IMPROVING ACCURACY FOR BONE AGE PREDICTION FROM X-RAY IMAGE USING CONVOLUTIONAL NEURAL NETWORK TECHNIQUE OVER C4.5 CLASSIFIER

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Abstract

Aim: To enhance accuracy in predicting bone age from x-ray image to that of chronological ages using novel Convolutional Neural Network technique in comparison with C4.5 Classifier.
Materials and methods: Classification is performed by a Convolutional Neural Network (N=10) over a C4.5 classifier (N=10). The sample size is calculated using Gpower with pretest power as 0.8 and alpha 0.05.
Results: Mean accuracy of the convolutional neural network (82.36%) is high compared to the C4.5 classifier (67.18%). The significance value for accuracy and loss is 0.263 ($p>0.005$).
Conclusion: The mean accuracy of bone age prediction using Convolutional Neural Network is better than the C4.5 classifier.

Keywords: Novel Convolutional Neural Network, C4.5 classifier, Accuracy, Prediction, Bone age, Chronological.

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1. Introduction

The skeletal and biological maturity of an individual is determined by a child's bone age. The most widely used clinical procedures for Bone Age Assessment (BAA) are based on a visual evaluation of individual bone ossification in radiographs of the left hand and wrist and a comparison to a standard hand atlas (Gilsanz and Ratib 2011), (Bouxsein 2016). Based on the discrepancy between the reading of the bone age and the chronological age, physicians can make a more accurate diagnosis of abnormal development in children. Currently, the left-hand X-ray image is widely used for assessing bone age as it can render the subtle bone/cartilage development pattern with minimum radiation exposure. (Wang et al. 2016; Dufau et al. 2019);. Although x-ray radiographs are widely available in many clinical sites, the reading of the bone age is non-trivial in radiology practice. (Mahayossanunt, Thannamitsomboon, and Keatmanee 2019). Bone age prediction using x-ray images is an important application. Some of the applications of bone age prediction are the study helps doctors estimate the maturity of a child's skeletal system. Similar applications of Bone Age Assessment Empowered with Deep Learning, Fully Automated Bone Age Assessment (Boyde, Elliott, and Jones 1993). Nowadays bone age prediction is applied in cybercrime departments, diagnosis of orthopedic related problems. (Jones, Elliott, and Boyde 1992)

In this research work, Bone Age Prediction from X-Ray Image using Convolutional Neural Network Technique around 80 Articles in Google Scholar Sciencedirect and 40 in Scopus (Amasya et al. 2020). Assessment of a child’s skeletal maturity is important for the management of skeletal disorder during growth. Differences between skeletal age and chronological Radiation exposure. Therefore BAA is an important tool in the monitoring of growth, and to diagnose and manage a multitude of endocrine disorders and pediatric syndromes (Zulkifley, Abdani, and Zulkifley 2020). Bone age has also been used Radiation exposure for computing the ultimate adult height of youngsters in traditional healthy kids and might be employed in determinant age where birth records don’t seem to be accessible (Mellits, Dorst, and Cheek 1971). The collected data is compared against the taken dataset of Convolutional Neural Network (Mahayossanunt, Thannamitsomboon, and Keatmanee 2019). Bone age classification using convolutional neural networks (CNN) as a support tool for related disciplines in bone age diagnosis in Radiation exposure. Although different types of study for bone age evaluation using CNN have been conducted, the Attention mechanism has not been thoroughly compared to standardized atlas collection of hand radiography for bone age assessment Radiation exposure (Tanner 1983). The regressor network, which is used to predict the bone age has utilized three-layer residual separable convolution units to produce a deep network but maintains an acceptable model size, which is around 20,000,000 parameters. The network has also been trained using variable learning rates where its value is linearly decreasing concerning the training epoch (Jhang and Cho 2019) (Jhang, Kang, and Kwon 2020).

Our institution is passionate about high quality evidence based research and has excelled in various domains (Vickram et al. 2022; Bharathiraja et al. 2022; Kale et al. 2022; Sumathy et al. 2022; Thanigaivel et al. 2022; Ram et al. 2022; Jothi et al. 2022; Anupong et al. 2022; Yaashikaa, Keerthana Devi, and Senthil Kumar 2022; Palanisamy et al. 2022).The existing system of bone age prediction has some obstacles in recognizing the difference between a child's bone age and his or her chronological age that might indicate a growth problem. But such differences do not always mean there exists a problem, because perfectly healthy kids can have bone ages that differ from their chronological ages and Radiation exposure. Though much research has been carried out in this field there exists a gap to formulate the performance when it comes to detecting and recognizing bone age automatically. Therefore an automatic system is required to predict and recognize number plates. This study aims to automatically predict and recognize bone age using novel convolutional neural networks, thereby improving performance and reducing false prediction rates.

