Multiclass Classifier based Cardiovascular Condition Detection using Smartphone Mechanocardiography

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ABSTRACT

In this supplementary information material, additional details on classification performances are presented. Four types of data were considered for two-class, three-class, and four-class classification tasks. Kernel support vector machines (KSVM) and ranfom forests (RF) were employed for all classification tasks with and without majority voting. Performance metrics in this study include sensitivity, specificity, accuracy, and F_1 score. The results of classifications are also given in confusion matrices for each classifier separately.

Supplementary tables for multiclass classifiers

Two-class classification

Confusion matrices of the each classification type is given for random forest (RF) and Kernel support vector machines (KSVM) with and without majority voting as follows:

Table 1. RF confusion matrix for 2-class classification with and without majority voting

	Normal	AFib		Normal	PrePCI		STEMI	PrePCI
RF-Without Majority Voting								
Normal	291	42	Normal	293	40	STEMI	239	62
AFib	32	552	PrePCI	73	197	PrePCI	100	170
RF-With Majority Voting								
Normal	22	1	Normal	21	2	STEMI	17	4
AFib	1	39	PrePCI	5	16	PrePCI	8	13

Table 2. KSV confusion matrix for 2-class classification with and without majority voting

	Normal	AFib		Normal	PrePCI		STEMI	PrePCI
KSVM-Without Majority Voting								
Normal	314	19	Normal	275	58	STEMI	240	61
AFib	29	555	PrePCI	48	222	PrePCI	107	163
KSVM-With Majority Voting								
Normal	23	0	Normal	21	2	STEMI	16	5
AFib	1	39	PrePCI	4	17	PrePCI	8	13

Performance metrics for each two-class type are defined as accuracy, sensitivity, and specificity according to the

following Equations:

$$Sensitivity(SE) = \frac{\sum TP}{\sum TP + \sum FN} \tag{1}$$

$$Specificity(SP) = \frac{\sum TN}{\sum TN + \sum FN} \tag{2}$$

$$Accuracy(ACC) = \frac{\sum TP + \sum TN}{\sum TP + \sum FP + \sum FN + \sum TN} \tag{3}$$

where TP is true positives, meaning that disease case correctly identified as diseased, FN is false negatives meaning that disease case incorrectly identified as healthy, TN is true negatives meaning that healthy case correctly identified as healty, and FP is false positives meaning that healthy subject incorrectly selected as diseased case.

Multi-class Classification Scoring
Classification scoring for multiclass case in this study was an F_1 measure, which is obtained as an average of

$$Normal : F_{1n} = \frac{2 * Nn}{\sum N + \sum n} \tag{4}$$

$$AFib : F_{1a} = \frac{2 * Aa}{\sum A + \sum a} \tag{5}$$

$$STEMI : F_{1m} = \frac{2 * Mm}{\sum M + \sum m} \tag{6}$$

$$PrePCI : F_{1p} = \frac{2 * Pp}{\sum P + \sum p} \tag{7}$$

The final scores are generated for each of the classification types as follows:

$$F_1 = \frac{F_{1n} + F_{1m} + F_{1p}}{3} \tag{8}$$

$$F_1 = \frac{F_{1n} + F_{1a} + F_{1m} + F_{1p}}{4}. \tag{9}$$

Table 3. Definition of parameters for scoring used in Eq. 8 and 9

	Normal	AFib	STEMI	PrePCI	Total
Normal	Nn	Naf	Nm	Np	$\sum N$
AFib	An	Aa	Am	Ap	$\sum A$
STEMI	Mn	Ma	Mm	Mp	$\sum M$
PrePCI	Pn	Pa	Pm	Pp	$\sum P$
Total	$\sum n$	$\sum a$	$\sum m$	$\sum p$	

Table 4. RF confusion matrix for 3-class classification with and without majority voting

RF- Without Majority Voting	Normal	STEMI	PrePCI	Total	RF-With Majority Voting	Normal	STEMI	PrePCI	Total
Normal	286	27	20	333	Normal	21	1	1	23
STEMI	6	246	49	301	STEMI	0	17	4	21
PrePCI	53	81	136	270	PrePCI	4	7	10	21
Total	345	354	205		Total	25	25	15	

Table 5. KSVM confusion matrix 3-class classification with and without majority voting

KSVM- Without majority voting	Normal	STEMI	PrePCI	Total	KSVM-With Majority Voting	Normal	STEMI	PrePCI	Total
Normal	273	28	32	333	Normal	21	1	1	23
STEMI	2	237	62	301	STEMI	0	17	4	21
PrePCI	30	90	150	270	PrePCI	2	6	13	21
Total	305	355	244		Total	23	24	18	

Table 6. RF Confusion matrix 4-class classification with and without majority voting

RF- Without majority voting	Normal	AFib	STEMI	PrePCI	Total	RF-With Majority Voting	Normal	AFib	STEMI	PrePCI	Total
Normal	276	20	12	25	333	Normal	21	1	1	0	23
AFib	46	471	48	18	583	AFib	4	33	2	1	40
STEMI	8	113	149	31	301	STEMI	0	7	12	2	21
PrePCI	30	71	22	147	270	PrePCI	3	4	1	13	21
Total	360	675	231	221		Total	28	45	16	16	

Table 7. KSVM Confusion matrix 4-class classification with and without majority voting

KSVM- Without majority voting	Normal	AFib	STEMI	PrePCI	Total	KSVM-With Majority Voting	Normal	AFib	STEMI	PrePCI	Total
Normal	267	21	21	24	333	Normal	20	1	0	2	23
AFib	8	461	97	18	584	AFib	0	35	5	0	40
STEMI	1	74	185	41	301	STEMI	0	5	13	3	21
PrePCI	21	54	49	146	270	PrePCI	2	5	3	11	21
Total	297	610	352	229		Total	22	46	21	16	