A Review of the Bone Age Assessment using Various Region Based Methods

Sunaina Rani[1], Pankaj Sharma[2]
[1]M.Tech (Scholar), [2]Assistant Professor
Adesh Institute of Engineering and Technology

Abstract – The bone age assessment is a significant clinical technique in the field of pediatrics, normally in related issues and growth disorders. It is a new approach which empowers us to consider the bone age with the help of personal computer image preparing an assessment of the computerized observations. BAA is used to evaluate the skeleton maturity of children. Evaluating the bone age assessment is a significant way of the management way in children with several of growth ad endocrine disorder. In this assessment techniques are famous to estimate the growth rate of children. To find the hormone issues like diabetes, thyroid and obesity and genes disorder i.e., chromosome abnormalities and genes delete. In this paper, presents an effective survey on BAA techniques. The several methods are used to evaluate the bone age such as ROI, EROI, and TW2 (Tanner and White house). In this paper main objective that to the define the best technique for evaluating bone age assessment based-on describes of some various methods with their performance parameters.

Keywords – Bone Age Assessment, Tanner and Whitehouse, Region of interest and enhanced region of interest.

I. INTRODUCTION

Skeleton maturity processes through a variable sequence of discrete or numeric phases, normally in the left and right-hand wrist. In such, pediatric medicine has used this normal progression of growth to assign a BAA and co-relate it with a child chronological age. Some laboratories are current, these help direct further diagnostic calculation of possible endocrine and metabolic disorder [1]. The bone age assessment is central to the calculation of several disease phases, the actual process of bone age assessment hasn't modified importantly because of the publication of the ground-breaking atlas in the 1950 year, which was implemented from analyzing children in Ohio from 1931-42. Bone Age Assessment is the main idea for automated image calculation as there are some images in an individual analyze and relatively standardized reported findings. This combination is an appealing target for machine learning, as it sidesteps many labor-intensive preprocessing steps such as using Natural Language Processing to process radiology reports for relevant findings [2]. The bone age is the most normally used premise of characteristic improvement and age. Bone age evaluations rely on upon considering the periods of improvement associated with skeletal headway through the appraisal of hand and wrist radiographs. The level of skeletal advancement can, essentially, is determined in light of two qualities: The level of improvement in extents encountering solidifying, and the level of calcium hoarding in those regions. From most punctual stages, these two qualities take after a certain and specific case and course of occasions till adulthood. Examines performed from the most punctual beginning stage of the twentieth century to the present have made use of left hand and wrist radiographs for examination purposes. There are certain ideal circumstances associated with using only the left hand as opposed to both hands. In particular, using one hand diminishes both the cost of strategies and the individual's presentation to radiation significantly. The way that the left hand has lower chances of experiencing disasters and damage on account of the higher pervasiveness of right-handedness in numerous social requests, and the way that researchers playing out the basic studies on bone age examination favored using the left hand is the fundamental reasons why the left hand is used in bone age assessments.

Fig.1: Left Hand Wrist Bone

The BAA estimation is usually done through a single X-ray of the left hand, wrist, and fingers. It is very simple, safe and painless that uses a small amount of radiation. The bone age is measured in years. The fingers and wrist of the child's radiographic images contain growth plates in growth zoning at both ends. The special cells in growth plates will determine the growth of the finger. Because of fewer minerals in radiograph images the growth plates can be found easily in x-rays. As a person grows the growth plate of the radiograph will change in appearance on the X-ray images and become thinner, eventually, the growth plates are closed. A doctor can assign a bone age based on the

appearance of the bones and growth plates. A child's skeletal maturity is assigned by using digital atlas which determining standard X-ray images with the atlas which is most closely related to the appearance of the child's bones on the X-ray [3].

