HAND WRIST X-RAY IMAGES IN BONE AGE ASSESSMENT USING EVOLUTIONARY –ARTIFICIAL NEURAL NETWORK ALGORIHTM

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Abstract: Bone age assessment (BAA) is utilised in medicinal, legalised and sports. X-ray pictures of the hand are basically utilised to assess the bone maturity of person. BAA is mainly accompanied by radiologists that usually assess bones of hand in x-ray pictures using Greulich – Pyle (GP) and Tanner Whitehouse (TW) method. The hand x-ray pictures related to atlas contains reference pictures from the phases of various ages in GP method. In TW method specific group of area of interest, where the growth of every area of interest is distributed among various stages and every stage is given a letter matching to alphanumerical score that varies by race and gender. Generally, skeleton bone maturity is computed by addition of the scores for region of interest (ROI). The manual evaluation of bone faces the issue of intra-observer inconsistency and consume maximum time. Hence, there is crucial requirement of the bone age assessment. However, bone experts need maximum quality x-ray scanning to achieve the maximum clinical results. The features are extracted using TW and GP technique. Lot of surveys has been done and some issues are found to face assessment in bone x-ray pictures. In existing work, CNN method is used. CNN method is based on deep learning concept to extract the features and classify the age based on X-ray Bone images. CNN model process all information through different layers. A classification method is used to estimate the bone age using Convolution Neural Network (CNN). They had also explained the configuration of different systems. In proposed method, parametric optimisation acquires accuracy upto 92% and 88%. In proposed research, an E-ANN technique is developed to extract the features using PCA technique and the specific features of x-ray pictures are extracted. Evolutionary technique is utilised to select the valuable features with the help of fitness function such as Fs, Ft and e parameters. The classification of features of x-ray images is done using ANN architecture. An Artificial Intelligence method has been used for quick assessment and increase the accuracy rate as compared to the existing method. It mitigates the error rate such as MSE, FAR and FRR. Experimental analysis has been done using MATLAB 2016a simulation tool. In addition, E-ANN method is utilised to improve the accuracy rate up to 97% as compared to CNN method.

Keywords: BAA (Bone Age Assessment), DOB (date of birth), CNN (convolutional neural network) and E-ANN (Evolutionary Artificial Neural Network).

1. Introduction

Bone age is the pointer of the skeleton and biological maturity of an individual. Bone is dissimilar from the chronological age that is computed using date of birth of an individual. Bone is generally demanded by the paediatricians and endocrinologists for comparison with chronological age for diagnosing diseases which results in tall or short stature in children [1][2]. The absent data on birth date is a big problem in different geographical areas . In South Asia, 65% of all births are not registered by the age of 5 years [3]. Thus, there is a need for accurate estimation of age arises in conditions, where the age of a child needs to be accurate, such as during Immigration law of suits and in competitive sports. In these cases, bone age is used to provide the closest estimate of chronological age. So in order to visualize the correct age of an individual different methods of bone age assessment has been developed using different techniques.

Fig 1. X-Ray Images (Right and Left Hand Wrist)

The non-radiation based method of visualisation hand bone age computation has been theorised but it is not correct as radiographic techniques [4].

Bone maturity of an individual can be computed from age 18-22 years through radiographs technology or medical analysis. X-ray picture of the left hand can be used to indicate the biological development of the bones based on ossification regions and calcium deposits in the ossification area [6].

In existing research, CNN method was used for Bone Age Assessment (BAA). The main function of the CNN can be described as, (i) Input Layer: The pixel rate of the picture is given as input layer. (ii) Convolution

layer: It recognises the output value of neurons, which are linked to the localised areas of input by computing scalar product among the weights and area linked to the input value. Commonly, RLU is developed to apply on the neural system as an activated function of that value. (iii) Pooling Layer: This is utilised as down sampling related to the spatial dimension of required value for decreasing the number of parameters in activated function. (iv) Fully connected layer: It performs the same function of neural networks and efforts to implement scoring from the activated function utilised for classification. RLU is utilised among the layers for producing scores to enhance the performance. In research, proposed method used is E-ANN method. Basically, it is a hybrid method used to select the features and classify the X-ray Images and assess the image. Kernel Principal Component analysis (KPCA) is is used to compress data sets of high dimension vector into low dimension vector. The minimization of error in the data compression finds the directions of data having large variety and the relation of data using transformations.

