A Review of Detection of Congenital Heart Diseases using Image Processing Techniques

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Abstract: **Congenital heart defect (CHD) or congenital heart anomaly is a defect in the structure of the heart and great vessels that is present at birth. Image processing based technique to detect congenital heart disease is a challenging work as image is acquired with 3D imaging techniques such as MRI image which is then pre-processed, after that some features are extracted with the help of feature extraction tools and finally disease type is identified. Early detection of congenital heart disease will definitely helpful to treatment. With the help of these methods severity can also be define, for immediate medication or surgery. This paper explains survey of types of CHD and image processing techniques which are available.**

Keywords: **CHD (Congenital Heart Disease), Magnetic Resoning Imaging (MRI), Multilayer Perceptron, Neural Network.**

I. INTRODUCTION

Congenital heart defect (CHD) or congenital heart anomaly is a defect in the structure of the heart and great vessels that is present at birth [1]. Many types of heart defects exist, most of which either obstruct blood flow in the heart or vessels near it, or cause blood to flow through the heart in an abnormal pattern. Other defects, such as long QT syndrome, affect the heart's rhythm. Heart defects are among the most common birth defects and are the leading cause of birth defect related deaths. Approximately 9 people in 1000 are born with a congenital heart defect. Many defects do not need treatment, but some complex congenital heart defects require medication or surgery.

General signs of congenital heart disease can include: Excessive sweating, Extreme tiredness and fatigue, Poor feeding, Rapid heartbeat, Rapid breathing, Shortness of breath, Chest pain, A blue tinge to the skin (cyanosis)

Complications

Children and adults with congenital heart disease can also develop a range of further problems, such as: problems with growth and development, repeated respiratory tract infections (RTIs) – infections of the sinuses, throat, airways or lungs, heart infection (endocarditis), pulmonary hypertension – raised blood pressure within the blood vessels that supply the lungs (pulmonary arteries), heart failure – where the heart is unable to pump enough blood around the body at the right pressure.

Classification

A number of classification systems exist for congenital heart defects [1] [2]. In 2000 the International Congenital Heart Surgery Nomenclature was developed to provide a generic classification system.

1. Obstruction defects

Obstruction defects occur when heart valves, arteries, or veins are abnormally narrow or blocked. Common defects include pulmonic stenosis, aortic stenosis, and coarctation of the aorta, with other types such as bicuspid aortic valve stenosis and subaortic stenosis being comparatively rare. Any narrowing or blockage can cause heart enlargement orhypertension.

2. Septal defects

The septum is a wall of tissue which separates the left heart from the right heart. Defects in the interatrial septum or the interventricular septum allow blood to flow from the right side of the heart to the left, reducing the heart's efficiency. Ventricular septal defects are collectively the most common type of CHD, although approximately 30% of adults have a type of atrial septal defect called probe patent foramen ovale.

3. Cyanotic defects

Cyanotic heart defects are called such because they result in cyanosis, a bluish-grey discoloration of the skin due to a lack of oxygen in the body. Such defects include persistent truncus arteriosus, total anomalous pulmonary venous connection, tetralogy of Fallot, transposition of the great vessels, and tricuspid atresia.

4. Hypoplasia

Hypoplastic left heart syndrome and Hypoplastic right heart syndrome Hypoplasia can affect the heart, typically resulting in the underdevelopment of the right ventricle or the left ventricle. This causes only one side of the heart to be capable of pumping blood to the body and lungs effectively. Hypoplasia of the heart is rare but is the most serious form of CHD [3]. It is called hypoplastic left heart syndrome when it affects the left side of the heart and hypoplastic right heart syndrome when it affects the right side of the heart. In both conditions, the presence of a patent ductus arteriosus (and, when hypoplasia affects the right side of the heart, a patent foramen ovale) is vital to the infant's ability to survive until emergency heart surgery can be performed, since

without these pathways blood cannot circulate to the body (or lungs, depending on which side of the heart is defective). Hypoplasia of the heart is generally a cyanotic heart defect.

