study lies in its potential to revolutionize the way we approach BMI assessment. By utilizing facial images, a resource readily available through smartphones and digital cameras, we envision a future where individuals can effortlessly track their BMI in real-time. This innovation can lead to early health interventions, personalized fitness regimens, and population-scale epidemiological studies.

Through these objectives, we aim to shed light on the potential of facial analysis as a transformative tool in the realm of health and well-being, setting the stage for a comprehensive investigation into our deep learning-based approach.

This introduction sets the stage for the research project, introducing the problem, its significance, and the overarching objectives of the study. It provides a clear context for the subsequent chapters, where the methodology, results, and implications will be explored in greater detail.

BMI is a measurement that is a ratio of your weight and square of height. The BMI (Body Mass Index) of any person is a crucial indicator of health. The higher your BMI, the higher your risk for certain diseases such as heart disease, high blood pressure etc

The BMI (Body Mass Index) of any person is a crucial indicator of health. It checks if the person is underweight, normal, overweight, or obese. In the current scenario, health is one of the most neglected factor. Technology which has more benefits also has some drawbacks. It has made humans lazy and thus reduced their physical activity leading to a sedentary lifestyle and a rise in BMI which adversely affects their health and increases the risk of chronic diseases.

The more the BMI, the more is the chance of developing cardiovascular and other harmful diseases. On the other side of the coin, some people have problems like malnutrition and deficiencies. So, BMI can help a person to keep a track record of their health. According to [1], on average, one out of every three adults is obese, which is about 36% of the population, and by the year 2030, an estimated 20% of the global population would be obese. Human faces carry a significant amount of information about a person.

Recent studies have shown a strong correlation * these three authors contributed equally to this work between the human face and the BMI of the person. The people with skinny faces have chances of less BMI and vice versa. Generally, obese people tend to have the middle and lower part of the face wider. It is difficult for the person to calculate BMI if they do not have a measuring tape and weighing machine. Recently there have been much advancement in deep learning where models can extract meaningful features from the images.

II. LITERATURE SURVEY

[2] Lingyun Wen, Guodong Guo, ”A computational approach to body mass index prediction from face images”, Image and Vision Computing, Volume 31, Issue 5, 2013, Pages 392-400, ISSN 0262-8856.

Human faces encode plenty of useful information. Recent studies in psychology and human perception have found that facial features have relations to human weight or body mass index (BMI). These studies focus on finding the correlations between facial features and the BMI. Motivated by the recent psychology studies, we develop a computational method to predict the BMI from face images automatically.

We formulate the BMI prediction from facial features as a machine vision problem, and evaluate our approach on a large database with more than 14,500 face images. A promising result has been obtained, which demonstrates the feasibility of developing a computational system for BMI prediction from face images at a large scale

[3] M. Barr, G. Guo, S. Colby, M. Olfert, Detecting body mass index from a facial photograph in lifestyle intervention, Technologies 6 (3) (2018) 83

This study aimed to identify whether a research participant’s body-mass index (BMI) can be correctly identified from their facial image (photograph) in order to improve data capturing in dissemination and implementation research. Facial BMI (fBMI) was measured using an algorithm formulated to identify points on each enrolled participant’s face from a photograph. Once facial landmarks were detected, distances and ratios between them were computed to characterize facial fatness. A regression function was then used to represent the relationship between facial measures and BMI values to then calculate fBMI from each photo image.

Simultaneously, BMI was physically measured (mBMI) by trained researchers, calculated as weight in kilograms divided by height in meters squared (adult BMI). Correlation analysis of fBMI to mBMI (n = 1210) showed significant correlation between fBMI and BMIs in normal and overweight categories ($p < 0.0001$). Further analysis indicated fBMI to be less accurate in underweight and obese participants. Matched pair data for each individual indicated that fBMI identified participant BMI an average of 0.4212 less than mBMI ($p < 0.0007$). Contingency table analysis found 109 participants in the ‘obese’ category of mBMI were positioned into a lower category for fBMI. Facial imagery is a viable measure for dissemination of human research; however, further testing to sensitize fBMI measures for underweight and obese individuals are necessary.

