Bone Age Assessment

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ABSTRACT

Bone age assessment defined as the measure of skeletal development is most often used in pediatrics and forensics to estimate the true age of a person. It is usually done by comparing the left hand X-ray of a person with the hand radiographs in the standard atlas or based on local regions of interests (ROI) that include epiphyseal regions of the phalanges (14 ROI’s). Both these assessments were labour intensive, prone to discrepancies and can only be used to estimate the age till 18. Hence there is a need to develop automated method to assess the bone age by exploiting the appropriate features. This paper attempts to identify a procedure in recognizing the respective bone that belongs to male or female with its corresponding age. The automated procedure comprises of segmentation of metacarpals using area based statistics followed by typical feature extraction. Nine features are extracted for the experimental study. A back propagation neural network is then applied to classify whether the given sample refers to male or female bone. It is observed from the simulation results that the proposed procedure is found to be less computation burden and the results are found to be comparable with the existing work reported in the literature.

Keywords: Assessment, Back Propagation Neural Network, Bone Age, Classifier, Metacarpal Index, Otsu’s Thresholding, Regions of Interests (ROI)

INTRODUCTION

Bone age assessment (BAA) is a non-invasive clinical procedure which is used to evaluate the stage of skeletal maturation based on a left hand radiograph of the subject. By convention, left hand radiographs are used as it is less prone to fracture compared to right hand. The age of a person is measured by matching their bone development (as shown by X-rays) with the bone development of a normal person of known chronological age. A difference between chronological age and skeletal age may suggest abnormalities in skeletal development.
Such a procedure is typically used by forensic scientists to confirm one’s age, especially in case of criminals when the date of birth of the child is unknown or cannot be confirmed. It can also be used in sports to estimate the age of athletes. In diagnosing growth disorders, the clinical measurements like height & width is done first. By combining these with the child’s bone age, it is possible to differentiate among the growth disorders. Any defect in skeletal system will indicate the slow growth of the bone. Such a procedure helps in monitoring the response to growth hormone in deciding when to start & stop special treatments.

HISTORICAL PERSPECTIVE ON BONE AGE ASSESSMENT:

According to the literature, two clinical methods were used to assess and evaluate the bone age:

1. **Greulich and Pyle Method:** The Greulich and Pyle method (Greulich & Pyle, 1959) is an atlas-based method. The assessment is performed by comparing a person’s left hand-wrist radiograph with an atlas containing standard radiographs for a range of skeletal ages in which the development stages of each bone is described. The method requires the assessor to work systematically through the atlas, comparing each of 31 bones and sesamoids in the hand-wrist with the standards in the atlas that varies with the race, age and sex. Then an age is assigned to each bone using data from tables associated with the standard that contains the closest match to the bone. If no match is found for a bone, the age is estimated from the closest matching radiographs.

2. **Tanner-Whitehouse Method:** The Tanner-Whitehouse method (Tanner & Gibson, 1994) is also known as bone ossification test. In this method twenty regions of interest namely distal radius, distal ulna, first, third and fifth metacarpals, proximal phalanges of the thumb, third and fifth fingers, middle phalanges of the third and fifth fingers, distal phalanges of the thumb, third and fifth fingers, the seven carpal bones: capitate, hamate, triquetral, lunate, scaphoid, trapezium and trapezoid are used. This method uses a detailed analysis of each individual bone. Each ROI is divided in three parts namely epiphysis, metaphysis and diaphysis. The development of each ROI is represented by letters A, B, C, D, E, F, G, H and I. Stage A represents bone is absent, Stage B represents single deposit of calcium, Stage C represents center is distinct in appearance, Stage D represents maximum diameter is half or more the width of metaphysis, Stage E represents border of the epiphysis is concave, Stage F represents epiphysis is as wide as metaphysis, Stage G represents epiphysis caps the metaphysis, Stage H represents fusion of epiphysis and metaphysis has begun and Stage I represents epiphyseal fusion completed By adding the scores of all ROIs, an overall maturity score is obtained. This score is correlated with the bone age differently for males and females.

PROPOSED METACARPAL INDEX METHOD:

In this proposed study, Metacarpal Index (MCI) is used to estimate the age of a person. MCI can be calculated either by using average of the length and width ratio of 2-5 metacarpals or the ratio of sum of lengths by sum of widths of 2-5 metacarpals. Walker (1979) and Ekpo et al (2007) have reported their work related to bone age assessment for African and Britain populations. Dann (2010) discussed denoising of carpal bones using computerized based image processing algorithm. Jian et al. (2008) proposed an automated method for bone age assessment. Zdenek et al. (2012) reported a data mining based approach for bone age assessment. Even though several works on age assessment
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