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Bone Age Estimation for Investigational Analysis

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Abstract - *Machine learning has slowly and steadily secured its way in our day to day lives. Similarly, there is a great scope for it to go hand in hand with medical science. The proposed paper paves a way for the same. Machine learning can curb the inconsistencies in medical science caused due to human error. Machine learning can be applied in many disciplines of medical science to enhance the user experience. A detailed approach to create a Bone age detection model is proposed in this paper. Bone age detection is an application used in forensic analysis to estimate the victim's age, whose age is more than 18 years. In this model, Xception architecture is used for transfer learning. Neural networks are custom trained using transfer learning. The dataset used for training the model contains around 200 pelvis bone images of different age groups and was obtained from various hospitals and radiologists across the country. The aim is to achieve as little Mean Average Error (MAE) as possible in the subjects. The final MAE obtained using Xception architecture is 12.352 years.*

Key Words: ***MAE (Mean Average Error), CLAHE (Contrast Limited Adaptive Histogram Equalization), CNN (Convolutional Neural Networks), Xception Architecture.***

1. INTRODUCTION

Radiologists and clinicians currently require a significant amount of time and experience to forecast a person's bone age from a pelvic X-ray. The automated bone age assessment system will save time and may be utilized by anyone without any prior knowledge of bone age prediction. The main idea is to use a pelvis X-ray to automatically anticipate a person's bone age (over 18 years) by focusing on the pubic symphysis area, which can be observed in the centre of the pelvis. This can be accomplished by utilizing deep learning neural networks to predict a person's age, and the accuracy of the prediction can be increased using CNN and Transfer Learning techniques. Tanner Whitehouse techniques are used by doctors to forecast the age of their patients.

Predicting age is a difficult operation that takes a long time. As a result, libraries such as 'keras,' are employed which aid in the training of the dataset, as well as the CLAHE approach, which aids in the enhancement of the most significant areas of the x-rays and provides definitive findings.

In India, a large portion of the rural population is illiterate, and many people lack government ID credentials, resulting in a lack of information in the government database. It is exceedingly difficult to determine the age of a victim who does not have government ID documents at a crime scene, thus our bone age estimation system will assist in determining the age quickly. This model can be used by the forensics department during post-mortem examination.

2. LITERATURE SURVEY

Bone age of adults is determined manually using Risser sign and iliac crest ossification process which is an indirect measure of skeletal maturity and shows inaccuracy. Artificial intelligence is applied in overcoming such inconsistencies in results. Convolutional Neural Networks (CNN) is used on pelvis X-rays for subjects above 18 years of age.

Earlier, Tanner-Whitehouse (TW3) or the Greulich and Pyle (G&P) method was used to estimate bone age manually. These processes are laborious and flawed due to the involvement of an excessive number of steps. Thus machine learning was introduced to ease the age detection model. S. Son[1] employed Visual Geometry Group (VGGNet) architecture to automate the TW3 and G&P approaches of the bone age assessment system, based on 13 regions of interest of the left hand. This approach gives an accuracy of 97.6% of the age group 2-18 years.

Another approach proposed by K. Panday[2] uses X-rays and ultrasonography of the pelvis for manual bone age assessment. Risser's staging system is used in the assessment of bone age of the age group 12-21 years, with an accuracy of 43%

Y. Li[3] have approached the use of AlexNet architecture by focusing on the iliac crest apophysis of the pelvis of the age group 10-25 years. This model provides an accuracy of ±1.5 years.

N. Poojary[4] have suggested an approach based on Xception architecture which uses X-rays of the left hand of the age group below 18 years. Contrast Limited Adaptive Histogram Equalization (CLAHE) is used to enhance the X-rays, hence aggrandizing the accuracy. This system achieves mean average error (MAE) of 8.175 months.

Xception architecture used by N. Poojary[4] has 71 layers, which refines the training model and enhances the machine learning capabilities of the model. This ensures that the accuracy is unmatched.

3. PROPOSED MODEL

Pelvis X-rays are provided in portable graphic network format (.png) The images are enhanced using the Contrast Limited Adaptive Histogram Equalization (CLAHE) and then the images are augmented to enhance the dataset and then the pre-processing is done and then the steps involved are explained below.

Fig 3.1: Regions of Interest of Pelvis X-ray

3.1 Data Collection and Augmentation

The X-ray images in the present dataset will be augmented with a Python code to generate 18 times the original number of images, which will boost the Xception learning algorithm to get accurate results. Every X-ray image is augmented 18 times by the code automatically, rotating it 10° anticlockwise each time till it is rotated 180° from the starting point. This process helps to obtain 18 versions of a single X-ray image at different inclinations which help the algorithm to learn and yield highly accurate results.

