**First Review**

**Left Ventricular Ejection Fraction Prediction for Pediatrics Patients Using Convolutional Neural Network**

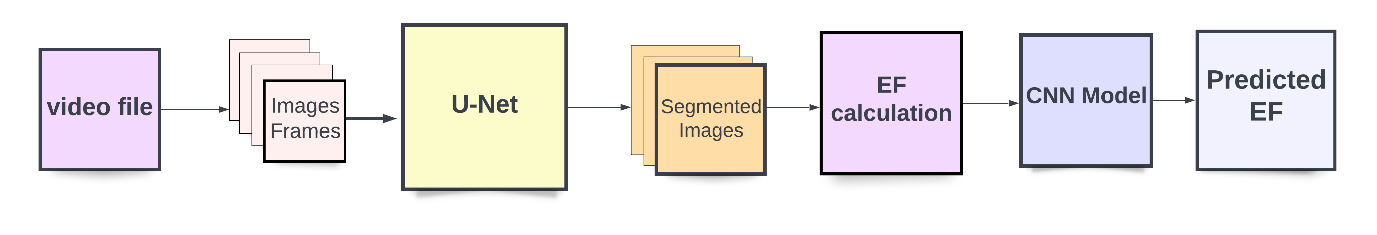
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**Extended Literature Survey:**

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| **Paper Title** | **Survey** |
| Video-Based Deep Learning for Automated Assessment of Left Ventricular Ejection Fraction in Pediatric Patients. J Am Soc Echocardiogr. | The authors developed a video based deep learning algorithm to calculate ejection fraction of left ventricle of pediatric patients. EchoNet-Peds contains a dataset of about 4000 echocardiograms collected from pediatric patients. The paper additionally finds EF based on A4C view and compares the result obtained from training the model on both A4C and PSAX views. The model performs better for pediatric data than an adult. Estimation of EF and systolic dysfunction show significant results. |
| Automatic Prediction of Paediatric Cardiac Output From Echocardiograms Using Deep Learning Models, CJC Pediatric and Congenital Heart Disease, Volume 2, Issue 1, 2023, Pages 12-19 | The paper uses deep learning techniques to calculate the cardiac output of pediatrics using the EchoNet dataset. Cardiac output is the amount of blood the heart pumps in one minute, and hence reflects how healthy the body is. Low cardiac output can cause many health problems and even mortality. Novel models are devised to calculate the left ventricular outflow tract diameter and velocity time integral estimation. The combined models automatically estimate the cardiac output. Results of performance metrics show that the model provides better estimation. Left ventricular volume, ejection fraction and myocardial strain are all important factors that contribute to the detection of heart diseases. |
| Machine Learning-Enabled Fully Automated Assessment of Left Ventricular Volume, Ejection Fraction and Strain: Experience in Pediatric and Young Adult Echocardiography. Pediatric Cardiology | The dataset consists of the echocardiograms of a group of fifty volunteers, which was assessed by a sonographer. ML based image analysis models are used to automatically estimate the left ventricular volume and results prove that the model estimation is as good as traditional methods. |
| Deep learning interpretation of echocardiograms. NPJ Digit Med. | The paper used deep learning CNN models on a dataset of about 2.6 million echocardiograms to identify local cardiac structures, estimate cardiac LVEF Estimation for Pediatric Patients using CNN Model 3 function and estimate risk factors. The models displayed high accuracy even for estimating ejection fraction and pacemaker leads, where previously obtained interpretation from clinical records are used for model training |
| Machine Learning for Pediatric Echocardiographic Mitral Regurgitation Detection | The paper aims to enable widespread echocardiography screening using automatic diagnosis for improved outcomes. A machine learning model is devised to identify mitral regurgitation (MR). The data is used to build two neural networks to classify the data set based on view and presence of MR. The two models recorded accurate measures and proved to be efficient. Repaired tetralogy of Fallot (rTOF) is a combination of four heart defects present at birth. Though it is rare, it causes adverse health outcomes. |
| 5/6 Area length method for left-ventricular ejection-fraction measurement in adults with repaired tetralogy of Fallot: comparison with cardiovascular magnetic resonance. | Two dimensional echocardiographic (2DE) methods are used to measure LVEF(left ventricular ejection fraction). The paper evaluates the performance of the 5/6 area method and studies the factors that affect the results of Cardiovascular Magnetic Resonance (CMR).Though the results are eminent, further improvement is needed to devise a model based on 3DE and more datasets. Echocardiographic evaluation of LVEF is mostly done manually followed by calculation of the end systolic and end diastolic LV volumes. |
| Automated Echocardiographic Quantification of Left Ventricular Ejection Fraction Without Volume Measurements Using a Machine Learning Algorithm Mimicking a Human Expert. Circ Cardiovasc Imaging. | Endocardial boundary identification is still prone to many errors, hence the authors formulated an automated machine learning algorithm to prevent these errors and estimate the degree of ventricular contraction. The model works on a dataset of about 5000 images, where estimated EF values are compared to calculated EF values. The result seems to be better. |
| Machine Learning Assessment of Left Ventricular Diastolic Function Based on Electrocardiographic Features. | The paper works on a machine learning model using clinical data, which estimates myocardial relaxation and reference thresholds for the assessment of LVDD. This innovative method may be used as a low-cost screening tool for early identification of LVDD. Heart failure (HF) can result in severe cardiac dysfunction and overall health instability. Echocardiograms of patients who were referred to their centre for HF are used as the dataset. |
| Multi-modality machine learning approach for risk stratification in heart failure with left ventricular ejection fraction <= 45. ESC Heart Fail | The authors used multilayer perceptron and multi task learning and compared it with logistic regression to estimate incident atrial fibrillation and mortality. Their model revealed that age, left atrial reservoir stain (LARS) and contractile strain (LACS) are all significant estimators of HF. Their models produced better results and are important for the overall risk stratification of HF. Many Deep Learning (DL) algorithms exist for LVEF measurement but the performance is mostly not evaluated for the heart disease phenotypes. |
| Multi-modality machine learning approach for risk stratification in heart failure with left ventricular ejection fraction <= 45. ESC Heart Fail | The authors devised a new DL algorithm for automatic LVEF estimation using Two-Dimensional Echocardiography(2DE) images collected from three centres. A DL algorithm based on U-net and Simpson’s method was applied for the LVEF calculation |

