CLASSIFICATION OF ECG IMAGES

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1. INTRODUCTION

- GOAL : We want to predict behaviour of the EKG signals.

- CLIENT : Our client is healthcare providers and hospitals. Some patients need to be kept under observation and those patients are connected to EKG machines. It is impossible to put a person 7/24 to watch them. It will be better if we can obtain and analyze EKG data simultaneously to check if everything is in normal condition.

- SOLUTION : By analyzing EKG data we can inform healthcare providers immediately so they can take immediate action.
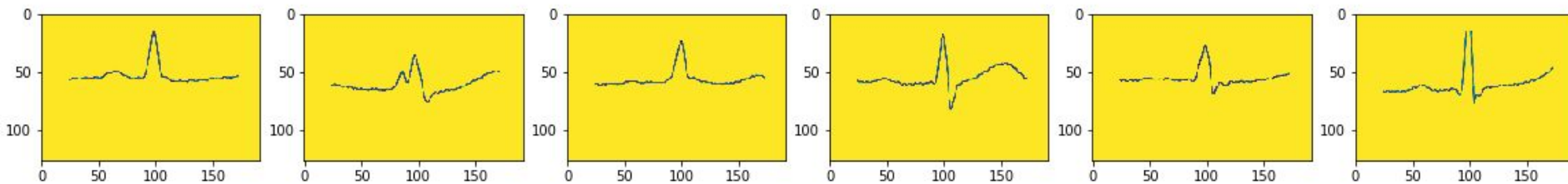
2. DATASET

- Physionet's MIT-BIH Arrhythmia Dataset.
- Kaggle project source link: https://www.kaggle.com/analiviafr/ecg-images
- There are 109445 samples in the dataset.
- Image Resolution : 196x128.
- Five categories
  - ❏ N (Normal beat)   : 90.589
  - ❏ S (Supraventricular ectopic beat)   : 2.779
  - ❏ V (Ventricular ectopic beat)   : 7.236
  - ❏ F (Fusion beat)   : 803
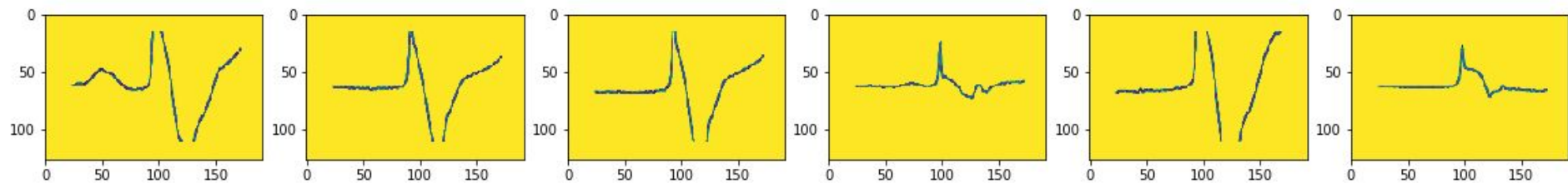 - ❏ Q (Unknown beat)   : 8.038
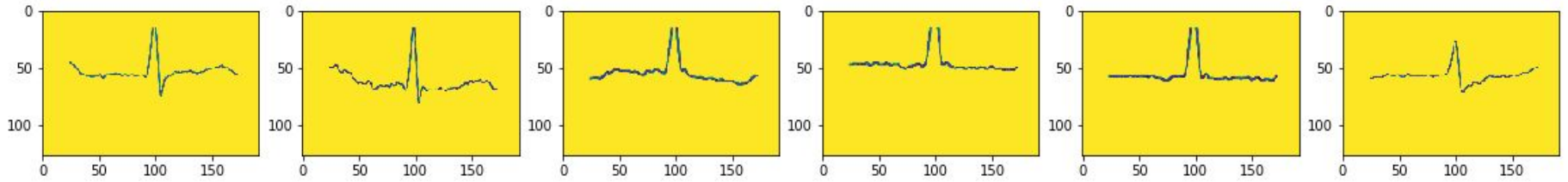
3. EDA

FUSION BEAT (F)
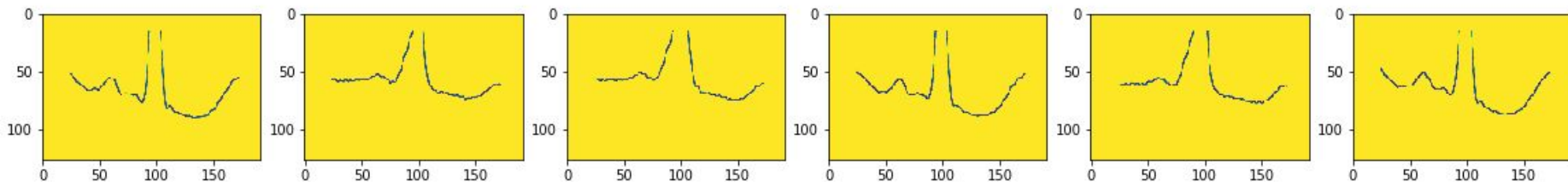
NORMAL BEAT (N)

