The Survey on Automatic Bone Age Assessment Methods, Applications and Characteristics

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Abstract- In the past few decades Computers are widely used in the field of medical research. In emerging medical technology imaging are widely used for estimation of age of the live or dead Human being. The bone age assessment directly depends on the growth of the skeletonassessment. Computer aided techniques are developed to check hisskeleton m maturity as well as the gender and the race. The most important feature of the bone assessment is to minimize the segmentation. The bone age of the child determine the structural and biological maturity rather than chronological age calculated from date of birth of a child. The different one estimation provides different applicability ethnicities and results using different methods and technologies

Keywords- SA (Skeleton Assessment), Segmentation.

I. INTRODUCTION

Bone Age Assessment is the method of evaluating the endocrine order and prediction of the adult height and age. Bone Age Assessment performed on different parts of the body, such as hands, elbows,knees, vertebra and pelvis.Bone Age Assessment (BAA) is a radiological study of the skeletal development of a left hand, wrist, the bone age that is assessed and then compared to the chronological age[3]. A discrepancy between the assessed age and chronological age indicated the abnormalities in Skeltondevelopment. This examination used basically in medicine due to the simplicity,minimal.Radiation exposure and the availability of multiple ossification centers for evaluating the maturity The background of the age is that there are two ages of the child a skeleton's age and the chronological age. Chronological age is the actual age in years from the birth of the child.The skeleton age assessment determines the degree of the maturation of the bones of the child. The basis of Skeleton age was that ossification center appears in the particular time of the age.

So the skeleton age assessmentwas the average age of child at particular maturation age. In the particular age of the bone maturation the changes in the development of the skeleton basically were similar to the development process and the development process continues at the same stage.The estimation of the age and gender was identified in different phases. Firstly, to estimate the gender from the skeleton and then estimation of the age , after that identifying the disease and understand the cause of the death and finally understanding the lifestyle , health conditions and climatic changes over the decades. The bone assessment allows the detection of the hormonal growth, geneticdisorder [1].Bone age had become a convenient measure of maturity in pediatrics, such as hormonal growing disorders since there are number of discriminants and unambiguous stages in the development of the hand and bones.

Fig.1: Bone Age Assessment

Bone age is the indication of the skeleton and biological maturity of an individual. Bone age is different from chronologicalage. Bone age is requested by pedestrians and endocrinologist for diagnosing the diseases.

Machine Learning is a technique used to handle the data more efficiently, sometimes after viewing data information and pattern cannot be interrupted, machine learning is applied in that case. Machine Learning Algorithm is that algorithm where external assistance is needed , the train data set has output variable which requires to be classified and predicted[2].

Procedure DDT inducer (T,B,x)

1. L=Tree growing (T,B,x)

2. Return Treeprening (T,B,)

Procedure Treegrowing (T,B,x)

1. Create a T tree

2. If the stopping criteria fulfilled then

Mark the root node in L as a leaf within the most common value of x in T as a class

3.Else

Find the discrete function f(A) of the input attribute value as splitting T according to f(b) outcomes (u1,u2)

4. If the best splitting metrices>equal to threshold then

5. Label the root node L as f(b)

For each outcome u_j of f(b) **do**

6. Subtract c_i=Treegrowing ((σ)f(b) = u_j,T,B,x).

7. Connect the root node of Las leaf to subtract c_i within edge that is labeled as u_j

End for

else

8.Mark thre root node L as a leaf with most common values in x as a class in T.

End if

Return L

8. repeat

9.Select the node l in L such that pruning it maximally imporove evaluation criteria.

If is not l equal to ∅ then

T = pruned(L,l)

