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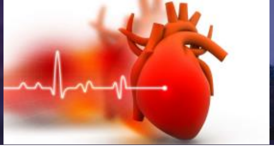
Cardiac function & structure –

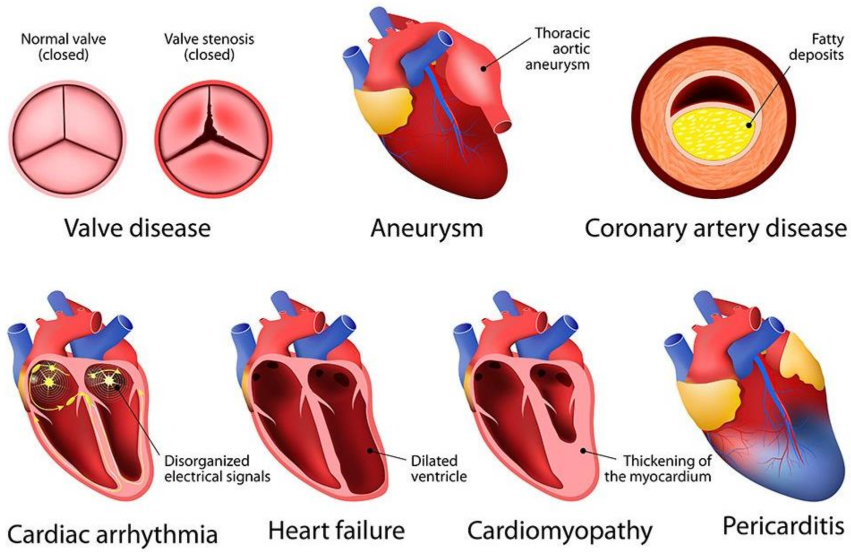
Case study using DL

Pablo Lamata
Eric Kerfoot
Esther Puyol

School of Biomedical Engineering & Imaging Sciences
King's College London



Heart disease is the leading cause of death globally, and evaluation of the structure and the function of the ventricles can provide useful information for diagnosis and characterization of disease.

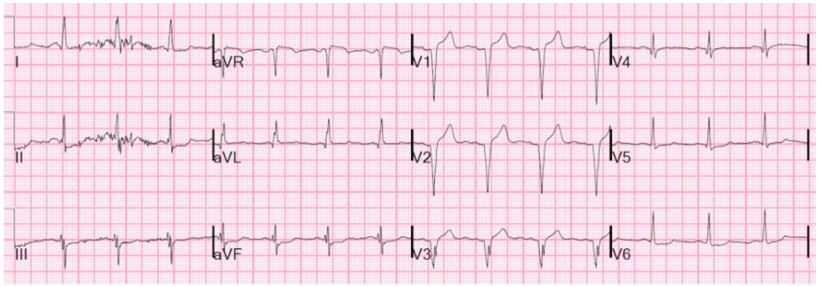


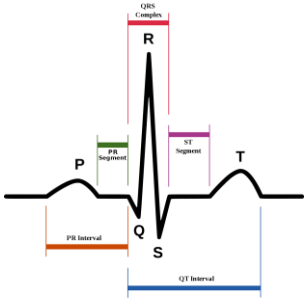
Heart failure (HF) is the primary cause of heart diseases, and that refers to a physiological state in which the heart is unable to pump sufficiently to maintain blood flow to meet the body's need. It usually occurs because the heart has become too weak or stiff.

Diagnosis

Stress test, which measure the health of your heart by how it responds to exercise.

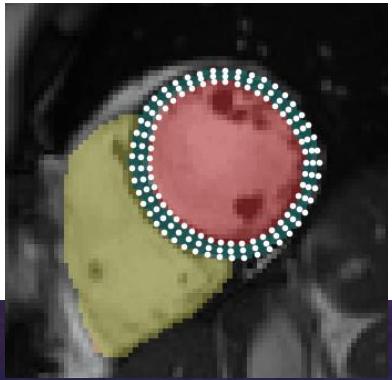
Electrocardiogram (ECG), which measure heart's rhythm and electrical activity.





QRS duration

MR or ultrasound imaging which provides structural and functional information of the heart.



