European Journal of Molecular & Clinical Medicine

ISSN: 2515-8260 Volume 07, Issue 11, 2020

Expert Systems for diagnosing diabetic by Statistical and Trees approaches

[1]Dr.Sarath Kumar Mohan Kumar, [2]Dr. Santhosh Kumar Mohan Kumar

Email: [1]msarathkumar.msk@gmail.com, [2]santhoshkumar.msk3@gmail.com

Abstract:
Around the world, type 1 diabetes (T1D) is being found in more among children. People with type 1 diabetes who were diagnosed at a young age are more likely to have heart disease and other problems linked to their diabetes. The Diabetes Control and Complications Trial (DCCT) showed that strict glycemic management lowers the chance of diabetes complications in people with type 1 diabetes. Teenagers with T1D had a higher amount of glycated hemoglobin A1c (HbA1c) than adults, even though they needed more insulin every day and gained weight. This suggests that insulin was less effective at keeping their blood sugar under control [4]. A rise in hormones related to puberty, like growth hormone and sex steroids, may be linked to insulin resistance in teens. So, the best way to treat T1D in teens is to focus on treatments that make the body more sensitive to insulin. This work finds that the When compared to other methods, both the Naive Bayes Network Updateable and the Naive Bayes itself produce the best results with an accuracy of 76.30%. When compared to the other stumps, the Decision one has the lowest accuracy, at only 71.88%. When compared to other methods, both the Naive Bayes Network Updateable and the Naive Bayes itself produce the same, best results with a precision of 0.76. When compared to the other stumps, the Decision stump has the lowest accuracy, at 0.72.the Naive Bayes Network Updateable and Naive Bayes both achieve the greatest results and have the same recall of 0.76 compared to other methods. When compared to the other stumps, the Decision one has the lowest recall (0.72).Naive Bayes and the Naive Bayes Network Updateable both produce the best results when compared to other methods, with a kappa of 0.47. When compared to the other stumps, the Decision one has the lowest kappa value (0.37).When compared to other methods, Naive Bayes and Naive Bayes Network Updateable get the best results (0.76 F-Measure). The lowest value is 0.72, which is held by the Decision Stump. When compared to other methods, Naive Bayes produces the best results (0.49 MCC). When compared to the other stumps, the Decision one yields the lowest MCC value (0.38 MCC). The MCC for the Naive Bayes Updateable is 0.47. The Naive Bayes, Naive Bayes Network Updateable, and Random Forest all achieve the same best-in-class result of 0.82 ROC. The Decision Stump has the lowest ROC of the available options, at 0.68. The greatest results, 0.82 PRC, are shared by the Naive Bayes, Naive Bayes Network Updateable, and Random Forest methods. When compared to other PRC values, the Decision Stump's 0.68 PRC is the lowest. The statistical learning approach shows least deviations compare with other models.

Keywords: Diabetic, Naïve Bayes, T1D, MCC, HbA1c, kappa

1. Introduction

Metformin makes insulin work better by decreasing the amount of glucose made by the liver and increasing the amount of glucose absorbed and used by the body's tissues.[1-6]

Metformin can be given to people over the age of 10 and to people with type 1 diabetes, according to the guidance. Even though it has been studied more and more [7, 8], treating teens with T1D with both metformin and insulin is not something that is commonly done in clinical work. Metformin acts primarily to decrease hepatic glucose output, increase peripheral glucose uptake and utilization, and thus improve insulin sensitivity. Metformin is allowed to be prescribed to patients over 10 years old and to patients with T1D in the instruction. However, metformin is not routinely used in daily clinical practice, although the treatment of metformin added to insulin in adolescents with T1D has been increasingly investigated. Metformin did not improve glycemic control in the above studies [9, 11], but it did lower insulin dosage and markers of adiposity and increase insulin resistance in both overweight/obese and normal-weight T1D teenagers. But these studies only looked at T1D people who were Caucasian. Compared to Caucasian patients, people with type 1 diabetes in China had a typical body mass index (BMI) of about 19.6 kg/m2 [12]. Metformin needs to be tested to see if it can help this group of people with a low body mass index control their blood sugar and fix other metabolic problems. The Diabetes Control and Complications Trial (DCCT) and its observational follow-up, the Epidemiology of Diabetes Interventions and Complications (EDIC) Study, are celebrating the 30th anniversary since the start of the DCCT and 20th since the reporting of the DCCT primary results. During the past three decades, our understanding of the relationship between metabolic control and complications and the treatment of type 1 diabetes (T1D) has been transformed by the results of DCCT/EDIC. Most importantly, the long-term prospects for patients have dramatically improved with the adoption of intensive therapy designed to achieve near-normal glycemia as the standard of care of T1D[6].