UNKNOWN BEAT (Q)
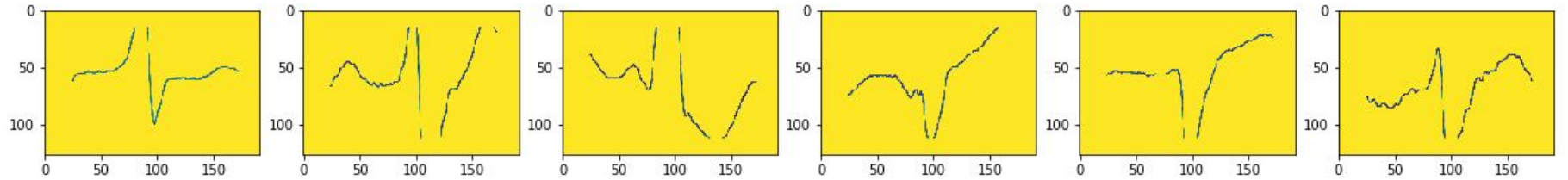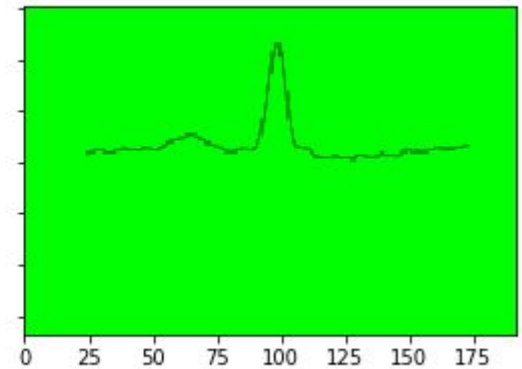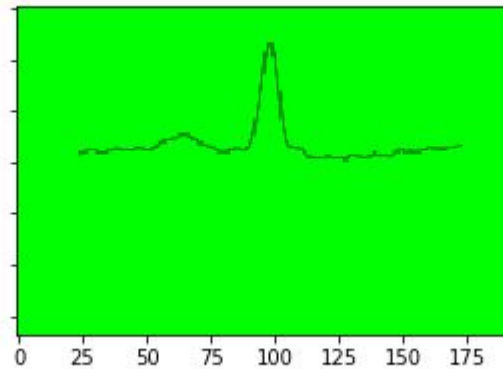
3. EDA

SUPRAVENTRICULAR ECTOPIC BEAT (S)

VENTRICULAR ECTOPIC BEAT (N)

3. EDA

Plot one image in 3 different channels: Red, Green, Blue
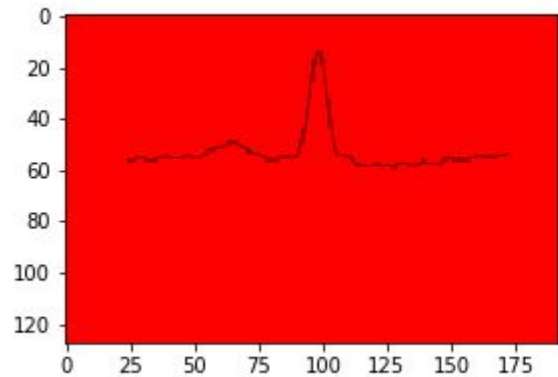
4. PREDICTIVE MODEL

MODEL DATA LOADER

Image size reduced from 196*128 to 120*120

Channel   : 1

Batch size : 32

Criterion   : Cross Entropy Loss

Optimizer   : Stochastic Gradient Descent (SGD)

Devise   : GPU on Kaggle Servers

4. PREDICTIVE MODEL

FIRST MODEL ARCHITECT

1. First Convolutional Layer   : 4 convolutional filters with kernel size 3*3, stride = 1, padding = 1.

2. Activation function   : Rectified linear unit (ReLU)

3. Max pooling   : Kernel size 2

4. Second Convolutional Layer : 4 convolutional filters with kernel size 3*3, stride = 1, padding = 1

5. Activation function   : Rectified linear unit (ReLU)

6. Max pooling   : Kernel size 2

7. Dropout (p = 0.5)

8. Linear layer   : Input 4*30*30 output : 5 (Because we have 5 classes)

FIRST MODEL: RESULTS ON TRAIN DATA

CONFUSION MATRIX

	ACTUAL				
	N	Q	S	V	F
P R E D I C T I O N S	71650	546	1451	1042	373
	150	5781	3	99	3
	234	2	734	35	1
	412	100	35	4567	75
	25	1	0	46	190

RECALL, PRECISION, F1-SCORE

class name: N, total number of class: 72471, Correctly predicted: 71650, Recall: 0.99%, Precision: 0.95%, F1-Score: 0.97%

class name: Q, total number of class: 6430, Correctly predicted: 5781, Recall: 0.90%, Precision: 0.96%, F1-Score: 0.93%

class name: S, total number of class: 2223, Correctly predicted: 734, Recall: 0.33%, Precision: 0.73%, F1-Score: 0.45%

class name: V, total number of class: 5789, Correctly predicted: 4567, Recall: 0.79%, Precision: 0.88%, F1-Score: 0.83%

class name: F, total number of class: 642, Correctly predicted: 190, Recall: 0.30%, Precision: 0.73%, F1-Score: 0.42%