[4] E. Kocabey, M. Camurcu, F. Ofli, Y. Aytar, J. Marin, A. Torralba, I. Weber, ”Face-to-BMI: Using Computer Vision to infer Body Mass Index on Social Media.” Proceedings of the International AAAI Conference on Web and Social Media (ICWSM), pp. 572-575, 2017.

A person's weight status can have profound implications on their life, ranging from mental health, to longevity, to financial income. At the societal level, "fat shaming'" and other forms of "sizeism" are a growing concern, while increasing obesity rates are linked to ever raising healthcare costs. For these reasons, researchers from a variety of backgrounds are interested in studying obesity from all angles.

To obtain data, traditionally, a person would have to accurately self-report their body-mass index (BMI) or would have to see a doctor to have it measured. In this paper, we show how computer vision can be used to infer a person's BMI from social media images. We hope that our tool, which we release, helps to advance the study of social aspects related to body weight.

[5] A. Haritosh, A. Gupta, E. S. Chahal, A. Misra and S. Chandra, ”A novel method to estimate Height, Weight and Body Mass Index from face images,” 2019 Twelfth International Conference on Contemporary Computing (IC3), 2019, pp. 1-6, doi: 10.1109/IC3.2019.8844872.

Body Mass Index (BMI) is the most commonly used tool to evaluate an individual’s health. It is used to classify a person as underweight, healthy weight, overweight or obese. BMI is co-related with body fat and is a vital indicator of possible diseases that can transpire with higher body fat ranges. Higher body fat is prevalent these days with a higher calorie diet and a low physical activity lifestyle. On the other end of the spectrum, Adult malnutrition is more common and widespread than we are conscious of these days.

The BMI can be used as a measure of adult nutritional status, both of individuals and of communities. Given that people have less time in their busy life and most people dont own a weighing machine and/or a measuring tape, we propose a time and cost efficient method of estimating Height, Weight and BMI from a persons face. In this paper, we propose a novel model using Convolution Neural Networks (CNN) and Artificial Neural Networks (ANN). We start by detecting the face from an image using the Viola-Jones algorithm. The image is fed to the Feature Extractor model.

The extracted features are passed to an Artificial Neural Network (ANN) model which gives the predicted Height, Weight and BMI values. We have evaluated our model on the Reddit-HWBMI dataset and Face-to-BMI dataset. We propose a novel dataset, the Reddit-HWBMI dataset which contains 982 subjects with their corresponding Height, Weight, BMI, Gender and Age. The best performance for BMI was given by the XceptionNet model when used as a Feature Extractor. The XceptionNet also performed best for weight, whereas VGG-Face (Resnet model) performed slightly better than XceptionNet for height

[6] Mayer C, Windhager S, Schaefer K, Mitteroecker P (2017) BMI and WHR Are Reflected in Female Facial Shape and Texture: A Geometric Morphometric Image Analysis. PLoS ONE 12(1): e0169336. doi:10.1371/journal.pone.0169336.

Facial markers of body composition are frequently studied in evolutionary psychology and are important in computational and forensic face recognition. We assessed the association of body mass index (BMI) and waist-to-hip ratio (WHR) with facial shape and texture (color pattern) in a sample of young Middle European women by a combination of geometric morphometrics and image analysis.

Faces of women with high BMI had a wider and rounder facial outline relative to the size of the eyes and lips, and relatively lower eyebrows. Furthermore, women with high BMI had a brighter and more reddish skin color than women with lower BMI. The same facial features were associated with WHR, even though BMI and WHR were only moderately correlated. Yet BMI was better predictable than WHR from facial attributes. After leave-one-out cross-validation, we were able to predict 25% of variation in BMI and 10% of variation in WHR by facial shape.