The initial population is created and and its size is taken to the appropriate level. The pattern of information and population will be taken as constant value. The real data sets are taken in the form of classes. Data set belongs to the data points and test of data. Several samples of data sets are taken for the purpose of testing. Testing and training data is based on the classification rules and verification is done on the basis of accurate rule of data. The data processing method, in which biological data is accessed by human brain. Human brain is connected through neurons that are interrelated by dendrites and gather data through connections. The important function of neurons in the brain is to process data in an accurate way which is expected by the brain.

Section I defines the overview of bone age assessment, existing methods used in BAA system and proposed techniques like KPCA, EGA and ANN methods. Section II and III defines related methods and elaborate the research development with novel approach in BAA system. Section IV defines the experiment result analysis with performance parameters. Section IV elaborates the conclusion and future scope in research work.

2. Prior Work

Adeshina, S. A., Cootes, T. F and Adams, J. et al., 2017[7] proposed research on an automated approximation of bone age in grown persons and teenagers. Bone age was an essential approach for monitoring of endocrine syndromes. The statistical method of shape and pattern for positioning the bone in radiograph and prediction of bone age was constructed. The data set of 600 in digital radiography form was analysed with random forest regression voting in constrained localised method scheme. In addition, globalised method was proposed for an individual bone. After that, they utilised similar method to position the noticeable bones of hand. Then, they estimate the outcome utilising multi local age group and multiple age prediction. They acquire the exactness of sum of the point to point fault of 0.87 mm on sparse point assignment for initial value of automated recordings. Finally, bone age assessment method gets the accuracy of total fault 0.41±0.02 and 0.47 ± 0.03 years for girls and boys separately. **Agrawal, A., Patil, U. and Ranjan, S et al., 2011[8]** described a complete automated technique for the removal of epiphysis. The division of metaphysis and epiphysis was done at various stages. The stages were pre-processing of the adjustment of strength, correcting the hand arrangement, alignment of fingers, removal of phalanges, and extraction of epiphysis from phalanges. The method had been confirmed on digital atlas information approximately up to 95% accuracy and detecting the non-appearance of epiphysis. **Asad, M. N., Cantürk, İ., Genç, F. Z. and Özyılmaz, L et al., 2018 [9]** studied the bone age assessment for diagnosis of bone sickness during growth. In this research, a CNN(convolutional neural network) technique has been applied by pre-processing the picture. The filtration of picture was done to link the accuracy of CNN for edge detection. The goal of this research was to compare the consequences of DOG filtration and wavelets for bone age assessment. The non-filtrated images were compared with filtrated images to achieve exactness. The bone of age group 0 to 7 years was analysed to access the age of female and male. It was perceived that accuracy of female was 14% better whereas it was 11% among filtered and non-filtered picture. The planned technique achieves up to 88% accuracy in female and 80% in males in nine months' time period. **Manjula Gururaj H1, Dr. G. S. Nagaraja [10]** presented research on the extraction of features from phalanx for bone age assessment. The method is related to well-known TW technique which depends on the ROI (region of interest) of phalanx. This method guarantees the exactness of bone age assessment of teenagers and children. The planned method was focused on pre-processing criteria in which phalanx region of interest was collected from internal picture. Generally, three geometrical characteristics were extracted using morphological method to achieve the group of 14 features. The removed features were utilised for training the system at starting upto the approximation of bone age. Experimental results were analysed to test the group of radiological features. **Bian, Z. and Zhang, R. et al., 2018 [11]** proposed research on the assessment of bone age for extraction and classification of features of X-ray picture of hand using Convolution Neural Network based on the deep learning technique. It was determined to achieve the x-ray thin film of hand with 301 cases using GoogLeNet CNN. Training database was extended thirty times to avoid the method from over fitting using data expansion technique. After that, the accuracy of bone age was achieved up to 91% on test group. Proposed method classify the validate performance of system. This method presents the theoretic and methodological concept to achieve

accuracy and deliver tools to medical experts in medical analysis. **Birhade, P., Khaparde, A. and Deshmukh, S et al., 2017[12]** presented a research on the estimation of maturity of bone through segmentation method. They compute statiscal metrics of distributed bone. The comparison of Skelton and chronological age was done and variance among two attributes recognises the irregularities in skeleton growth of bone. This research demonstrated that contour snake achieves maximum accuracy and needs 10 sec for execution, Whereas, DLRS and graphical approach requires 46 sec approximately. They analysed width, height and region of the required bone. The experimental results described that every age group from 6 to 14 years has been analysed. It was concluded that the maximum accuracy was achieved for better accuracy of bone maturity and better performance of snake.