FIRST MODEL: RESULTS ON TEST DATA

CONFUSION MATRIX

		ACTUAL			
	N	Q	S	V	F
P R E D I C T I O N S	17959	127	381	299	96
	26	1476	0	43	1
	49	0	169	5	0
	80	14	6	1093	33
	4	0	0	7	3

RECALL, PRECISION, F1-SCORE

class name: N, total number of class: 18118, Correctly predicted: 17959, Recall: 0.99%, Precision: 0.95%, F1-Score: 0.97%

class name: Q, total number of class: 1608, Correctly predicted: 1467, Recall: 0.91%, Precision: 0.95%, F1-Score: 0.93%

class name: S, total number of class: 556, Correctly predicted: 169, Recall: 0.30%, Precision: 0.76%, F1-Score: 0.43%

class name: V, total number of class: 1447, Correctly predicted: 1093, Recall: 0.76%, Precision: 0.89%, F1-Score: 0.82%

class name: F, total number of class: 161, Correctly predicted: 31, Recall: 0.19%, Precision: 0.74%, F1-Score: 0.31%

4. PREDICTIVE MODEL

FORTH MODEL ARCHITECT

1. First Convolutional Layer : 4 convolutional filters with kernel size 3*3, stride = 1, padding = 1.

2. Activation function : Rectified linear unit (ReLU)

3. Max pooling : Kernel size 2

4. Second Convolutional Layer : 4 convolutional filters with kernel size 5*5, stride = 1, padding = 1

5. Activation function : Rectified linear unit (ReLU)

6. Max pooling : Kernel size 2

7. Dropout (p = 0.5)

8. Linear layer : Input 4*30*30 output : 5 (Because we have 5 classes)

FORTH MODEL: RESULTS ON TRAIN DATA

CONFUSION MATRIX

		ACTUAL			
	N	**Q**	**S**	**V**	**F**
P R E D I C T I O N S	27781	2426	832	2165	248
	3994	317	133	335	35
	5705	471	164	406	51
	11495	1100	341	1044	117
	2349	2116	753	1839	191

RECALL, PRECISION, F1-SCORE

class name: N, total number of class: 18118, Correctly predicted: 17959, Recall: 0.38%, Precision: 0.83%, F1-Score: 0.52%

class name: Q, total number of class: 1608, Correctly predicted: 1467, Recall: 0.05%, Precision: 0.07%, F1-Score: 0.06%

class name: S, total number of class: 556, Correctly predicted: 169, Recall: 0.07%, Precision: 0.02%, F1-Score: 0.04%

class name: V, total number of class: 1447, Correctly predicted: 1093, Recall: 0.18%, Precision: 0.07%, F1-Score: 0.10%

class name: F, total number of class: 161, Correctly predicted: 31, Recall: 0.30%, Precision: 0.01%, F1-Score: 0.01%

FORTH MODEL: RESULTS ON TEST DATA

CONFUSION MATRIX

	ACTUAL				
	N	Q	S	V	F
P R E D I C T I O N S	6892	595	224	510	43
	1060	69	30	70	10
	1463	124	52	113	7
	2803	304	71	263	43
	5900	516	179	491	58

RECALL, PRECISION, F1-SCORE

class name: N, total number of class: 18118, Correctly predicted: 6892, Recall: 0.38%, Precision: 0.83%, F1-Score: 0.52%

class name: Q, total number of class: 1608, Correctly predicted: 69, Recall: 0.04%, Precision: 0.06%, F1-Score: 0.05%

class name: S, total number of class: 556, Correctly predicted: 52, Recall: 0.09%, Precision: 0.03%, F1-Score: 0.04%

class name: V, total number of class: 1447, Correctly predicted: 263, Recall: 0.18%, Precision: 0.08%, F1-Score: 0.11%

class name: F, total number of class: 161, Correctly predicted: 58, Recall: 0.36%, Precision: 0.01%, F1-Score: 0.02%

5. CONCLUSION

- 4 different models are tested.

- The first model which has the less complexity than others gives the best results.

- Reported scores for classes: N, Q, S, V, F are Recall: 0.99, 0.90, 0.33, 0.79, 0.3;
  Precision: 0.95, 0.96, 0.73, 0.88, 0.73; F1-Score: 0.97, 0.93, 0.45, 0.83, 0.42.

- Forth model reported scores for classes: N, Q, S, V, F are Recall: 0.38, 0.04, 0.09, 0.18, 0.36;
  Precision: 0.83, 0.06, 0.03, 0.08, 0.01; F1-Score: 0.52, 0.05, 0.04, 0.11, 0.02.

- Second model and third models' Recall, Precision, and F1-Scores are less than first and forth models'
  scores.