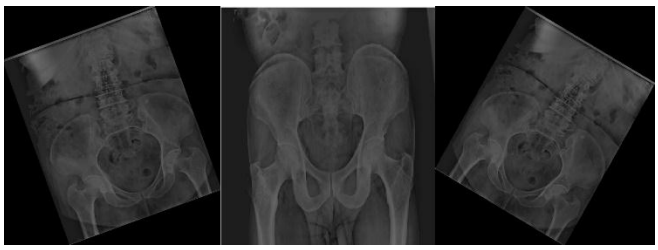

Fig 3.1.1: Augmented X-rays

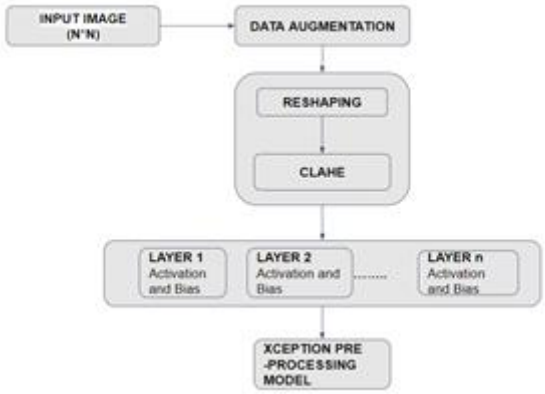

Fig 3.1.2: Block Diagram of a General Bone Age Prediction

3.2 Data Preprocessing

These augmented X-ray images are reshaped and equalized to accentuate the X-ray image. These augmented X-ray images are then processed by the Contrast Limited Adaptive Histogram Equalization (CLAHE) algorithm. The CLAHE algorithm helps to increase the contrast of the image by converting the images into small tiles and applying histogram equalization on those tiles which then highlight the X-ray image. Ranging of these processed images helps to retain the specific intensities and filters out the vital aspects of the X-rays. The X-rays are then processed through the Xception pre-processing function, which is a 71-layer deep convolutional neural network.

3.2 Bone Age Estimation Model

Then the images are processed through a simple neural network. An approximate age is obtained. The final bone age is received as the output which is calculated using the standard deviation of the whole dataset.

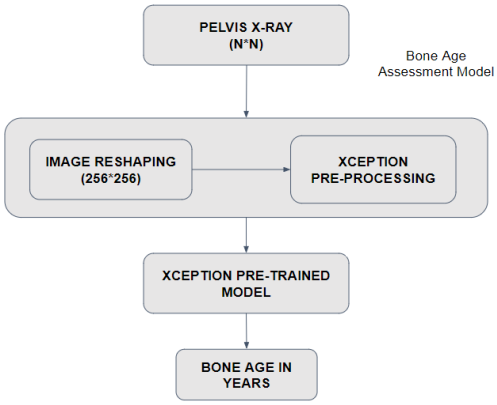

Fig 3.2: Block Diagram of a Pre-processing Model

4.RESULTS

The analysis obtained is as follows after examining the different x-rays and it is listed in the tables given below.

The table 4.1 represents the model predicted MAE for the different age groups for both the genders. Different age groups give out different model predicted results.

Table -1: MAE for various age groups for both genders

MAE for various age groups for both genders		
Age Group	Original Age (in years)	Model Predicted Age (in years)
20-40	26	38.257
40-60	48	37.632
60-80	69	77.612

The table 4.2 shows the model predicted MAE for the age group 40-60 years for males.

Table -2: Age group 40-60 years (male)

Age Group	Original Age (in years)	Model Predicted Age (in years)
40-60	48	59.932

The table 4.3 shows the model predicted MAE for the different age groups 40-60 and 60-80+ years for females.

Table -3: Age group 40-80 years (female)

Age Group	Original Age (in years)	Model Predicted Age (in years)
40-60	55	47.537
60-80 & above	77	89.818

The final MAE obtained using Xception architecture is 12.352 years.

4. FUTURE SCOPE

Machine learning has a great scope in forensic science. The results of machine learning models can be furnished by having an abundance of data. Thus the accuracy of this algorithm can be increased by adding an immense number of X-rays to increase the dataset. Various filters and different pre-processing steps can be implemented to boost the accuracy. Accuracy, efficiency and open source availability are the focal points of this project. This will help in reaching forensic anthropologists in all parts of the world.

5. CONCLUSION

Xception architecture helps us to obtain a Mean Average Error (MAE) of 12.352 years which can also be considered to be the accuracy of the project. Refining the results, we obtain different MAE for both genders, individual genders and different age groups.

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