II. RELATED WORK

C. Spampinato et al., 2016 [4] surveyed both clinical procedures show several limitations, from the examination effort of radiologists to significant Intra and inter-operator variability. To address these problems, several automated approaches have been proposed; nevertheless, none of them has been proved able to generalize to different races, age ranges, and genders. Proposed and test several deep learning approaches to assess skeletal bone age automatically; the results showed an average discrepancy between manual and automatic evaluation. **Hyun Kwang Lee et al., 2017[5]** compared to chronological age in the evaluation of endocrine and metabolic disorders. While central to numerous disease assessments, little has changed to advance the tedious procedure since its introduction in 1950. In this study, they propose a fully automated deep learning pipeline to segment a region of interest, standardize and preprocess input radiographs, and perform BAA. **Simerjeet Kaur et al., 2016**[6] reviewed various methods for bone age assessment like active shape modeling random forest regression method, Greulich & Pyle method, Tanner and Whitehouse method and RUS method with their advantages and disadvantages. All of the above methods provide effective assistance in processing phase of the bone age assessment. **Manjula Gururaj H et al., 2013 [7]** described Standard Deviation based skeletal Bone Age Assessment based on features extracted from phalanx. The system works according to the renowned Tanner and Whitehouse method based on the Phalanx Region of Interest. The system confirms accurate and vigorous bone age assessment of children among the age group 0-10 years. The proposed work focuses on pre-processing stage in which cropping the phalanx ROI from the input image by followed by the filter is done.

III. MANUAL APPROACH IN BONE AGE ASSESSMENT

Dead human do tell stories" about its sex, age, height and diseases they had at the time of death. Bone age estimation is a clinical method for identifying the skeleton maturation of the human as per the age. Initially, forensic scientists have proposed tooth eruption as the bone age assessment method. Though it was reliable and robust for age assessment, what if the skeleton is found only in parts, not as a whole? Because of these alternative solutions of age estimation have been investigated.

The main problem in manual approach in BAA:

- Forensic study on bone analysis mainly focuses on measuring the bone lengths, angles and shape variations [8].
- These measurements may vary from scientist to scientist and from observation to observation.
- The manual measurements may lead to errors.
- Time-consuming processes.
- All calculations are specific laboratory tool dependent for measuring the values.
- These methods can be applied on dead human bones only.

In case of age-related bone surgeries or bone replacements, the measurements must be accurate. The surgery may fail due to overestimation or underestimation of bone length or bone angle and hence leads to disability or deformity.

IV. AUTOMATED SYSTEMS IN BONE AGE ASSESSMENT

Bone phase, Bone development, Bone Gender and Bone Sickness valuations all are assessed using the radiographic images. These images are prone to noise, low intensity, low contrast etc. Every visual imaging system for radiograph analysis must have pre-processing, segmentation and measurement stages. These three stages can be further categorized into five stages as[9];

- Image Enhancement (such as background removal, Noise filtering Histogram equalization and etc.)
- Rotation of bone pixels to proper angle (if required)
- Segmentation (such as dynamic thresholding, edge detection, etc.),
- Measurement analysis and
- Decision making.

Every x-ray image of human bone has three sets of pixels bone pixels, soft-tissue pixels, and background pixels. The contextual and soft-tissue pixels are not desirable for analysis so image improvement in spatial or frequency domain is required for removing them. Further noise has to be removed using specialized filters. The positions of bones vary from image to image so rotation of bony pixels is also required. Thereafter identification of Region of Interest (ROI) for measurement is achieved through Segmentation techniques. From these ROI's the lengths and angles are to be measured automatically through specialized algorithms. Finally, the Decision making is performed based on specific application. These five stages are performed in different ways on different bone images.

