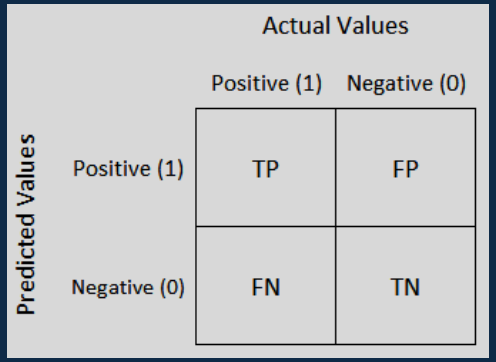
Results (Discussion)



- Confusion Matrix: It is a matrix consist of four outcomes of binary classification.

  True Positives: Data points labeled as positive that are actually positive.

  False Positives: Data points labeled as positive that are actually negative.

  True Negatives: Data points labeled as negative that are actually negative.

  False Negatives: Data points labeled as negative that are actually positive.

- Accuracy: It is the ratio of number of correct predictions to the total number of input samples.

$$\text{Accurcay} = \frac{\text{True Positives} + \text{True Negatives}}{\text{Total Number of Samples}}$$

- Precision: It is the fraction of relevant instances among the retrieved instances, while recall is the fraction of relevant instances that were retrieved.

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

- Recall: It can be viewed as the probability that a relevant document is retrieved by the query.

$$\text{recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Neagtives}}$$

- F1 Score: It is the weighted average of Precision and Recall. This score takes both false positives and false negatives into account

$$F1 = 2 * \left({}^{1}\Big/ \left(\frac{1}{\text{Precision}}\right) + \left(\frac{1}{\text{recall}}\right) \right)$$

Results (Classifier Alone)

Training (1487)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	1296	8	12	171	98.65	99.38	99.07	99.22
Decision Tree	1291	5	9	182	99.05	99.61	99.3	99.46
Gaussian Process	**1296**	**0**	**0**	**191**	**100**	**100**	**100**	**100**
Linear SVM	1199	48	49	145	93.48	96.29	96.21	96.25
Naïve Bayes	1017	279	14	177	80.29	78.47	98.64	87.4
K Nearest Neighbor	1271	25	50	141	94.95	98.07	96.21	97.13
Neural Net (MLP)	1263	33	104	87	90.78	97.45	92.39	94.85
QDA	**1296**	**0**	**0**	**191**	**100**	**100**	**100**	**100**
Random Forest	**1296**	**0**	**0**	**191**	**100**	**100**	**100**	**100**
RBF SVM	**1296**	**0**	**0**	**191**	**100**	**100**	**100**	**100**
SGD Classifier	1199	97	74	117	88.5	92.51	94.18	93.34

Testing (638)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	512	25	22	79	92.63	95.32	95.88	95.61
Decision Tree	513	21	34	70	91.69	96.06	93.78	94.91
Gaussian Process	534	0	103	1	83.85	100	83.83	91.2
Linear SVM	499	38	27	74	89.81	92.92	94.86	93.88
Naïve Bayes	406	128	11	93	78.21	76.02	97.36	85.38
K Nearest Neighbor	509	25	44	60	89.18	95.31	92.04	93.65
Neural Net (MLP)	522	12	59	45	88.87	97.75	89.84	93.63
QDA	534	0	103	1	83.85	100	83.83	91.2
Random Forest	**523**	**11**	**32**	**72**	**93.26**	**97.94**	**94.23**	**96.05**
RBF SVM	534	0	103	1	83.85	100	83.83	91.2
SGD Classifier	486	48	45	59	85.42	91.01	91.52	91.26

Results (Classifier + Hyper-Parameter Tuning (GridSearchCV))

Training (560)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	**274**	**0**	**0**	**286**	**100**	**100**	**100**	**100**
Decision Tree	**285**	**0**	**0**	**275**	**100**	**100**	**100**	**100**
Gaussian Process	**283**	**0**	**0**	**277**	**100**	**100**	**100**	**100**
Linear SVM	266	10	24	260	93.92	96.37	91.72	93.99
Naïve Bayes	241	46	16	257	88.92	83.97	93.77	88.6
K Nearest Neighbor	260	18	23	259	92.67	93.52	91.87	92.69
Neural Net (MLP)	283	5	8	264	97.67	98.26	97.25	97.75
QDA	254	29	146	131	68.75	89.75	63.5	74.37
Random Forest	**279**	**0**	**0**	**281**	**100**	**100**	**100**	**100**
RBF SVM	**286**	**0**	**0**	**274**	**100**	**100**	**100**	**100**
SGD Classifier	237	39	19	265	89.64	85.86	92.57	89.09