Global parameters: volume, ejection fraction

Regional parameters: strain, velocity, displacements

Clinical descriptors of cardiac function

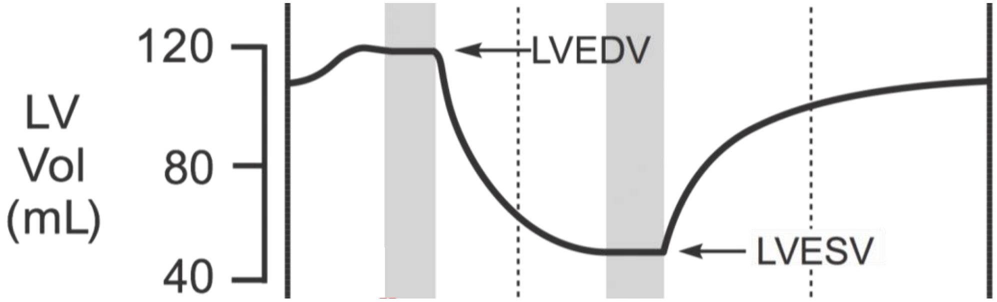
Gold standard parameters to identify cardiac patients is:

Ejection fraction (EF)

- Computes the amount of blood of the left ventricle (LV) pumps out with each contraction.
- Represents difference between end diastolic LV volume (LVEDV) and end systolic LV volume (LVESV) as a percentage of LVEDV

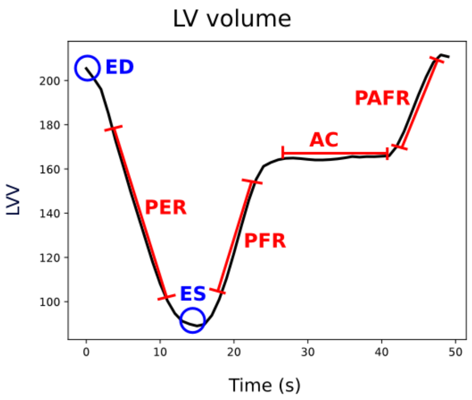
$$LVEF = (LVEDV - LVESV)/LVEDV * 100$$

- Normal heart's ejection fraction between 50 and 70 percent

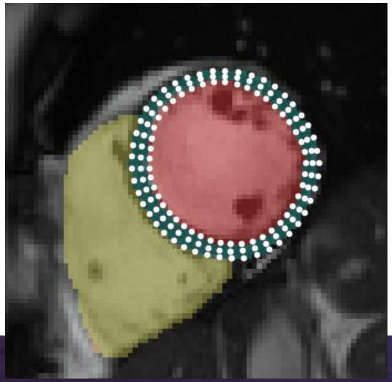


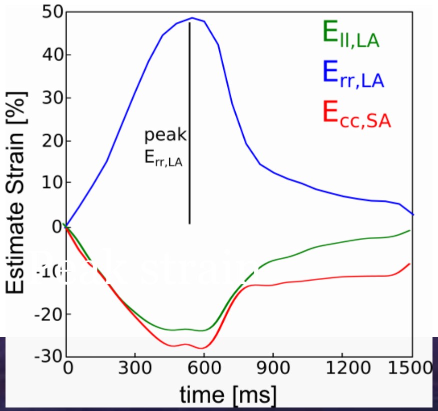
Clinical descriptors of cardiac function

Peak ejection and filling rates: indices of systolic and diastolic function.



Myocardial strain: Quantify regional LV function (shortening, thickening and lengthening of the myocardium)






Case study:

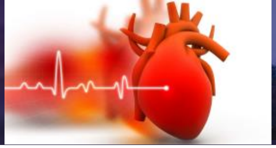
Clinical database

45 subjects with cine short axis MR sequence

- Normal: 9
- Heart failure: 24
- Hypertrophy: 12

Part 1: Classification between different groups using clinical metrics

Part 2: Automatic segmentation of cine MR sequence



Data

Download file called scr_segsonlly_cropped.npz

images – ED and ES cine short axis images

segs – ED and ES segmentation of cine short axis images

caseNames – Patient name

caseIndices – Start and end of ED and ES for each subject

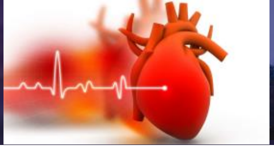
caseTypeNames - ‘Normal’, ‘Hear Failure’ and ‘Hypertrophy’

caseVoxelSize – Voxel size

caseTypes – 1, 2or 3

isEDImg – 1 for ED and 0 for ES

segTypes – ‘Background’, ‘LV pool’, ‘Myocardium’




Performances measures :

