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Deep Learning Method for Estimation of Morphological Parameters Based on CT Scans

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Abstract. In this study, we propose a Convolutional Neural Network (CNN) with an assembly of non-linear fully connected layers for estimating body height and weight using a limited amount of data. This method can predict the parameters within acceptable clinical limits for most of the cases even when trained with limited data.

Keywords. Height, Weight, Deep Learning, Electronic Health Records (EHRs), CNN.

1. Introduction

In this study, we investigate the performance of a CNN-based regression model to estimate height and weight using limited data (Femur scans of less than 50 patients). This Deep Learning method can extract features from images and potentially establish a relation between features and morphological parameters [1]. Estimation of height and weight using CT scans can be used for completing associated missing Electronic Healthcare Records, and/or generating synthetic patient data.

2. Method

Fig.1. shows a CNN model with convolution blocks and a stack of non-linear fully connected (FC) layers to map the hierarchical image features and the morphological parameters. In the assembly, the first FC layer is fed with the feature vector and output is as $Y_i^{(L_i)} = \phi\left(\sum_{p=1}^{f_1^{(c)}} \sum_{q=1}^{f_2^{(c)}} \sum_{r=1}^{f_3^{(c)}} w_{g,p,q,r} \left(P_p^{(c)}\right)_{q,r}\right)$ in which L_1 is the first dense layer, $f_1^{(c)}$ is the number of feature maps of size $f_2^{(c)} \times f_3^{(c)}$, $P^{(c)}$ is the output from the c[th] convolutional block, w is the weighted connection from position (q,r) in feature map p to g^{th} unit in layer L_1 and ϕ is the Leaky ReLU function [2]. The consequent FC layers act like Multilayer Perceptron with previous layer inputs. We have used limited training data (36

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patients/10k images) and two test sets (11 and 12 patients). The methods have been implemented using TensorFlow 2.9.0 Library and assessed using metrics: Absolute Error=$|y_i - \hat{y}_i|; 1 \le i \le S$; Percentage Accuracy=$\frac{N_{S<Thr}}{N_S} \times 100$ where $N_{S<Thr}$ is the number of patients with predictions less than or equal to 5 kg/cm (for more precise estimations) and N_S is the total number of patients where S is the size of the test dataset.

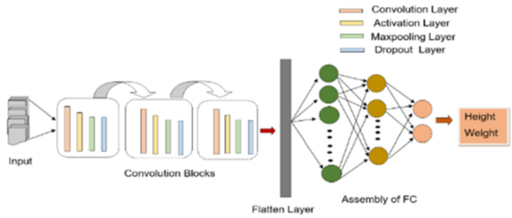

Figure 1. Architecture of Stacked-CNN Model.

3. Results and Discussion

Table 1 shows the predictions of height and weight for two patients from both test sets by Stacked-CNN. It also shows that the overall accuracy of Stacked-CNN is larger than 63% for estimating height in both sets, whereas the weight estimations are less good in Set 2 (42%). However, absolute differences between measurements and the actual value are within clinically acceptable limits (respectively , ±10 kg or ±10 cm) for all patients.

Table 1. Estimations and assessment of the method proposed [H: Height (in cm); W: Weight (in kg)]

Test Set ID	Actual(H /W)	Predicted (H/W)	Accuracy for (H/W)	Absolute Error for (H/W)
Set 1	159/60	158.6/60.1	63.6% (H) 63.6% (W)	4.5±2.8 (cm) 5.0±3.3 (kg)
Set 1	150/50	156.5/54.6		
Set 2	164/65	159.9/57.8	75% (H) 41.7% (W)	3.1±2.0 (cm) 5.4±2.8 (kg)
Set 2	158/58	162.5/60.3		

4. Conclusion and Future Work

The Stacked-CNN model shows good accuracy for the threshold of deviation (±5 kg or ±5 cm **:** acceptable limit for meticulous estimations) for body weight/height respectively. Due to relationship class imbalance, i.e., inequal number of patient datasets for the height-weight relation, height is predicted more accurately than weight.

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