People with T1D are four to eight times more likely to get CVD [13]. Also, it's becoming clear that insulin resistance plays a big role in how CVD happens in people with T1D [14–16]. But cardiovascular death and illness are strongly linked to abnormal cardiovascular autonomic function in diabetes [17, 18]. In particular, a sympathovagal mismatch that makes it hard to control the heart rate is a major cause of cardiovascular death and illness. It's easy to miss, especially in young people, because it doesn't usually cause any symptoms in its early stages, but it can lead to heart problems in the long run. Patients with type 2 diabetes who take metformin have a better mix of their heart's sympathetic and parasympathetic nerves [19]. Multiple randomized studies [9–11] have shown that Metformin affects metabolic parameters and insulin resistance in youth with T1D. However, the effects of the drug on the autonomic function of the heart in this group have not yet been studied in detail.

This article organizes the following: In section 2 has related researches; in section 3 has terms and definition of related work; in section 4 has implementation and interpretation; and section 5 has conclusions of this work.

Literature Survey

Type 1 diabetes (T1D) that starts in children is becoming more common around the world [20-22]. Patients with T1D that started in youth have to deal with hyperglycemia for the rest of their lives. This makes them more likely to develop complications of diabetes early, such as cardiovascular disease (CVD). The Diabetes Control and Complications Trial (DCCT) showed that strict glycemic control in people with type 1 diabetes (T1D) reduced complications of diabetes [23]. But the DCCT also showed that teenagers with T1D had a higher level of glycated hemoglobin A1c (HbA1c) than adult patients, even though they needed more insulin every day and gained weight. This suggests that insulin was less effective at controlling blood sugar in the teen group, possibly because insulin resistance

happens during puberty [24]. The rise in hormones that come with puberty, like growth hormone and sex steroids, may cause insulin resistance in teenagers [25, 26]. So, for better management of T1D in teens, methods that could make them more sensitive to insulin should be thought about. It is a serious but overlooked complication of diabetes, especially in youth, because it is mostly asymptomatic in early stage but ultimately leads to cardiovascular complications. In patients with type 2 diabetes, metformin treatment is associated with improvements in cardiac sympathovagal balance [19]. Type 1 diabetes (T1D) is a chronic, immune-mediated disease associated with destruction of the insulin-producing beta cells of the islets of the pancreas. Approximately 40-50% of the risk of disease arises from genetics with the remaining risk arising from poorly defined environmental etiologies. The class I and II human leukocyte antigen (HLA) genes contribute about half of the genetic risk of disease with about 40-50 non-HLA genes accounting for the remainder of genetic risk.

Metformin's main effect is to lower the amount of glucose made by the liver, increase the amount of glucose taken in and used by the body's tissues, and improve insulin sensitivity. Metformin can be given to people over the age of 10 and to people with T1D, according to the guidance. Metformin is not usually used in daily clinical practice, but it is being studied more and more as a treatment for T1D in teens when it is added to insulin [27, 28]. Previous studies [29–31] showed that metformin did not improve glycemic control, but it did reduce insulin dose and measures of adiposity and increase insulin sensitivity in teens with T1D who were overweight or obese or of normal weight. But these tests were done on people with T1D who were Caucasian. Compared to Caucasian patients, T1D patients in China have a baseline body mass index (BMI) of 19.6 kg/m2 [32], which is much lower. It remains to be seen if metformin can improve glucose control and other metabolic problems in this group with a relatively low BMI.

Four to eight times more likely to get CVD if you have T1D [33]. Also, it is becoming clearer that insulin resistance plays a major role in how CVD develops in people with T1D [34–36]. On the other hand, cardiovascular morbidity and mortality [37, 38] are closely linked to abnormal cardiovascular autonomic function, which is characterized by a sympathovagal imbalance and poor control of the heart rate. It is a dangerous but often overlooked complication of diabetes, especially in young people, because most people don't notice it in its early stages. However, it can lead to heart problems in the long run. When people with type 2 diabetes take metformin, their heart's sympathetic-vagal balance gets better [39]. Even though the effects of metformin treatment on metabolic parameters and insulin resistance in teenagers with T1D have been shown in several randomized trials [31-40], the effects of metformin on cardiovascular autonomic function in this group have not yet been fully studied.

Terms and Definition

This sections focuses on the related terms and definition of this work. The diabetic dataset collected from UCI public data repository. Which is having 786 records and Pregnancies eight attributes which is Glucose, Blood Pressure, Skin Thickness, Insulin, BMI, Diabetes Pedigree Function, Age and Outcome.