2. Materials and Methods

This study setting was done in the Data Analytics Lab, Department of Information Technology, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences. The sample size taken for this research work is 20 (Group 1=10, Group 2=10). In predicting the bone age from an x-ray image, to modify the problem of low accuracy rate convolutional neural network and C4.5 classifier exposure. Convolutional neural networks learn about the age of the bone approximately. The C4.5 classifier enables thorough exploration of bone age data present. The mean accuracy of convolutional neural networks is 82.36%. The mean accuracy of the C4.5 classifier is 67.18%. Dataset for this instance is collected from (https://www.kaggle.com/saksham219/bone-age-prediction-through-x-rays/data?select=boneage-training-dataset) website with 12,611 instances (Safiri and Ayubi 2017).Novel Convolutional Neural Networks (CNNs, or ConvNets) are a type of artificial neural network used to evaluate visual information. Based on the shared-weight architecture of the convolution kernels or filters that slide along input features and give translation equivariant responses known as feature maps as explained in Fig. 1. Most Novel Convolutional Neural Networks are only equivariant under translation, rather than invariant. They are used in image and video recognition, recommender systems, image classification, image segmentation, medical image analysis, and natural language processing, among other things.

The input to a CNN is a tensor with the following shape: (number of inputs) x (input height) x (input width) x (number of outputs) x (number of outputs) x (number of outputs) x (number of outputs) x (number of outputs) x (number of output (input channels). The image is abstracted to a feature map, also known as an activation map, after passing through a convolutional layer, with the following shape: (number of inputs) x (feature map height) x (feature map width) x (feature map height) x (feature map width) x (number of inputs) x (number of inputs) x (number of inputs) x (number of inputs) x (number of input (feature map channels). The input is convolved by convolutional layers, which then pass the result on to the next layer. A cell in the visual brain comparably responds to a given stimulus. Each convolutional neural only processes data for the receptive field in which it is located. Although fully linked feedforward neural networks can be used to learn features and categorize data, there are several limitations. Pseudocode for novel convolutional neural network described in Table 1.

The C4.5 algorithm is used in Data Mining as a Decision Tree Classifier which can be employed to generate a decision, based on a certain sample of data. C4.5 is an associate formula used to generate a call tree developed by Ross Quinlan. C4.5 is an extension of Quinlan's earlier ID3 formula. The choice trees generated by C4.5 are used for classification, and for this reason, C4.5 is commonly said as an applied mathematics classifier. In 2011, authors of the wood hen machine learning code represented the C4.5 formula as "a landmark call tree program that's most likely the machine learning workhorse most generally utilized in observe to date". The root of the tree is always the variable that has the minimum value to a cost function. In this example, the probability of Parents Visiting is 50% each, leading to easier decision making if you think about it. Pseudocode for the C4.5 classifier is described in Table 2.

Statistical Analysis

The analysis was done by IBM SPSS version 26. In SPSS, datasets are prepared using 10 as a sample size for both the algorithm convolutional neural network and the C4.5 classifier. Group id is given as 1 for convolutional neural network and 2 for C4.5 classifier, group id is given as a grouping variable, and accuracy is given as a testing variable. An independent sample T-test was conducted for accuracy. Standard deviation, standard mean errors were also calculated using the SPSS Software tool. The significance values of proposed and existing algorithms contain group statistical values of proposed and existing algorithms.

3. Results

In statistical tools, the total sample size used is 20. This data is used for the analysis of convolutional neural networks and C4.5 classifiers. Statistical data analysis is done for both the prescribed algorithms namely convolutional neural networks and C4.5 classifiers. The group and accuracy values are being calculated for given filtering systems. These 20 data samples used for each algorithm along with their loss are also used to calculate statistical values that can be used for comparison. Table 3, shows that group, accuracy, and loss values for two algorithms convolutional neural network and C4.5 classifier are denoted. The Group statistics table shows the number of samples that are collected. Mean and the standard deviation is obtained and accuracies are calculated and entered.