II. SYSTEM ARCHITECTURE OF CONGENITAL HEART DISEASE DETECTION

The general system architecture of any image processing based system includes image acquisition, pre-processing, feature extraction and finally classification [4]. Let us discuss each stage briefly.

A. Image Acquisition

Magnetic Resonance Imaging (MRI) technique is used to acquire heart image in fetus or new born child. It is a medical imaging technique used in radiology to image the anatomical and the physiological processes of the body in both health and disease conditions. Other imaging techniques include Nuclear medicine, Cardiac CT & Echocardiography. The basis of MRI is the directional magnetic field, or *moment*, associated with charged particles in motion. Nuclei containing an odd number of protons and/or neutrons have a characteristic motion or precession. Because nuclei are charged particles, this precession produces a small magnetic moment.

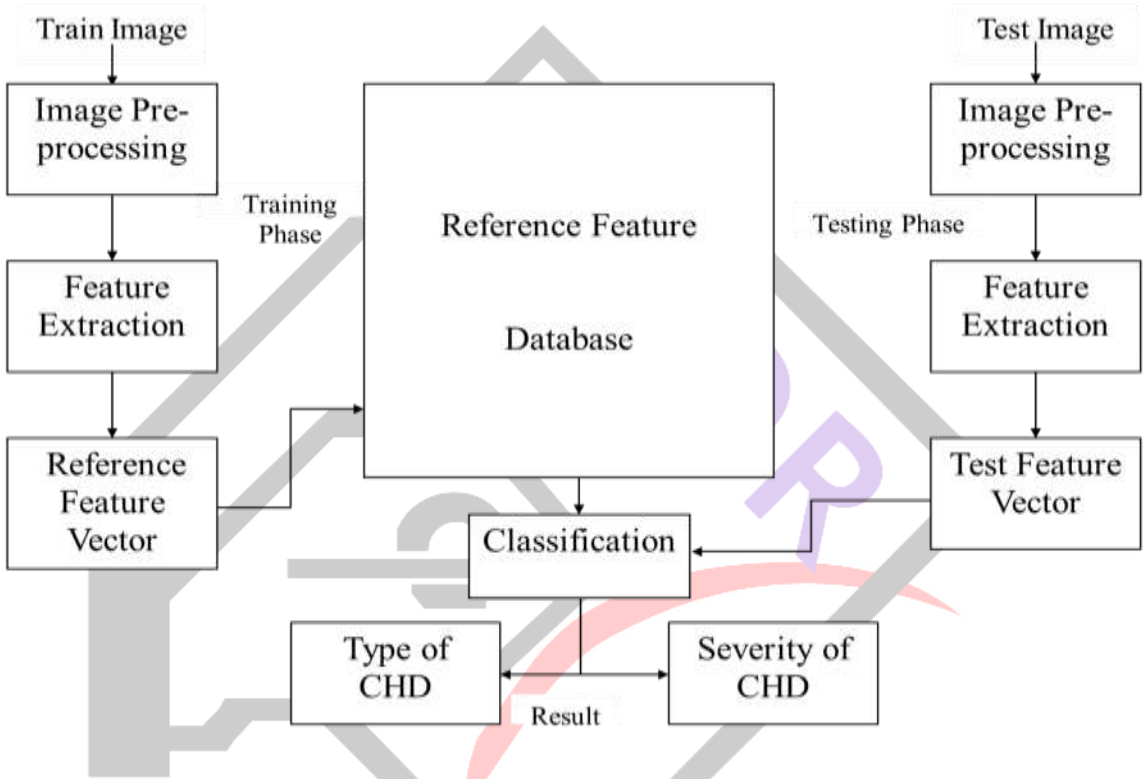

Figure1 System Architecture for Detection of Congenital Heart Diseases using Image Processing Techniques

B. Image Pre-processing

Pre-processing is essential to decrease execution time and to enhance detection. Various pre-processing techniques are available among them Image gray scale conversion & Image adjusting are two used in detection of congenital heart diseases.