End if

Until If is not l equal to ∅ then

10.Return L

II. PRIOR WORK

ArsalanManzoorMughaletetal., **2014**[3**]** proposed a research on bone age using various methods and different skeleton elements. Mainly bone age was biological maturity of an individual. Bone age of child indicates maturity of an individual, using radiography of hand or wrist was commonest modality techniques. Non radiation based techniques of visualizing hand & wrist bones such as ultrasonography for bone age calculation have theorized but are not as accurate as radiographic methods. By the age of 18 years, bone age cannot bone age cannot be computed from wrist or radiographs, there medical test is done between age 18-22 years of age. Bone age is an indicator of the skeletal and biological maturity of an individual. That was different from chronological age, which is calculated using the date of birth of an individual. Bone age is often requested by pediatricians and endocrinologists for comparison with chronological age for diagnosing diseases which result in tall or short stature in children. Serial measurements are also used to assess the effectiveness of treatments for these diseases. In this paper formulae had also been designed for computing the final adult height of children from bone age values in normal healthy children. In order to compute bone age various methods have been developed using different skeletal elements and various visualization techniques. **Hans Henrik Thodberg et al., 2009[4**] proposed a research on Bone age rating was associated with a considerable variability from the human interpretation, and this is the motivational new method for automated determination of bone age (skeletal maturity). The method, called BoneXpert, reconstructs, from radiographs of the hand, the borders of 15 bones automatically and then computes “intrinsic” bone ages for each of 13 bones (radius, ulna, and 11 short bones). Finally, it transforms the intrinsic bone ages into Greulich Pyle (GP) or Tanner Whitehouse (TW) bone age. The main motive of this paper was to change the status of bone assessment by introducing a new, computerized, and 100% automated approach called Bone Xpert. Common Problem of these systems is the ability to reconstruct the bone orders and to automatically locate each bone relevant locations. The systems are not fully automate and able to process 90% of the case , a technique has been developed to supervise by Xpert.**A.T. Al-Taani et al ., 2007[5]** proposed a research on new approach classifying bones of the hand wrist images in to pediatric stages of maturity using point distribution module. This method consists two phases: the training phase and classification phase. During training, examples of bones from each class are collected to allow shape deformations for each class are learnt. A modelrepresenting each class is generated.These models are subsequently used to classify new examples of the bones.During classification all models was compared to the input image and theobject is assigned to the class whosemodel is the closest match. In this paper experimental results obtained using 120 images of the third distal and middle phalanxes showed the usefulness of the method for classifying these bones in to their proper stages of maturity.**Pradnya Birhade et al., 2017[6]** proposed a research on different segmentation techniques that can be used to extract different bones in the wrist like distal, middle, radius and the results shows in snake algorithm. Estimation of age is one the

emerging topic in medical imaging. Bone age assessment isa semi-automated method based on radiological examination ofleft-hand wrist which was used to find the age of skeletal and itfurther compared with chronological age(actual age from birthdate). A difference between these two values indicatesabnormalities in the skeletal development. In order to get better results of BAA segmentation of the desired bone is necessary. In this paper Edge Based Segmentation Algorithms was used as there is multiple ossification centers available for the evaluation of the bone maturity. In the paper, they basically based on measuring bone length, angles and shape variations and variation may occur from person to person and observer to observer.**Jung-Ah Choi et al.,2018[7]** proposed a research on the concept of capitohamate (CH) planimetry and compare it with Greulich-Pyle (GP) method. The method discussed about the age of children's up to 180 months. The method based on the measurement of the capitates and hamate on plain radiographs. The limitations exists are deficiency, chronic illness and problems in the growth of the children. In this review paper, there was no difference seen in the left and right capitates and between the right and left hamates. It was noted that using the 3d computing technology there was no significant difference between left and right hands. The correlation between the chronological age and CH planimetry was measured. The accuracy between the CH planimetry and GP method was seen in the method. In this review paper, it was seen that the value of the CH planimetry was greater than GP method.**Lee, H et al.,2017[8]**proposed a research on fully automated pipeline for the segmentation of the regions using the radiographs. The model based on the Image Net to achieve the accurate test images of the females. The female test radiographs was assigned bone age assessment within the year time up to 98%. The male test radiographs were assigned 94% within a year for performing BAA. The problem occurs in the multiple process of the system in areas of the Digital Atlas of Skeletal Maturity The input occlusion method created the features of the trained model to perform the bone age assessment. The human experts manually perform BAA system for obtaining the faster and accurate interpretation time. The variation in the ages was marked during the clinical assessment.