**Proposed Work**

The proposed architecture of AI based LVEF estimation model



The procedure is of **Three** **modules**: Image segmentation, calculating area, length and volume and finally construction of CNN model. The dataset contains two types of views, A4C and PSAX. Videos are converted into sequence of frames and fed as input into the segmentation model.

**First Module: (Image Segmentation)**

Image Segmentation is done on the echocardiogram of A4C and PSAX views to delineate the left ventricular region. U-Net model is used for image segmentation. It is a semantic segmentation technique originally proposed for medical image segmentation. Each frame from a video is accessed using the OpenCV library.

From the given data set, binary masking is done for each of the frame in the data set to annotate them. With the help of masked images, the U-Net model is trained for both A4C and PSAX views separately and stored in separate folders.

**Tools:**

* **OpenCV library**: OpenCV (Open-Source Computer Vision Library) is an open-source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products.
* **Kaggle** with Accelerator GPU T4

**TimeLine of Completion (Module-1): 10/04/2023**

**Second Module: (Area Length and Volume)**

From the segmented images of A4C view, length is found using contours in the OpenCV library and stored in a separate csv file. Similarly, segmented images of PSAX view are used to find the area of systole and diastole using contours in the OpenCV library. From the area and length, volume is calculated using the Bullet.

EF is calculated as the relative difference between systolic and diastolic volume with respect to diastolic volume in percentage.

**Tools:**

* **OpenCV library**: OpenCV (Open-Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products.
* **Google Colaboratory:** Colab allows anybody to write and execute arbitrary python code through the browser, and is especially well suited to machine learning, data analysis and education.

**TimeLine of Completion (Module-1): 15/04/2023**

**Third Module: (CNN Model)**

Label encoding is performed on the categorical values in the data set, and the data set will be split into train, test and validation in the ratio of 3:1:1. MinMaxScaler will normalize the data. Convolutional neural network (CNN) DL model have to be constructed to estimate EF and to start the treatment immediately. Random search and hyper parameter tuning are done to further improve the performance of the model.

**Tools:**

* **Scikit learn Library:** Scikit-learn is an open-source data analysis library, and the gold standard for Machine Learning (ML) in the Python ecosystem. Key concepts and features include: Algorithmic decision-making methods, including: Classification: identifying and categorizing data based on patterns
* **TensorFlow:** TensorFlow is an open-sourced end-to-end platform, a library for multiple machine learning tasks.
* **Keras:** Keras is a high-level neural network library that runs on top of TensorFlow
* **Google Colaboratory:** Colab allows anybody to write and execute arbitrary python code through the browser, and is especially well suited to machine learning, data analysis and education.

**TimeLine of Completion (Module-1): 05/05/2023**

**References:**

* **Dataset:** <https://echonet.github.io/pediatric/index.html#dataset>
* **Scikit Learn:** https://scikit-learn.org/stable/
* **OpenCV:** https://opencv.org/
* **TensorFlow:** https://www.tensorflow.org/