Facial texture predicted only about 3–10% of variation in BMI and WHR. This indicates that facial shape primarily reflects total fat proportion, rather than the distribution of fat within the body. The association of reddish facial texture in high-BMI women may be mediated by increased blood pressure and superficial blood flow as well as diet. Our study elucidates how geometric morphometric image analysis serves to quantify the effect of biological factors such as BMI and WHR to facial shape and color, which in turn contributes to social perception

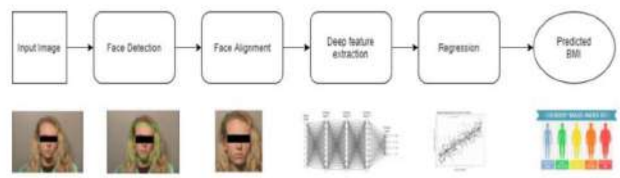
[7] Jiang, Min & Shang, Yuanyuan & Guo, Guodong. (2019). On Visual BMI Analysis from Facial Images. Image and Vision Computing. 89. 10.1016/j.imavis.2019.07.003.

Automatically assessing body mass index (BMI) from facial images is an interesting and challenging problem in computer vision. Facial feature extraction is an important step for visual BMI estimation. This work studies the visual BMI estimation problem based on the characteristics and performance of different facial representations, which has not been well studied yet. Various facial representations, including geometry based representations and deep learning based, are comprehensively evaluated and analysed from three perspectives: the overall performance on visual BMI prediction, the redundancy in facial representations and the sensitivity to head pose changes.

The experiments are conducted on two databases: a new dataset we collected called the FIW-BMI and an existing large dataset Morph II. Our studies provide some deep insights into the facial representations for visual BMI analysis: 1) The deep model based methods perform better than geometry based methods. Among them, the VGG-Face and Arc face show more robustness than others in most cases; 2) Removing the redundancy in VGG-Face representation can increase the accuracy and efficiency in BMI estimation; 3) Large head poses lead to low performance for BMI estimation. The Arc face, VGG-Face and PIGF are more robust than the others to head pose variations.

III. PROPOSED METHOD

3.1 Flow Chart:



A. Data Preprocessing

We are using front-facing images from the dataset. However, some images have tilted head position and are inconsistent with respect to amount of zoom. To make images similar, we used the pre-processing by StyleGan FFHQ Dataset [10], using the DLIB 68 landmark detection [11] model to align the face vertically and then blurred the surroundings while focusing on the face.

For training on Tensor Processing Units (TPU) we converted our dataset into Tensor flow Records Dataset (TFRecord) format. Each record consisted of 1024 images and was resized to 256 × 256 × 3, pre-processed according to the backbone network used for transfer learning. The label for the image is the BMI value.

B. Transfer Learning BMI

Calculation from facial images is rather complicated so learning all required features from relatively small datasets would be infeasible. Many tasks in computer vision have used transfer learning to boost performance and reduce the training time. Hence we have used state of the art pre-trained models such as:

- **Inception-v3 [12]:** Inception-v3 is a deep convolutional neural network. It is the 3rd edition model of the Inception CNN developed by Google. This model is trained on more than a million images from the popular ImageNet database. It gave a Top-1 accuracy score of 0.779 and a Top-5 accuracy score of 0.937 with around 24 Million parameters only and thus computationally effective when compared to other models.

- **VGG-Face [13]:** VGG-Face model is developed by the researchers of the Visual Geometry Group (VGG) at Oxford. This model uses the VGGFace2 [14] dataset that consists of 3.31 million facial images of 9131 subjects. It was created with the primary intention of training robust face recognition models. We used a pre-trained Resnet-50 model of this dataset for our study.
- **VGG-19 [15]:** VGG-19 model is a deep convolutional neural network, a successor of the VGG-16 model and developed by the researchers of the Visual Geometry Group. Like the Inception-v3 model, it is trained on the popular Image Net database. It achieved a Top-1 accuracy score of 0.752 and a Top-5 accuracy score of 0.925 with around 143 million parameters.
- **Xception [16]:** Feature extraction base of the Xception model is formed by 36 convolutional layers. It is an extension of the Inception model architecture where it uses depthwise Separable Convolutions in place of the standard inception modules. It was also trained on Image Net Database and achieved a Top-1 accuracy score of 0.79 and a Top-5 accuracy score of 0.94 with around 22 million parameters.