Table 1: Comparison analysis of different features of BAA techniques [13]

Features	**GP method**	**TW method**	**Computerise method**	**Ultrasound technique**
Technique	Visualised investigation. Matching technique.	Visualised and score technique.	Computation of the bone age through computerised method by wrist radiographs.	This method utilise dimension of the growth plate in three phases - anterior, posterior and adjacent operator.
Demerits	Maximum difference during inter observer	Inconsistency because of the selective nature of SA. Consume more time.	Inappropriate nature. Automated assessment may not remove radiologist.	Uneasy standardisation.
Merits	Fast assessment	More reliable	Standard assessment Accuracy	Fast scan period
Radiation issue	Low	Low	Low	Radiation free

3. Research Proposal

The main objective is defined as (i) search the bone age assessment database from UCI machine learning respository site. (ii) to develop a filtration and optimized feature vector extraction algorithm to smooth the hand wrist X-Ray images. (iii) to implement an E-ANN method to classify the assessment rate in X-Ray images. (iv) to calculate the performance metrics like Error Rate, Accuracy and comparison with the existing parameters.

Step 1:- Dataset Searching (X-Ray Images)
Step 2:-Conversion (Gray level) or dimension reduction.
Step 3:-2d transformation to calculate the smooth X-ray images and local maxima.
Step 4:- Region calculation
Step 5:- Optimized Feature vector means fetch the features based on the optimized eigen values and vectors.
Step 6:- Evolutionary -ANN classification method to classify the age assessment and evaluate the performance metrics.
Step 7:- Comparison.

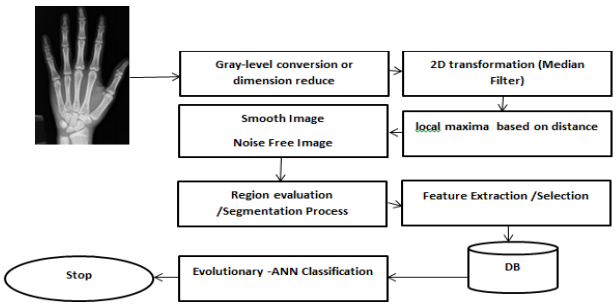

Fig 2 Research Proposal Flow Chart

4. Experiment Analysis

In this section,various designing models are described below:-

(i) Image Uploading (Knowledge Base Creation)
(ii) Feature extraction and
(iii) Classification and Assessment Phase.

Knowledge Domain:

Creation of the dataset from age 1 to 18 years. It generates and uploads a knowledge dataset with multiple pictures in X-rays.In addition, Pre-processing phase has been designed to check the interference in the X-ray images.Feature extraction method is used to extract the unique features in the form of eigen vectors and eigen values.

Classification and Testing Section:

It develops a E-ANN technique to classify the features of the X-ray pictures. After that, it training ang testing features are compared and validation is done to assess the x-ray images.

Performance Metrics:

It evaluates the performance metrics such as FAR, FRR and ACC and compare with the existing method CNN.

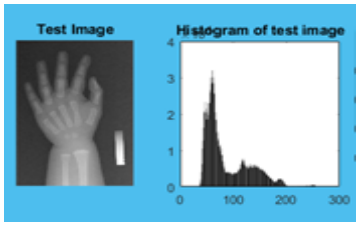

Fig 3. Image Uploaded and Histogram

Fig 3 testing database image; upload test image from dataset. It converts the image histogram which defines the image frequency and image pixels.

Fig 4. X-Ray Image Pre-processing

Here fig 4 shows the pre-processing phase (i) upload test image (ii) Image Histogram (iii) interference checking (iv) Filtration image (Smooth Image) (v) Edge Detection using region detection in the X-ray Images.

The tracked postion is analysed through the feature extraction method. It is used to compress data sets of high dimension vector into low dimension vector.