Table 4, shows group statistics values along with mean, standard deviation and standard error mean for the two algorithms are also specified. Independent sample T-test is applied for data set fixing confidence interval as 95%. Table 5 shows independent t sample tests for algorithms. The comparative accuracy analysis, mean of loss between the two algorithms are specified. Figure 2, shows a comparison of the mean of accuracy and means loss between the convolutional neural network and the C4.5 classifier.

4. Discussion

From the results of this study, Convolutional Neural Networks are proved to be having better accuracy than the C4.5 classifier. Convolutional Neural Network has an accuracy of 82.36% whereas the C4.5 classifier has an accuracy of 67.18%. The group statistical analysis on the two groups shows that Convolutional Neural Networks (group 1) have more mean accuracy than the C4.5 classifier (group 2) and the standard error mean including standard deviation mean is slightly less than Convolutional neural networks.

This research increases prediction for recognition systems to find better bone age prediction using x-ray images by their data. This model has a slow processing rate with better accuracy (Rajvanshi and Dhaka 2016; Prateek et al. 2019). The slow processing rate is due to the usage of a large database but in the case of a smaller database, both the processing and accuracy are faster and better. The above problem's complexity will be reduced once a model is built (Moolayil 2018). Although many researchers have discovered various recognized models, many of them cannot accurately perform better algorithms (Liu et al. 2019). Many applications can be developed to predict accurately for sensitivity from various platforms.

The novel Convolutional Neural Network algorithm has the drawback of not being user-friendly and is very time-consuming. This means that the novel convolutional neural network algorithm is not easy to use and takes a little time to process the data(Chen et al. 2021). In the future, this bone age prediction using x-ray images can be further improved by developing a novel convolutional neural network.

5. Conclusion

From this study of bone age prediction using x-ray images, the mean accuracy of C4.5 classifier algorithms is 67.18% whereas novel convolutional neural networks have a higher mean accuracy of 82.36%. Hence it is inferred that the novel convolutional neural network is better in accuracy when compared to C4.5 classifier algorithms.

DECLARATIONS

Conflicts of Interest

No conflict of interest in this manuscript.

Authors Contribution

Author MA was involved in data collection, data analysis, and manuscript writing. Author RK was involved in conceptualization, data validation, and critical reviews of the manuscript.

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Table 1. Pseudocode for Novel Convolutional Neural Networks

// I: Input dataset records
1. Import the required packages.
2. Convert the image into machine-readable after the extraction feature.
3. Assign the image to the output variables.
4. Using the model function, assign it to the variables.
5. Compiling the model using metrics as accuracy.
6. Evaluate the output
7. Get the accuracy of the model.
OUTPUT //Accuracy

TABLE 2. Pseudocode for C4.5 classifier

// I: Input dataset image
INPUT: Capture Image
Step 1: Pre-process the image of the particular x-ray.

Step 2: Segment and normalize the images.
Step 3: Extract the feature vector of each normalized candidate
Step 4: Train c4.5 classifier based on a saved sample database.
Step 5: Recognize the bone age by the set of c4.5 classifiers trained in advance.
Step 6: If there are no more unclassified samples, then STOP.
Step 7: Add these test samples into their corresponding database for further training. **OUTPUT:** Bone age prediction.
OUTPUT //Accuracy

Table 3. Group, Accuracy, and Loss value uses 8 columns with 8 width data for bone age prediction.

SI.NO	Name	Type	Width	Decimal	Columns	Measure	Role
1	Group	Numeric	8	2	8	Nominal	Input
2	Accuracy	Numeric	8	2	8	Scale	Input
3	Loss	Numeric	8	2	8	Scale	Input

Table 4. Group Statistical analysis for Novel convolutional neural network and C4.5 classifier Algorithm Mean, Standard Deviation and standard error mean are determined

	Group	N	Mean	Std Deviation	Std.Error Mean
Accuracy	**CNN**	10	82.2250	0.10146	0.03208
	C4.5 Classifier	10	67.1010	.05744	.01816
Loss	**CNN**	10	17.7380	.07983	.02525
	C4.5 Classifier	10	32.8990	.05744	.01816

Table 5. Independent sample T-test t is performed on two groups for significance and standard error determination. the p-value is greater than 0.05 (.263) and it is considered to be statistically insignificant with 95% confidence interval

		Levene's Test for Equality of variance		T-Test for equality of mean						
				t	df	Sig(2-tailed)	Mean difference	Std.Error Difference	95% confidence of Difference	
		F	Sig						Lower	Upper
Accuracy	**Equal variances assumed**	7.531	.013	410.208	18	.000	15.12400	.03687	15.04654	15.20146
	Equal Variances not assumed			410.208	14.231	.000	15.12400	.03687	15.04504	15.20296
Loss	**Equal variances assumed**	1.335	.263	-487.489	18	.000	-15.16100	.03110	-15.22634	-15.09566
	Equal Variances not assumed			-487.489	16.348	.000	-15.16100	.03110	-15.22682	-15.09518