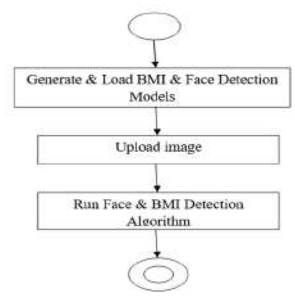
C. Training

We used the same fully connected layers at the end of all pre-trained models. The layers, we added at the end are shown in Fig. 2. Before feeding the output of the pre-trained model into the fully connected layers, we perform Global Average Pooling [17]. To prevent over fitting, we added one dropout layer [18] with a dropout of 50% into our model architecture.

We also used Gaussian Error Linear Unit (Gelu) [19] as an activation function, it combines the properties of the RELU activation function, Dropout, and Zoneout. Due to this, it tends to generalize better when there is more noise in the data so we used it in our models. As we found a comparatively larger dataset for our study we also fine-tuned our models. In deep convolutional networks, layers near the input learn basic features such as edges and corners.

As we move towards the output, the layers generally learn advanced features from the images used for training it. We used a higher learning rate for the new fully connected layers and a much lower learning rate for some of the final layers of the pre-trained model so that it extracts more features from the images. Due to these reasons, we used Adam optimizers [20] with decreasing learning rates as we move to deeper layers of the model. We implemented it with the help of the Multi Optimizer [21], [22] provided by Tensor Flow Addons.

Activity Diagram



IV. RESULT

In this project we are using python CNN (convolution neural networks) algorithm to predict BMI by analysing facial features. CNN will take image as input and then extract facial features from image and based on facial features BMI will be predicted. To implement this project we have designed following modules.

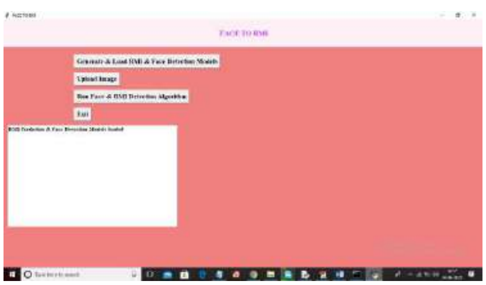
1) Generate & Load BMI & Face Detection Models: Using this module we will load facial detection CV2 library and BMI detection CNN model. Facial detection library help us to detect human face from uploaded image and then facial features will input to CNN model to predict BMI
2) Upload Image: using this module we will upload image to application

3) Run Face & BMI Detection Algorithm: This model extract face from given input image and then facial features will be analyse to predict BMI. Based on predicted BMI insurance policy will be quoted to users.

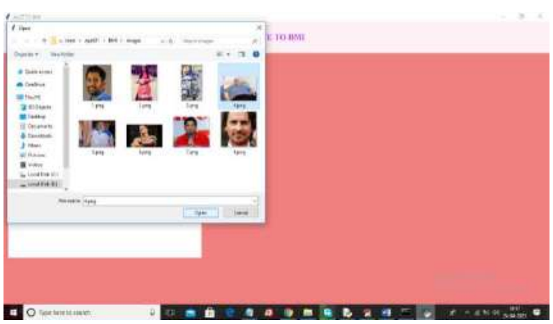
SCREEN SHOTS

To run project double click on ‘run.bat’ file to get below screen

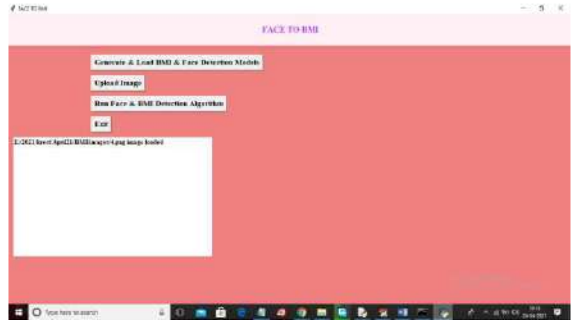
In above screen click on ‘Generate & Load BMI & Face Detection Models’ button to load face detection library and CNN model to detect BMI.



