Bone Crack Detector based on X-Ray using Fuzzy Logic and Neural Network

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***Abstract* - Large number of X-Ray images are analyzed by doctors in hospitals daily to identify various diseases and anomalies in human body. One particular area is identification of problems in bones in that sense, based on X-Ray images doctors are going to predict the problem in that bone such as bone crack, damage etc. These kinds of manual inspection of X-Ray images consume a lot of time and the process itself is monotonous made during the inspection.**

As a solution to these problems here we introduce Computer-assisted decision-making system to detect cracks in bones which are visible in X-Ray image using Fuzzy Logic and Neural Networks.

1. INTRODUCTION

An x-ray (radiograph) is a medical test that helps doctors inspect and treat medical conditions with bone damage. Bones contain calcium element and calcium has high atomic number. Therefore calcium absorbs X-Rays efficiently than other elements in the bone structure. Small amount of X-Rays reaches the shadows of the bones and make them clearly visible on the radiograph [3].

X-Ray images are used by doctors to detect the Fractures of broken bones, bone tumors (abnormal growth of the bone cells may be cancer), degenerative bone conditions, Osteomyelitis, Osteomalacia and etc. [1]. Daily, doctors are analyzing thousands of X-Ray images at hospitals, which is a monotonous and a time consuming activity.

X-Ray images are input to the computer via a scanner with transparency adaptor or use a X-Ray illuminator and take the photos of that X-Ray [2].

The main objective of this study is to develop a Computer-assisted decision-making system to detect cracks in bones in X-Ray images. Hence the developed recognition system consists of three components, namely: Image Processing and feature extraction component, Fuzzy Logic based identification component and Neural Network based verification component.

2. METHODOLOGY

The system is developed to detect simple bone structures as well as complex bone structures. Femur bone structure is used to represent simple bone structures and single figure structure is used to represent complex bone structures. Below given figure 1 shows the basic system architecture. C#.net, Emgu CV image processing library and Aforge.net framework are the technologies used to develop the system.

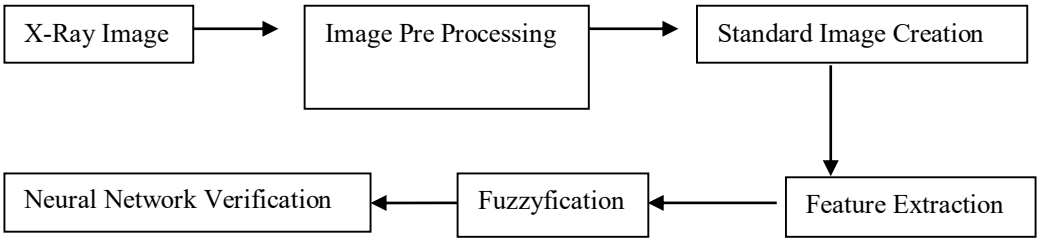

Figure 1: Basic system architecture

2.1 Image Processing Module

Image processing module consists of several sub modules namely; Image Preprocessing, background elimination, crack detection, rough line and smooth line separation and actual crack detection modules. Image Preprocessing is used to enhance the features of the image. Edge based filters are applied to enhance the edges because, edges are an important factor for detecting cracks of in bones in X-Rays. Then system detects the edges of the image using canny edge detector.

After detecting the edges, it eliminates the background of the image. System finally detects the edges that could be cracked or not. The system is capable of detecting actual cracks and also some specific features of the bone such as bends. Those specific features of the bone are smooth lines and cracks are rough lines. Using that specific characteristics system separate crack lines from some other features of the bone. Finally abstract the feature information of crack line for Fuzzyfication.

2.2 Fuzzy Classifier Module

Fuzzy Classifier contains fuzzy inference engine and input output variables. Input variables are information about the crack lines finally detected by image processing module. Output variables are detected as cracks. System is using two fuzzy sets and three fuzzy functions for each fuzzy set. One fuzzy set is Fuzzy Multiplication and other is Fuzzy Variation. Fuzzy functions for each Fuzzy variable are used for following classifications.

- High chance to be a crack
- Mid chance to be a crack
- Low chance to be a crack

Fuzzy Multiplication is calculated by number of times the crack lines change their direction, multiplied by number of rough lines of the crack, detected by the image processing module. Fuzzy Variation is creating a line from start point of crack to end point of crack and taking the variation of the crack line from the already created center line.

1. **RULE 1**: If Fuzzy Multiplication is high and Fuzzy Variation is high then there is a high chance of a crack on the bone
2. **RULE 2**: If Fuzzy Multiplication is mid and Fuzzy Variation is mid then medium chance to be a crack on the bone
3. **RULE 3**: If Fuzzy Multiplication is low and Fuzzy Variation is low, no crack on the bone

The fuzzy rules calculate the output and those outputs send to Neural Network for verification.

2.3 Neural Network Module

Neural Network takes some input from the Fuzzyfication and some parameters are taken from image processing module.

Fuzzyfication parameters are three functions for two of Fuzzy variable returns six outputs and two extra parameters taken from the image processing module. These parameters are

- Bone Length Ratio= actual bone length/ crack length of bone;
- Bone Width Ratio= actual bone width/ crack width of bone;

Eight neurons for input layers, ten neurons for hidden layer and three neurons for output layer were used to train the Neural Network under supervised learning. Output is obtained as a pattern. Finally Neural Network verifies the fuzzy output and correctly says whether the bone is cracked or not.

3. RESULTS

System is able to detect the crack in the long bone X-ray image as well as in single figure. Bones are not in same size and not in same shapes, but the fuzzy module detects the crack in long bone as well as in single figure. Neural Network further clarify that bone contain cracks or not.

Long bone and single figure are also not in same shape and not in same sizes. Single figure contains complex structure rather than long bone.

Some characteristics of bone also sometimes display as cracks of the bone. But fuzzy classifier is eliminating those characteristics. Neural Network verifies that X-Ray contain cracks or not. Output of the system displays in the user interface and marked the crack of the bone.

3. Evaluations

Evaluation of the project can be done in two ways at the beginning. We can take the X-Ray image into system via a scanner with a transparency adaptor or with using X-Ray illuminator machine and camera. Those images first provides to the image processing module for preprocessing, background elimination, crack detection, separate the crack line from smooth lines and finally the actual crack detection. The output of the image processing module, forwards to the input of fuzzy logic detection module. And the output of the Fuzzyfication forwards to the input of the neural network for further verification and neural networks detect the crack of the X-Ray images from non crack X-Ray images.

4. CONCLUSION

System can detects the crack of the bone of X-Ray images in femur bone and also in finger as simple bone structure and complex bone structure. Also system is able to mark intensive places that could be a crack. Fuzzy logic detects the crack and Neural Network verifies the crack correctly.

Further Work:
This system is implemented to detect the cracks in the long bone through X ray image. In addition to this feature the system provides some features that can apply further.

- Bones are different in shape of the bones and can expand this system to detect the crack in different types of bones.
- Detect the crack in the complex bone structure (eg: Hand X Ray image).
- Detect the hole in the teeth and guess amount of plaster wanted to fill that hole.

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