James Powell et al.,2015[9] studied the bone density using the radiograph techniques. The protocols of the bone assessment was developed using the ultrasound device. The limitations in the reference of the datasets for the species were unreliability. The skeleton pin of the radius of the dolphins was defined using a distribution pattern. The overall density of the bones was determined. The specimens of all the datasets were recognised based on the age, sex, body length and handiness. The clinical health assessment assigned using the clinical protocols and established ultrasound of the bones.**Chih-Yen Chen, Chi-Hung Hwang et al.,2014[10]** proposed research on children's bone analysed on the histogram of epiphyseal region of interests(EMRIO).Firstly, in this paper 9 EMROIs was taken from ring finger, middle finger and index finger into our analysis and thenextract the 13 geometrical features for each of them. And then they utilized the KNN classification under the binary decision tree structure for determining the bone age. In the classification phase, two algorithms were considered. For the first one, features from the 9 knuckles were concatenated into one before the classification. Secondly it had been analyzed the features of theindividual 9 knuckles to produce 9 bone age results, and then to choose their mode as the final bone age. In this paper it had been demonstrated that the proposed algorithm approaches the accuracies of about 60% in 1 year error and 80% in 2 year error for thefirst algorithm, and the accuracies of about 65% in 1 year errorand 80% in 2 year error for the second algorithm, respectively. In this paper the bone age of an individual had been evaluated to get the appropriate result.**Darko Stern at al.,2015[11]** proposed on research on automatic 3D method for the determination of legal maturity from MR images based on the ossification of the radius bone. Age estimation was performed by legal regression model of the epiphyseal gap volume over the known ground actual age of training data.In this paper, the results was comparable with the established Greulich/Pyle (GP) and Tanner/Whitehouse (TW) methods, but do not involve harmful radiation. In this paper main research is done to develop an automated method for determine legal majority age based on BAE of all hand bones from MR images. This paper presented first on determination of legal majority based on 3D segmentation of the gap between radius bones. They focused radius of bones examined by radiologists in BAE. To determine whether a person is juvenile or adult, the linear regression model was used to define a binary classification into below and above 18 years, where the threshold in gap volume is derived from the training data.

III. APPLICATIONS AND CHARACTERISTICS OF BAA

i)One Age and Sex Hormones Estrogen:-The Hormones are necessary for the bone maturation after a bone age corresponding to normal age of puberty.

ii) Prediction using Bone Age:-The onset of Puberty is not available in normal children. The timings of peak height velocity is probably available in normal children.[12]

iii) Adult Height Prediction Method:-The adult height prediction methods are Bayley-Pinneau, Tanner-Whitehouse mark II, Growth Potential II.

TABLE 1: CHARACTERISTICS FOR BONE AGE ASSESSMENT [13]

Method	Technology	Evaluation	Through
Conventional Method are Greulich- Pyle Tanner-Whitehouse Method 2	Radiograph	Hand and wrist bones	Atlas and scoring Method
Ultrasonographic Methods	Ultra sonogram	Radius	Measuring sound velocity
M R Imaging Method	MR image	RUS(Radius Ultra Short Bones)	Scoring method
Computerized Method	Radiograph	RUS(Radius Ultra Short Bones)	Automated calculation
Bone Xpert	Radiograph	RUS(Radius Ultra Short Bones)	Automated calculation

TABLE 2: CHARACTERISTICS OF ADULT HEIGHT PREDICTION METHOD [14]

Method	Targets	Limitations
Bayley-Pinneau	Normal Height Children	Not suitable for children having short structure
Tanner-Whitehouse mark II	Normal Height Children	Not suitable for children having short structure
Growth Potential II	Puberty children	Chronological age at the onset puberty are needed
Based on Bone Xpert	Normal height children	Need Bone Xpert software

IV. METHOD FOR BONE AGE ASSESSMENT IN X-RAY IMAGES

Bone age assessment is method for evaluating the maturity, generally by comparing an X-ray of hand wrist with the standard samples in the clinical procedure. An x-ray machine controlled by beam of radiations used to create the image of your body.The x-ray beam passed through the body and the beam of light falls on piece of film and special plate to casts a type of shadow. The tissues in the block of the body absorbs the radiations.The densed tissues appears as white film. The soft tissues appears darker on the film. The multiple images are viewed from different angles .The images determined during x- ray examination is viewed on the film.In x-ray the the contrast images are seen and the contrast parts of the images clearly seen on the X-ray images.

In bone Age Assessment different methods are:-

i) *G P(Greulich and Pyle) Method:-* In GP method bone age is evaluated by comparing the radiograph of the patient with the standard radiograph in atlas,G P Method developed by usingradiographs of upper middleclass Caucasian children in Cleveland,Ohio, United States, and the radiographs wereobtained between 1931 and 1942.in recent study in USA, it was difficult to access bone age accurately in the current children using GP Method[4].

ii) *TW2(Tanner Whitehouse) Method:-* In this method radiographs was used with average socioeconomic children in united kingdom in 1960's. The Tanner Whitehouse (TW3) was developed to update the relation between the bone maturity score and the bone age in 2001.The standardized Tanner Whitehouse was reported in several countries which changes the relation between the total bone maturity score and the bone age[15].

iii) *GR(Gilsanz and Ratibin) Atlas Method:-* This method produce idealized and artificial image which are specific for age and sex standards of the skeleton maturity by analyzing the shape, size, density of ossification centers and morphology in the hand radiographs of healthy children while generating images. This method was developed in 2005 by Gilsanz and Osman. The images of new GR Atlas was much precise than older GP atlas.

iv) *Conventional Method:-*In bone age assessment Pediatric endocrinologists commonly used X- rays and evaluate the growth of children and physical development.

