A Semi-Automated Computer Program for Assessment of Skeletal Maturity in Children

Sara Gharabaghi – gharabaghi.2@wright.edu
Thomas Wischgoll, Ph.D. – thomas.wischgoll@wright.edu
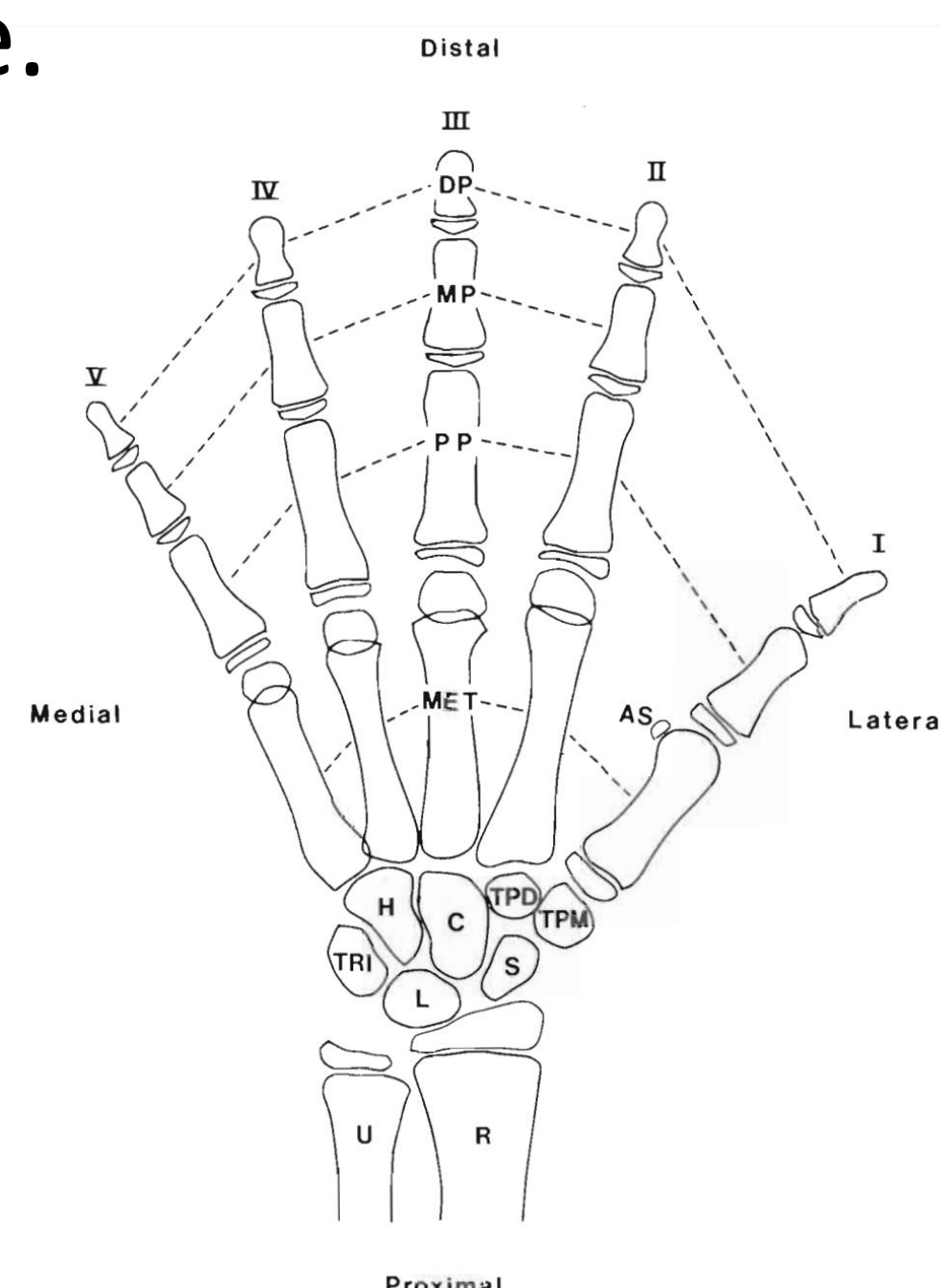*Computer Science and Engineering Department, Wright State University*

Introduction

In pediatric patients, skeletal maturity is an important tool for detection of hormonal, growth or genetic disorders. The Fels method is a well-known visual assessment method in which the skeletal age is estimated by grading 98 skeletal indicators in the hand-wrist radiographic (X-ray) image.

These indicators are features that reflect the three-dimensional shape of the bones and change during the maturation process. Generally, the Fels indicators could be categorized into three main groups of the status of ossification, the ratios of of bone widths, and epiphyseal-diaphyseal fusion.

Since the assessment of the maturity indicators are performed visually, the precision of this method highly depends on the observer. Furthermore, visual assessment of a large number of images requires extra time and effort and may affect the accuracy of the results.

The objective of this study is to develop a semi-automatic computer program for assessment of skeletal maturity using the Fels indicators.

Methods

The proposed computer program is composed of five steps:

- Preprocessing:
    - Detect images with poor contrast and improve them using Contrast-Limited Adaptive Histogram Equalization (**CLAHE**)
    - Background removal using morphological filters
    - Re-orient the image toward the standard protocol

- Region of Interests (ROIs) Extraction:
    - Locate carpus, wrist, finger I, III, and V regions using prior knowledge on standard hand protocol and analysis of hand silhouette

- Segmentation:
    - Segment different bones in each ROI using different segmentation method such edge-based, gradient-based thresholding, k-means and etc.

- Grading the Fels Indicators

- Integrating the Fels indicators and estimate the skeletal maturity.

R1 Indicator : Grade 3
R2 : 1.19
R3 : Grade 2
R4 : Grade 2
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Discussion

The datasets used in this study include hand-wrist radiographic images of 100 children in the range of ages 0 to 20 years.

The analysis of X-ray images taken from various sources capturing children's hands can be challenging because of hand position variation, poor contrast, and non-uniform background. Therefore, the preprocessing step plays an important role in the success of the program. For tackling this challenge, the proposed program takes the input from the user whether the outcome of the preprocessing step has enough accuracy.

Samples of X-ray images in datasets.

The first three steps of preprocessing, ROIs extraction, and bone segmentation are tested on a subset of the available datasets and the success rate is approximately 80%. The grade subset of the Fels indicators are to be compared with the reference values provided by well-trained specialists.

Conclusion

Automated skeletal age assessment is a challenging task because of the hand position variation and non-uniform background of the images as well as a significant amount of noise in some images. The proposed computer program in this study is able to grade a subset of Fels indicators automatically, and it could be extended to a fully-functional version in future.

Reference

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