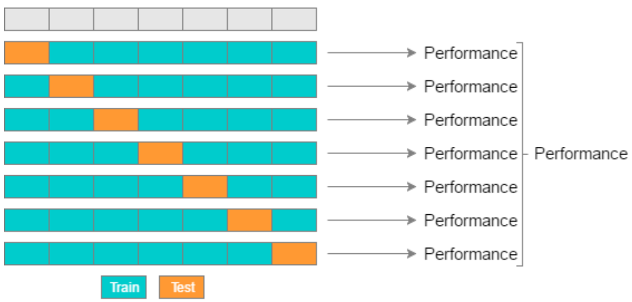
- **Accuracy:** total number of subjects correctly classified
- **Precision:** proportion of subjects among the patients with positive test result
- **Recall (SEN) :** proportion of patients correctly classified

ACC = (TP + TN) / (TP + TN + FP + FN)
PRE = TP / (TP + FP)
SEN = TP / (TP + FN)

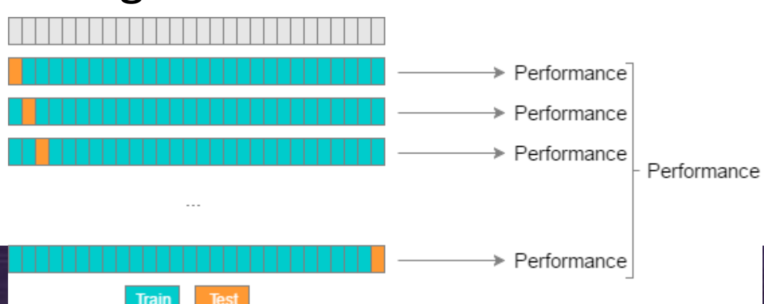
Cross validation (balanced classes)

Holdout: Divide data into training and test set

***k*- fold**: First divide the data into folds, and then apply holdout in each fold (non-exhaustive method)

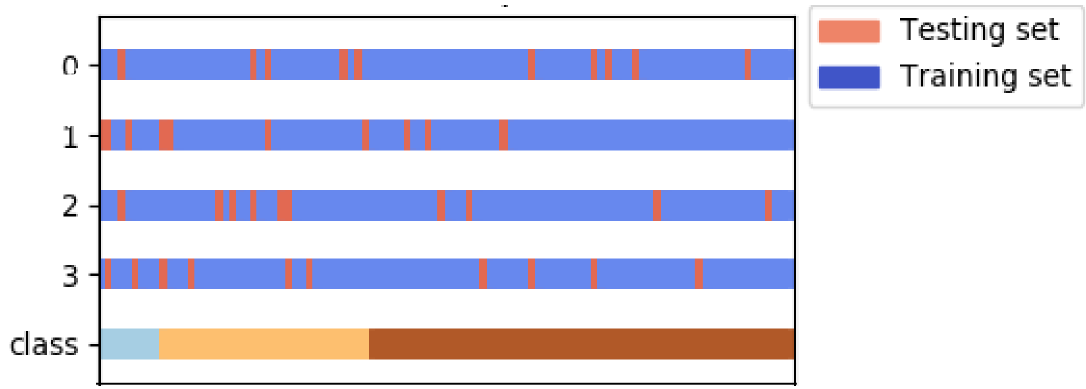


Leave-one-out: In each iteration there is a single sample that is reserved for testing wile the others are used for training.

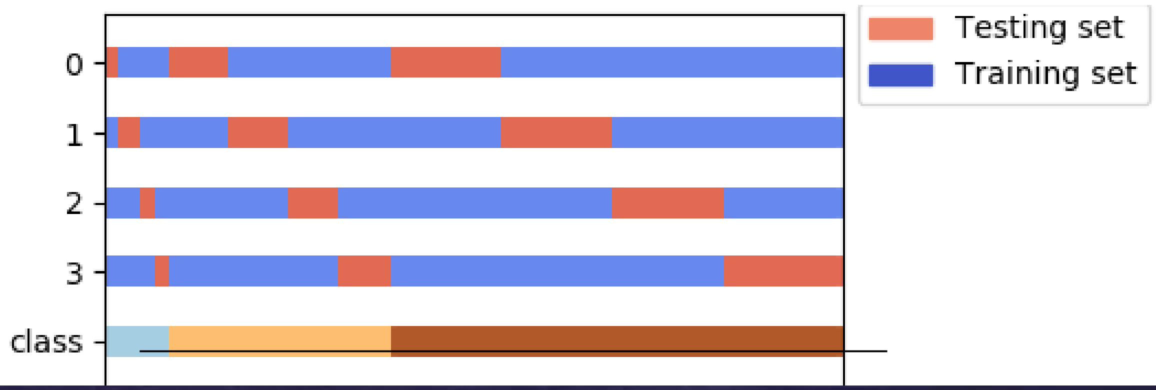


Cross validation (unbalanced classes)