1) Gray Scale conversion

MRI image is first converted to a gray scale image to reduce the size of image and to increase the speed of detection [4] [5] [6]. There are two methods for conversion first is average method in which you have to take average of three colures (Red, Green, and Blue) but it results in a dark image. Therefore second method which is weighted method is generally adopted. Since red color has more wavelengths of all the three colors, and green is the color that has not only less wavelength then red color but also green is the color that gives more soothing effect to the eyes. It means that we have to decrease the contribution of red color, and increase the contribution of the green color, and put blue color contribution in between these two. Compare to the result of average method, weighted method image is brighter.

2) Image Adjusting

When we get the image from a MRI scanner, the size of the image is so big. In order to reduce calculation, we decrease size of image. It is done with the help of image interpolation [5]. Interpolation is the technique mostly used for tasks such as zooming, rotating, shrinking, and for geometric corrections. Mainly there are two types of interpolation Bilinear and Bicubic. In the first

one concept of four nearest is used to estimate the intensity at a given location. Let (m, n) denotes coordinates of the location where we want to assign an intensity value and $Z(m, n)$ denote that intensity value so to evaluate assigned value we use equation

$$Z(m, n) = am + bn + cmn + d \quad (1)$$

Where four coefficients viz. a, b, c & d can be obtained from the four equations from the four unknown can be written using four nearest neighbours of point.

III. FEATURE EXTRACTION & CLASSIFICATION FOR CONGENITAL HEART DISEASE

There are various methods available for feature extraction in image processing. It is a challenging work to extract exact features [7] so as to increase efficiency of the system. During the feature extraction process dimensionality of data is reduced. Extracting too many features will not only increase the cost but it also affects system performance in terms of execution time needed. Some popular methods of feature extractions are explained below.

Heart diagnosis equipment is not always available in every medical centre, especially in the rural areas where less support and care. Physician intuition and experience are not always enough to attain high quality medical results. Therefore, medical errors and unwanted results are reasons for a need for unconventional computer-based diagnosis systems, which in turns reduce medical fatal errors, increasing the patient safety and save lives. To date, two different methods are used for three-dimensional echocardiography in the foetus. The technique currently employed at numerous institutions derives from a complex assembly of sequentially acquired and reconstructed two-dimensional images and is analogous to the 3-D technology assessed in studies on neonates, children, and adults [8]. Although an electromagnetic location device is used to register transducer position during data acquisition, this technique has important limitations due to foetal movement artifacts and difficulties in cardiac gating. This often results in inadequate image quality when compared with 2-D echocardiography. Recent progress in the design and fabrication of higher-frequency real-time volumetric transducers has greatly improved 3-D echocardiographic imaging resolution and allows more immediate three-dimensional "on-line" analysis of cardiac anatomy.

The system developed by [8], which is based on Artificial Neural Networks (ANNs), provides a decision support system to classify the heart diseases: mitral stenosis, aortic stenosis and ventricular septal defect. Additionally, the system offers a promising opportunity to develop an operational screening and testing device for heart disease diagnosis and can provide great assistance for clinicians to make advanced heart sound diagnosis, especially in rural areas where high tech devices may not be available.

The neural network based approach is also explained in [9] which uses feed forward neural network architecture and genetic algorithm. They have used hybridization concept to train the neural network using genetic algorithm. This method is more stable than back propagation. The system mainly concentrates on detection of heart disease which is alternative to the solution of complex medical diagnosis [9]. Also they have shown detail analysis of genetic algorithm behaviour and its relationship with neural networks learning performance.

Multilayer perceptron algorithm has been successfully implemented in [10]. They divide the dataset into multiple subsets by improved multilayer perceptron algorithm. Then MLP algorithm implemented for each subset and then obtained results from various subsets are combined with the help of voted combiner with majority probability rule. Execution time is very much reduced by improved MLP method over the conventional MLP approach and the results are far better.

IV. CONCLUSION

The overall incidence of Congenital Heart Disease (CHD) is 1 per 100 live births, which is higher in premature infants. Efficient implementation of detection CHD system will offers a promising opportunity to develop an operational screening and testing device for heart disease diagnosis and can provide great assistance for clinicians to make advanced Congenital heart diagnosis. Also it can be used as a great assistance to physicians in realization accurate and unfailing detecting heart problems at early stages and prevent patients going to proficient cardiologists.

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