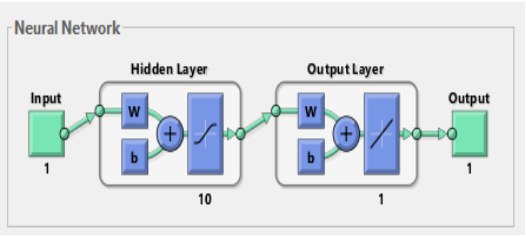

Fig 5 Neural Network Architecture

Here fig 5 defines the ANN architecture using three layers such as;

(i) Input Layer
(ii) Hidden Layer and
(iii) Output Layer

The features of input layer are selected through evolutionary algorithm.

In EGA, three operators are used (i) Selection (ii) Crossover and (iii) Mutation.

Fitness Function is initialized to calculate the fit value based on the number 0 and 1. The accepted or not selected features are verified by the hidden layer. After that, it selects the hidden neurons and compute the final outcome.

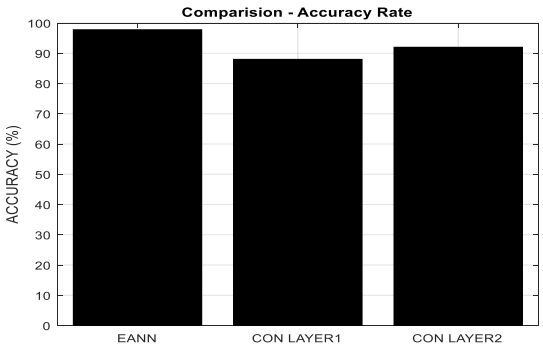

Fig 6. Comparison – Accuracy rate (%)

Here fig 6. shows the comparison between proposed and existing parameters such as 97.7 % accuracy rate achieved in proposed work, 88% in CONV-LAYER 1 and 92% in CONV-LAYER 2.

Table 1. Proposed Parameters

Parameters	Values
FAR	0.0209
FRR	0.0012
MSE	0.1383
ACCURACY	97.7

Parameters	Proposed E-ANN	Existing CNN Layer-1	Existing CNN Layer-2
Accuracy Rate (%)	97.7	88	92

Table 2. Comparison Analysis

Table 1 and 2 shows the performance metrics such as FAR, FRR and Accuracy Rate. Comparative Analysis with Accuracy Rate with E-ANN, CONV-LAYER 1 and 2 accuracy rates have improved as compared to the existing parameters.

5. Conclusion and Future Scope

An automated bone age assessment is studied by many researchers to decrease the burden on medical experts. In this research, E-ANN technique has an application area in artificial intelligence area and utilised to pre-process X–ray pictures in MATLAB version. After that, pictures are distributed and Google-Net is linked for the classification procedure. The sequence of automated bone age assessment gives more exact outcomes and help medical experts to diagnose specific extension. The main provision of artificial intelligence is estimation of skeleton bone age from 0 to 18 years that is based on E-ANN and KPCA approach. The main purpose is to explore the model through features of unseen x-ray pictures and dissimilar data such as race and sexual category. They transformed the deep neural network from other domain to estimate bone age and refine the structures from x-ray pictures. In addition, KPCA and E-ANN technique is used to determine diverse structures irrespective of using one kernel that improves the performance. The other issue is that BAA is reliant on left hand wrist bones standard cases with appropriate features. However, there is no outcome for such cases which have unexpected injuries on hands. The research described that there is absence of automated resolution for noisy pictures or absence of information of hand radiographs. The main issue of all the techniques are that these are not reliable for bone age assessment. The valuable features are selected using a fitness function by evolutionary technique. Some of the fitness function values are F_S,F_t and e parameters. ANN architecture is used to classify the age and assess the features. Moreover, Artificial Intelligence method has been used to increase the accuracy rate as compared to the existing method. It mitigates the error rate such as MSE, FAR and FRR. Experimental analysis has used MATLAB 2016a simulation tool and E-ANN method is used to improve the accuracy rate up to 97% as compared to CNN. CNN method has achieved 88% accuracy in Layer 1 and 92 % in Layer 2.

In this future work, it will identify the class of FEMALE and MALE in BAA (Bone Age Assessment). Age detection can be done from age 3 yrs and 5 months, 5 yrs and 2 months of the X-Ray bone images. DNN (Deep Neural Network) method can be used for Knowledge Domain based on training and testing procedure to achieve higher response interval time and reaction time with fewer exception probabilities.

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