Shuffle split: Randomly divide data into training and test



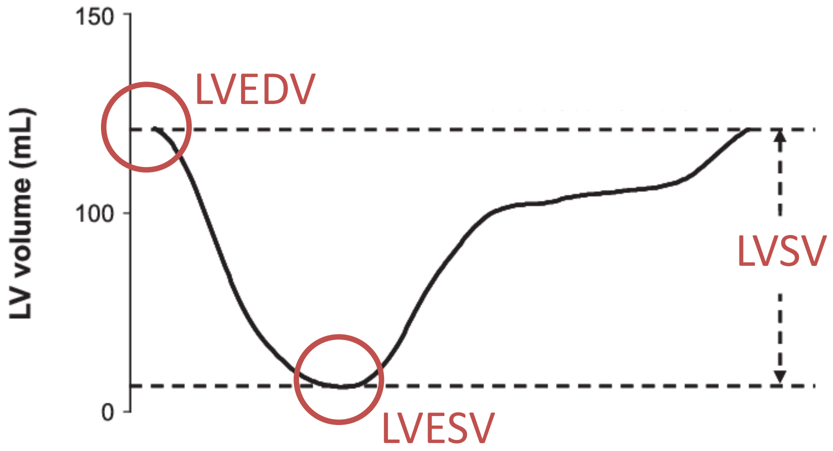
Stratified *k*-fold: variation of k-fold which returned stratified folds (each set contains approximately the same percentage of samples of each target class)



Part 1:

Aim: Classification between different groups using clinical metrics

Compute LVEDV, LVESV, LVSV and LVEF and use them with a DNN for classification

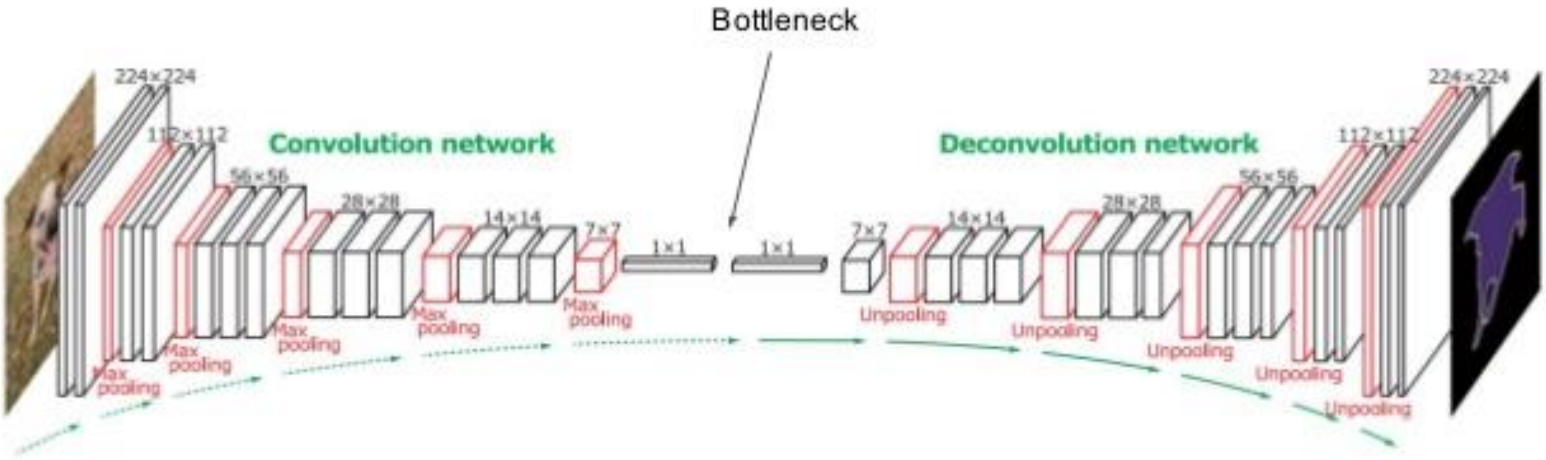


LVEF = (LVEDV – LVESV)/LVEDV * 100

Split training/test: 80/20 with balanced classes

Part 2:

Aim: Automatic segmentation of cine MR sequence using autoencoder architecture



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Questions?

Slides adapted from the Machine Learning for Biomedical Application course from King's College of London