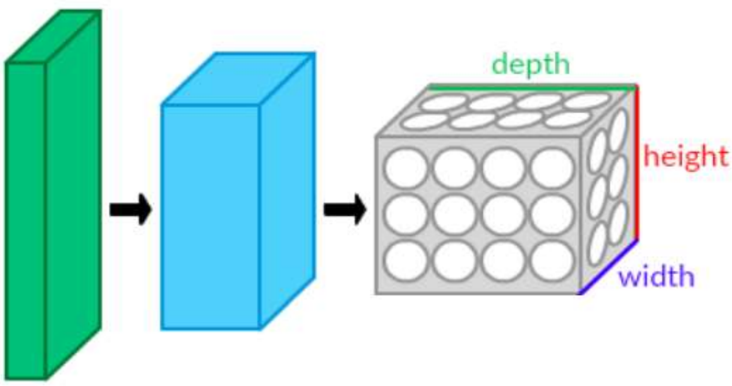

Fig. 1. Convolutional neural network

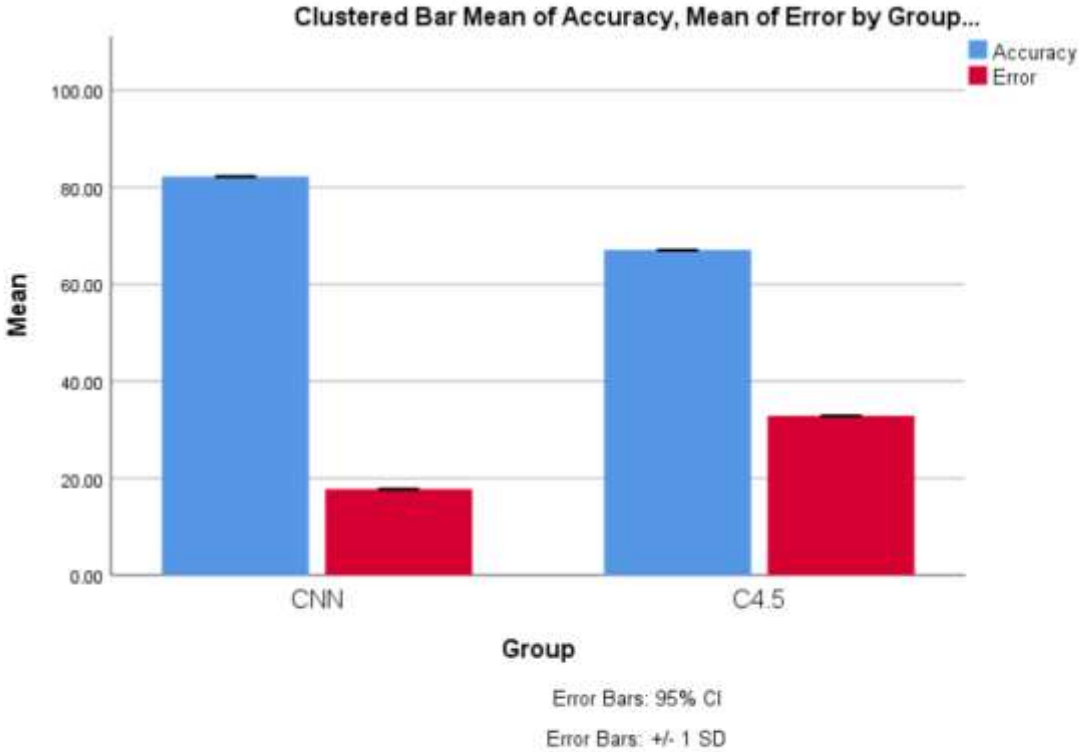

Fig. 2. Comparison of Novel Convolutional neural network and C4.5 classifier Algorithm in terms of mean accuracy. The mean accuracy of the Novel Convolutional neural network is better; than the C4.5 classifier Algorithm. The standard deviation of the Novel Convolutional neural network is slightly better than the C4.5 classifier Algorithm(Gilsanz and Ratib 2011). X-Axis: Novel Convolutional neural network vs C4.5 classifier. Y-Axis: Mean accuracy of detection ± 1 SD.