V. TANNER AND WHITEHOUSE WITH ROI METHOD

Another atlas has been proposed by Tanner and Whitehouse (TW: TW1, TW2, TW3) in the year 1962. Here the study was focused on the age estimation but relies on the bone standard maturity. The TW method used bone joints location as ROIs for bone maturity. Each ROI is further divided into three parts: epiphysis, diaphysis, and metaphysics. Out of these three, the epiphysis ossifies from the age zero to teenage and later gets combined with diaphysis. So the age assessment of the TW and GP methods is only up to 19 years. Epiphysis has 9 stages in total starting with An (as no epiphysis bone) to B, C, D ...I as shown in Figure.6. Further authors have developed alternative methods for the skeleton growth assessment system. They are stated as below[10]:

- TW2 (20 bones): This is a modified method published in the year 1975 of an initial TW1 method. It uses 20 ROIs for bone analysis including first, middle, fifth fingers and the carpal bones.
- RUS (Radius, Ulna and Short bones): This is same as the TW2 method but excludes the carpal bones.
- CARPAL: This study is using the carpal bones alone. These bones ossify till the age of 9 years. So the age assessment using this method is limited to 9 years.

Fig.2: Left hand Radiograph with TW2 ROIs

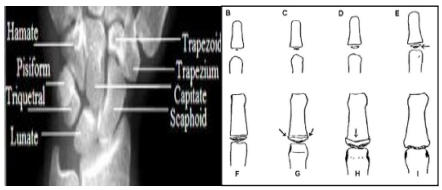

Fig.3: Carpal Bones and Epiphysis region of ossification

VI. ENHANCEMENT REGION OF INTEREST

It conducted a computer-assisted BAA procedure by extracting and using the epiphyseal/ metaphyseal ROI (EMROI), in 2001. The system used two types of images:

- CR images and
- Digitized images[11].

Two preprocessing steps were performed- image orientation correction and background removal to increase the accuracy of ROI segmentation. Then with each phalanx 3 EMROIs were extracted which include: metaphysics, epiphysis, and diaphysis of the distal and middle phalanges and for the proximal phalanges, it includes metaphysis, epiphysis and upper part of metacarpals of proximal phalanges. The diameters of metaphysics, epiphysis, and diaphysis of each EMROI were measured by extracting three lines within each EMROI. Various combinations of the above yield two features or indicators of development:

1) Ratio of epiphyseal diameter divided by metaphyseal diameter and

2) Epiphyseal diameter divided by width of the gap between metaphysics and diaphysis. The accuracy of the system was measured independently at three stages, namely detection of the phalangeal tip, extraction of EMROI and location of diameters and a lower edge of ROIs. The extracted features described the stage of skeletal development more objectively than visual comparison. Finally, a time-frequency domain analysis was performed.

VII. LIMITATIONS OF HAND X-RAY ANALYSIS

The main restriction of hand x-ray analysis is the age group. This can be used to approximation only the age up to 18 or 19 years.

- The consequences vary for male and female.
- The atlases established will vary with regions. So, changed atlases have to be produced for various countries and regions.
- Age can't be appraised if the images have loss of data such as less no. of fingers, joint fingers, cracked bones etc [12].

V. CONCLUSION AND FUTURE SCOPE

On the basis of conversation in numerous sections, the following conclusions can be inferred. The assessment of skeletal maturity involves a rigorous examination of multiple factors and a fundamental knowledge of the various processes by which bone develops. Of all the indices describing the chronological situations of humans, such as height, dental age, and bone maturity, bone age measurement plays a significant role because of its reliability and practicability in diagnosing diseases and growth disorders. Bone age is assessed based on a radiological examination of the skeletal development of the left-hand wrist In most children growth, puberty and related endocrine changes follow a well-orchestrated pattern. The step of maturing varies extensively so that these events should be associated to physical maturity rather than chronological age. Hence bone age reflects physical maturity and is considered as a sort of "biological age". Bone age is useful in the clinical evaluation of children with growth and puberty disorders. The main clinical methods for skeletal bone age estimation namely, the GP method and the TW method, and the various attempts to automate them are reviewed. TW method yields the most reliable results and hence is the preferable spite of its high complexity.

In future scope, it will implement the optimal BAA techniques on the optimal ossification centers for the corresponding subject would yield excellent results.

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