Testing (140)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	66	8	2	64	92.85	89.18	97.05	92.95
Decision Tree	61	4	7	68	92.14	93.84	89.7	91.72
Gaussian Process	52	15	10	63	82.14	77.61	83.87	80.62
Linear SVM	71	4	6	59	92.85	94.66	92.22	93.42
Naïve Bayes	51	10	7	72	87.85	83.6	87.93	85.71
K Nearest Neighbor	58	16	16	50	77.14	78.37	78.37	78.37
Neural Net (MLP)	55	8	10	67	87.14	87.3	84.61	85.93
QDA	57	8	40	35	65.71	87.69	58.76	70.37
Random Forest	**69**	**3**	**4**	**64**	**95**	**95.83**	**94.52**	**95.17**
RBF SVM	67	0	73	0	47.85	100	47.85	64.73
SGD Classifier	63	14	6	57	85.71	81.81	91.3	86.3

Results (Classifier + Hyper-Parameter Tuning (RandomizedSearchCV))

Training (560)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	270	1	3	286	99.28	99.63	98.9	99.26
Decision Tree	**271**	**0**	**0**	**289**	**100**	**100**	**100**	**100**
Gaussian Process	**279**	**0**	**0**	**1**	**100**	**100**	**100**	**100**
Linear SVM	258	21	37	244	89.64	92.47	87.47	89.89
Naïve Bayes	242	31	16	271	91.6	88.64	93.79	91.11
K Nearest Neighbor	265	18	28	249	91.74	93.63	90.44	92.01
Neural Net (MLP)	270	12	8	270	96.42	95.74	97.12	96.42
QDA	281	10	42	227	90.71	96.56	86.99	91.53
Random Forest	**280**	**0**	**0**	**280**	**100**	**100**	**100**	**100**
RBF SVM	**286**	**0**	**0**	**274**	**100**	**100**	**100**	**100**
SGD Classifier	253	24	57	226	85.57	91.33	81.61	86.2

Testing (140)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	71	8	3	58	92.14	89.87	95.94	92.8
Decision Tree	72	7	6	55	90.71	91.11	92.3	91.71
Gaussian Process	58	13	7	62	85.71	81.69	89.23	85.29
Linear SVM	63	8	11	58	86.42	88.73	85.13	86.89
Naïve Bayes	68	8	6	58	90	89.47	91.89	90.66
K Nearest Neighbor	49	20	19	52	72.14	71.01	72.05	71.53
Neural Net (MLP)	64	5	10	61	89.28	92.75	86.48	89.51
QDA	58	2	21	59	83.57	96.66	73.41	83.45
Random Forest	**66**	**3**	**5**	**66**	**94.28**	**95.65**	**92.95**	**94.28**
RBF SVM	64	0	76	0	45.71	100	45.71	62.74
SGD Classifier	63	12	11	54	83.57	84	85.13	84.56

Results (Classifier + Hyper-Parameter Tuning (HalvingGridSearchCV))

Training (560)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	283	0	1	276	99.82	100	99.64	99.82
Decision Tree	**278**	**0**	**0**	**282**	**100**	**100**	**100**	**100**
Gaussian Process	**277**	**0**	**0**	**283**	**100**	**100**	**100**	**100**
Linear SVM	267	14	19	260	94.1	95.01	93.35	94.17
Naïve Bayes	237	49	40	234	84.1	82.86	85.55	84.19
K Nearest Neighbor	250	30	29	251	89.46	89.28	89.6	89.44
Neural Net (MLP)	266	19	6	269	95.55	93.33	97.79	95.51
QDA	155	130	5	270	75.89	54.85	96.87	69.66
Random Forest	**273**	**0**	**0**	**287**	**100**	**100**	**100**	**100**
RBF SVM	**291**	**0**	**0**	**269**	**100**	**100**	**100**	**100**
SGD Classifier	254	28	32	246	89.28	90.07	88.81	89.43

Testing (140)

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	64	1	6	69	95	98.46	91.42	94.81
Decision Tree	68	5	7	60	91.42	93.15	90.66	91.89
Gaussian Process	52	25	5	58	78.57	67.53	91.22	77.61
Linear SVM	67	3	10	60	90.71	95.71	87.01	91.15
Naïve Bayes	49	19	16	56	75	72.05	75.38	73.68
K Nearest Neighbor	58	13	19	50	77.14	81.69	75.32	78.83
Neural Net (MLP)	56	10	14	60	82.85	84.84	80	82.35
QDA	33	33	1	73	75.71	50	97.05	66
Random Forest	**72**	**4**	**2**	**62**	**95.71**	**94.73**	**97.29**	**96**
RBF SVM	58	0	82	0	41.42	100	41.42	58.58
SGD Classifier	61	7	14	58	85	89.7	81.33	85.31

Results (Classifier + Hyper-Parameter Tuning (HalvingRandomSearchCV))

Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	286	0	1	273	99.82	100	99.65	99.82
Decision Tree	**278**	**0**	**0**	**282**	**100**	**100**	**100**	**100**
Gaussian Process	**286**	**0**	**0**	**274**	**100**	**100**	**100**	**100**
Linear SVM	245	27	1	283	94.28	90.07	98	93.86
Naïve Bayes	265	8	25	262	94.1	97.06	91.37	94.13
K Nearest Neighbor	260	26	27	247	90.53	90.9	90.59	90.75
Neural Net (MLP)	275	2	4	279	98.92	99.27	98.56	98.92
QDA	250	39	90	181	76.96	86.5	73.52	79.49
Random Forest	**283**	**0**	**0**	**277**	**100**	**100**	**100**	**100**
RBF SVM	**283**	**0**	**0**	**277**	**100**	**100**	**100**	**100**
SGD Classifier	254	29	31	246	89.29	89.75	89.12	89.43

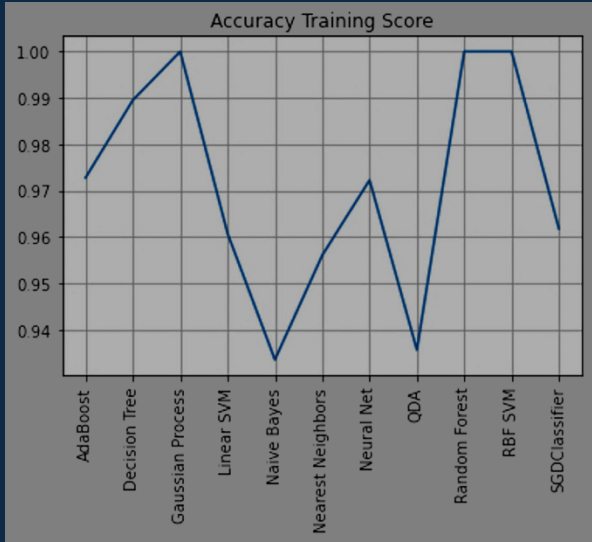
Training (560)

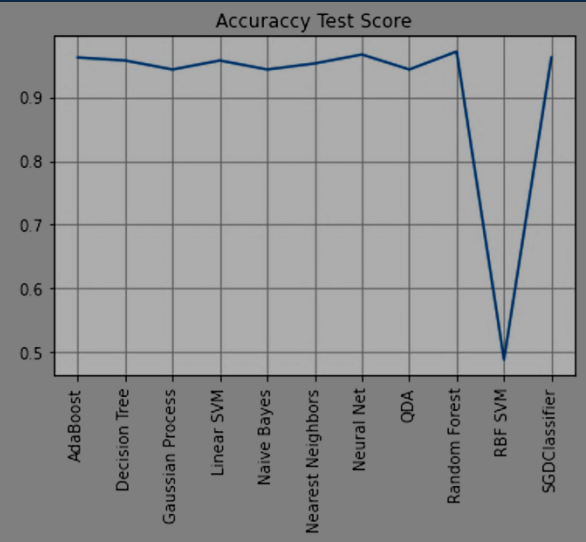
Classifiers	Confusion Matrix				Accuracy	Precision	Recall	F1 score
	True Positive	False Positive	False Negative	True Negative				
AdaBoost	59	3	4	74	95	95.16	93.65	94.4
Decision Tree	68	3	6	63	93.57	95.77	91.89	93.79
Gaussian Process	55	7	11	67	87.14	88.7	83.33	85.93
Linear SVM	68	8	1	63	93.57	89.47	98.55	93.79
Naïve Bayes	74	1	13	52	90	98.66	85.05	91.35
K Nearest Neighbor	51	11	10	68	85	82.25	83.6	82.92
Neural Net (MLP)	68	6	11	55	87.85	91.89	86.07	88.88
QDA	49	13	26	52	72.14	79.03	65.33	71.53
Random Forest	66	1	3	70	97.14	98.5	95.65	97.05
RBF SVM	66	0	74	0	47.14	100	47.14	64.07
SGD Classifier	55	11	15	59	81.42	83.33	78.57	80.88

Testing (140)

Performance & Analysis

- Previously the better result 99.06 percent using random forest in the Fetal Heart Rate Classification using Random Forest Classifier.
- This model obtains 99.15 percent accuracy using the random forest and halving random search CV.





Conclusion

- Random Forest, Ada Boost and Decision Tree are better in classify the fetal conditions.
- Initially the classifiers alone are trained and tested then accuracy of Random Forest is 97.14%, Ada Boost is 95% and Decision Tree is 93.57%.
- Next performing all classifiers with Hyper Parameter Tuning Techniques.

Table represents the 90 percent above classifiers in Testing Accuracy

Classifiers	Halving Random Search CV	Randomized Search CV	Halving Grid Search CV	Grid Search CV
Random Forest	97.14	94.28	93.57	96.42
Ada Boost	95	93.21	90.71	90
Decision Tree	93.57	90.71	91.57	95

- Finally Random Forest is better classifier with 99.15% after performing with Halving Random Search CV.