ISSN: 2515-8260 Volume 07, Issue 11, 2020

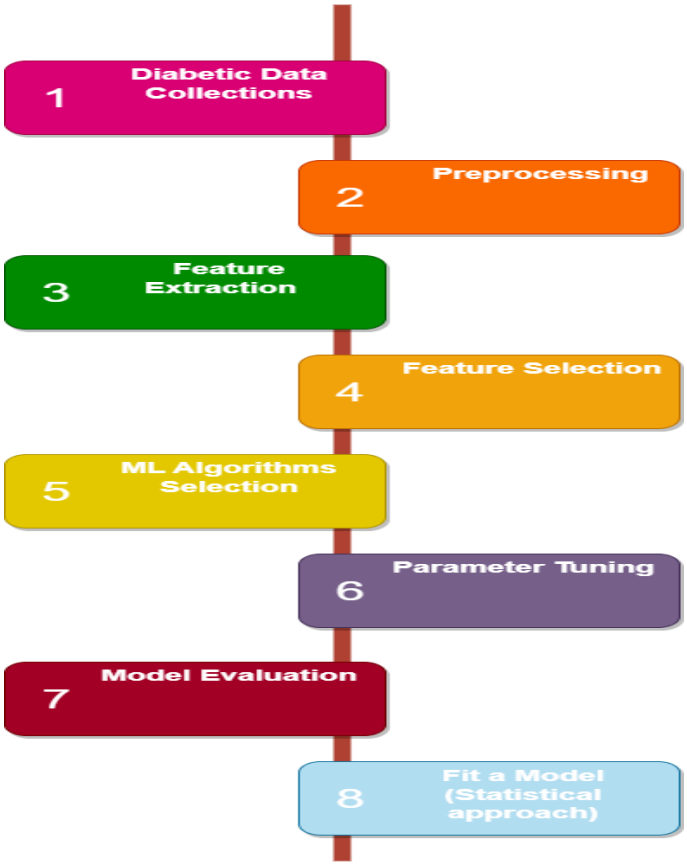

Figure 1: System Architecture

The following algorithms are implemented in Weka 3.9.5. tool by 90(training):10(testing) cross fold validation.

- Bayesian Network
- Decision Stump
- Naïve Bayes
- J48
- Naïve Bayesian Network Updateable
- Random Forest

Implementation and Interpretation

This work focuses on the implementation and interpretation of governed research work. Here implemented the following algorithms Bayesian Network (Statistical learning), Decision Stump (Tree learning), Naïve Bayes (Statistical learning), J48(Tree learning), Naïve Bayesian Network Updateable(Statistical learning), Random Forest(Tree learning) for getting best outcome.

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Table 1: Outcome of selected ML algorithms

Classifier	Accuracy	Precision	Recall
Bayesian Network	74.35	0.74	0.74
Decision Stump	71.88	0.72	0.72
Naïve Bayes	76.3	0.76	0.76
J48	73.82	0.74	0.74
Naïve Bayesian Network Updateable	76.3	0.76	0.76
Random Forest	74.74	0.74	0.75

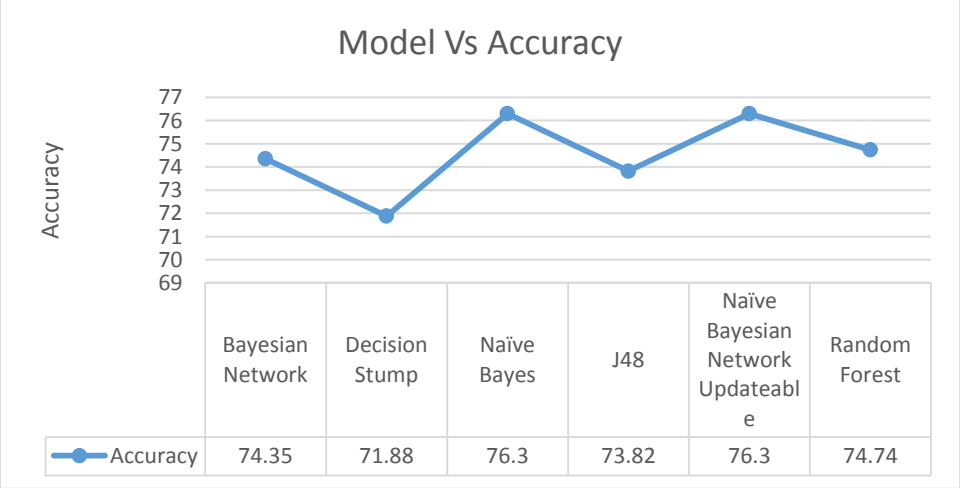

Figure 2: Model Vs Accuracy

The figure 2 shows that the Naïve Bayes Network Updateable and Naïve Bayes has same accuracy as well best outcome compare with others which is 76.30% accuracy. The Decision stump has least outcome compare with others which is 71.88% accuracy. The Bayesian Network has 74.35% accuracy; J48 has 73.82% accuracy; Random Forest has 74.74% accuracy.