In above screen both libraries are loaded and now click on ‘Upload Image’ button to upload image

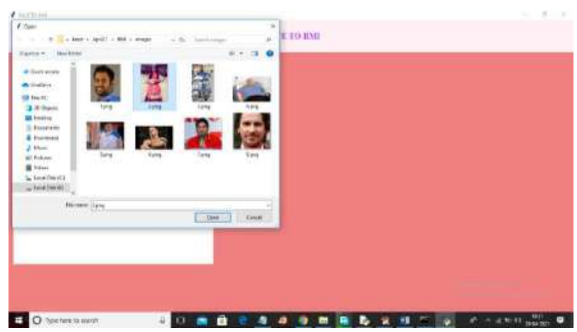


In above screen selecting and uploading ‘4.png’ file and then click on ‘Open’ button to load image and will get below screen

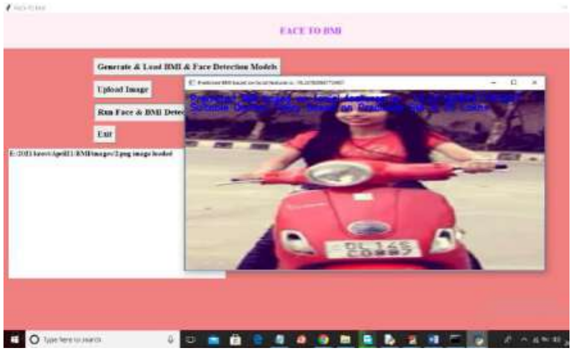


In above screen image is loaded and now click on ‘Run face & BMI Detection Algorithm’ button to get below result

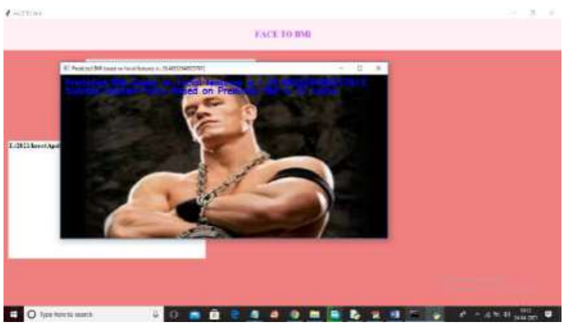
In above screen for given image detected BMI is 32.81 and suggested insurance policy is for 15 lakhs and now try other image



In above screen selecting and uploading 2.png file and then click on ‘Open’ button and then click on ‘Run Face & BMI Detection Algorithm’ button to get below screen



In above screen for uploaded image predicted BMI from face is 19.24 and suggested policy amount is 25 lakhs and similarly you can upload other images and test



V. CONCLUSION

We observed that people with more BMI have a higher risk of developing health issues. We found that there exists a strong association between BMI and the face of a human. So, we proposed an approach to predict BMI from facial images using deep learning. We used 3 publicly available datasets of diverse domains containing images of prisoners and Hollywood celebrities to evaluate our model. We pre-processed the facial data by aligning the faces to the center using the Dlib 68 landmark detection algorithm. For faster processing, we used TPU and created Tensor flow Records for our images of the dataset. As a part of future work, a more robust model may be obtained by training on a balanced dataset of people of different countries, ethnicity, and age. Federated Learning can be used to train a model on images that are not available publicly. We hope that this study assists companies and government and also help people to be aware of their BMI and maintain their health accordingly.

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