DESIGN AND DEVELOPMENT OF A SYSTEM FOR PROPHYLACTIC CORONARY ARTERY DISEASE PREDICTION AND PREVENTION

A THESIS

Submitted by

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ABSTRACT

Recent advancements in the field of computer science and information technology have contributed tremendous enhancements in designing and developing Medical Decision Support Systems (MDSS). MDSS play an important role in diagnosing the disease by interpreting medical information. This system serves the purpose of an electronic doctor to detect abnormalities, disease progress and diagnosis. It makes use of data processing techniques by accepting textual data from medical records and medical images for predicting the prevalence of disease automatically. On positive prognosis of disease, the patient can undertake prophylactic treatment to prevent its severity. The system is also helpful to follow up the current status of the disease occurred in the patient. Coronary Artery Disease (CAD) is one of the major rampant causes of death in humans worldwide. The purpose of this thesis is to design algorithms and develop computer aided diagnosis system for predicting the presence or absence of coronary artery disease. The heart disease severity level is determined and confirmed using cardiac image that is obtained from invasive clinical procedure.

We designed MDSS to predict the risk of CAD using Multi Criteria Decision Making (MCDM) methods, computational intelligence techniques and medical image processing. Initially, CAD risk prediction is carried out by using MCDM methods namely Analytic Hierarchy Processing (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Simple Additive Weighting (SAW) methods. AHP is employed to analyze the hierarchy structure of CAD diagnosis and determine the attribute weights based on the individual contribution of risk attributes for disease diagnosis as

prescribed by a medical expert. The extended TOPSIS and SAW methods are designed for predicting CAD risk using attribute weights obtained from AHP. Performance of the proposed system is evaluated using Cleveland heart disease dataset as benchmark which is available online in University of California at Irvine (UCI) machine learning repository. The proposed MCDM methods provided accurate prediction results on the diagnosis of CAD risk similar to the medical experts.

Secondly, the risk of coronary artery disease is predicted and risk severity level is classified using Neuro-fuzzy technique. Artificial Neural Network (ANN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) intelligent approaches are employed to serve the purpose. The attribute weights obtained using AHP method is used for neural network initialization to make negligibly small associated error in ANN. Multilayer Backpropagation Neural Network (MLBPNN) is designed and trained using gradient descent algorithm with adaptive learning rate and momentum (traingda) for predicting the presence (1) or absence (0) of CAD. On presence of CAD risk, the risk severity level is classified as Type 1 to Type 4 CAD by executing ANFIS. The fuzzy logic rules of ANFIS are framed and the system is trained using Generalized Bell Curve Member Function (GBELLMF) to handle uncertainty and provide better CAD risk status classification. The performance of the proposed hybrid system is evaluated by K-Fold cross validation on Cleveland heart disease dataset and standard performance metrics. The proposed system produced CAD diagnosis results with an average accuracy rate of 94.15%, sensitivity of 91.44%, specificity of 95.59% and precision of 92.61%.

Finally, the risk level of CAD is confirmed by processing cardiac medical image. X-Ray coronary Angiogram (XRA) is considered as the golden standard for diagnosing the coronary artery disease. The proposed

stenosis grading task segments the coronary artery tree from coronary angiogram image using mathematical morphology and thresholding technique. The percentage level of stenosis and stenosis grading is described by determining the diameter narrowing of coronary artery. Based on the diagnostic results, Myocardial Infarction (MI) can be treated by providing right dosage of medicines to the patients based on the stenosis rate. A real-time clinical dataset consisting of 25 conventional coronary angiographies with 865 frames is used to evaluate the performance of the proposed system. Rate of accuracy, sensitivity, specificity, and precision of the stenosis grading are 92%, 94.74%, 83.33% and 94.74% respectively with an average computational time of 0.84 sec. Kappa value also showed perfect system agreement for stenosis grading. The execution of the proposed works are inspected by an experienced cardiologist and confirmed the system performs well in producing desired diagnosis results.