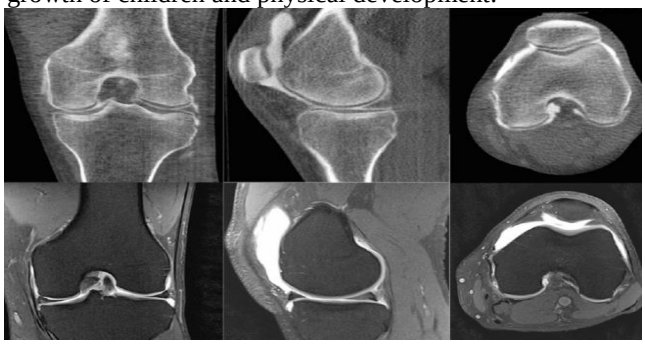

Fig.2: MRI of bone as conventional method

MRI (Magnetic Resonance Imaging) is alternative technique for identifying the image and contrast with multiplanar cross sectional imaging [5]. In MRI the growth assessment provides skeleton maturity during infancy. MRI is powerful technique, non-invasive, on radiative method used by radiologists.

TABLE 3: SEVERAL METHODS FOR BAA COMPARISON STUDY

Characteristics	GP	TW	Computer technique	MRI
Method	Inspection matching visually	The sum of all scores reflects overall stage of bone development	Calculating by radiographs	Grading scheme of growth maturity
Disadvantages	High inter observer variation compared to TW	Inconsistencies due to subjective nature	Automated technique not fully eliminate radiologists	Expensive equipment
Advantages	Quick usage	More reliable	Accuracy precision	Excellent soft tissue contrast
Radiation Risk	Very low	Very low	Free of radiation risk	Free of radiation risk

X-Ray Image Methods [17]

X-rays plays important role in medical tool for doctors. X-rays are ionized forms of radiation for capturing the image using rays. Doctors found that they could not get a detailed view of patient's body .Digital x-ray are widely used in medical technology. Digital x-ray used digitally enhancing, altering, improving quality of image or transferring image from one place to another. Digital x-ray is advance technology to determine photographic film which is less efficient. Digital x-ray is capture the bone/chest x-ray images and convert it in the form of digital files but sometimes digital images are not clear so that before saving the digital x-ray image noise [12].

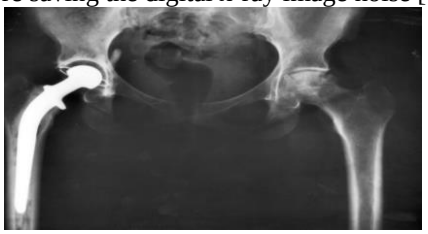

Fig.3: X Ray of Hip Replacement

The digital X-ray are used for the fractured bones and health problems which are to be described in detail.

i) Capture Digital X-Ray

Digital X-ray imaging X-ray Imaging in which the digital sensor chips used instead of photographic film. Digital X-ray needs less radiation for producing an imager of similar contrast to Conventional X-ray. The digital not use the X-ray film while digital X-ray uses image capture device.

ii) Image Preprocessing

In preprocessing technique on digital images the conversion of RGB to gray scale is done appropriate filtering techniques.

iii) Image Edge Detection

Edge detection used for reducing the pixels and saving the images where two methods are used first to derivate the X-ray image and second to find the edge

iv) Image Feature Extraction

In this method the textual features like entropy, correlation, contrast and homogeneity determined by using the Gray Scale matrix [16].

V. CONCLUSION AND FUTURE SCOPE

In this survey, the performance of bone age assessment is evaluated and machine learning algorithm is explained. In machine learning the data is handled more efficiently. The height and age of the adults and children is predicted through different methods which includes X ray technique,GP Method, TW method and conventional methods. Greulich and Pyle method aids us with the ability to predict the height and age of adult children. The application of bone age includes the prediction of age and sex hormones, prediction of height and adult age.In the future work we will experiment with other regression techniques like Artificial Neural Networks based Regression to test the improvement of accuracy. Further, we will experiment with ICA instead of PCA in Active Shape Models to test the results

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