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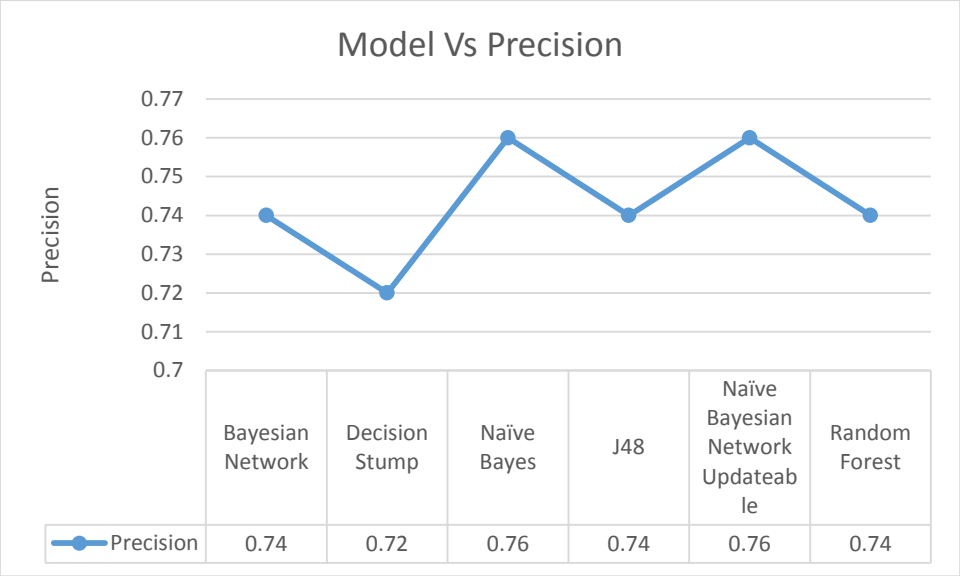

Figure 3: Model Vs Precision

The figure 3 shows that the Naïve Bayes Network Updateable and Naïve Bayes has same precision as well best outcome compare with others which is 0.76 precision. The Decision stump has least outcome compare with others which is 0.72 precision. The Bayesian Network , J48 and Random Forest has same value which is 0.74.

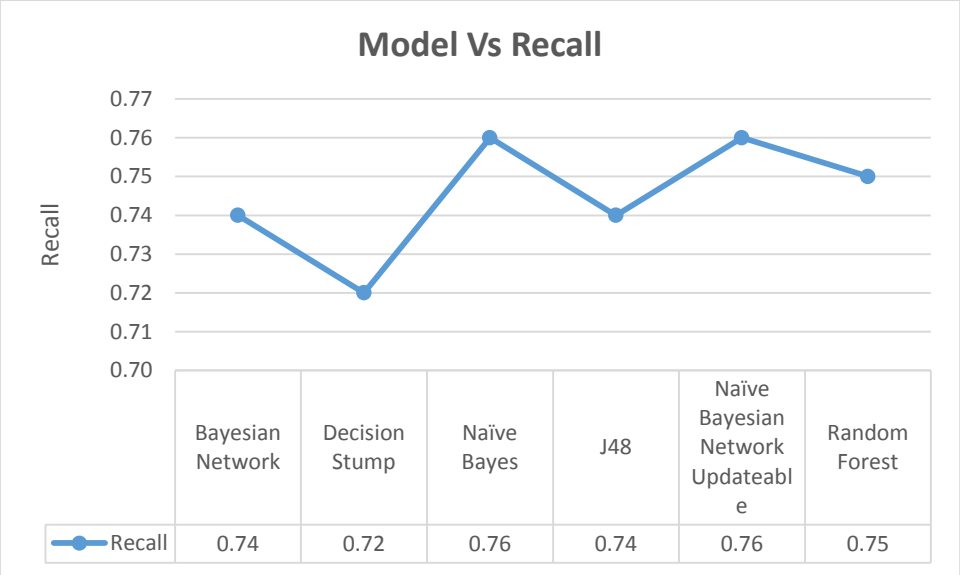

Figure 4: Model Vs Recall

The figure 4 shows that the Naïve Bayes Network Updateable and Naïve Bayes has same recall as well best outcome compare with others which is 0.76 recall. The Decision stump has least outcome compare with others which is 0.72 recall. The Bayesian Network and J48 has 0.74 recall ; Random Forest has 0.75 recall.

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Table 2: Kappa, F-Measure and MCC Outcome of selected ML algorithms

Classifier	Kappa	F-Measure	MCC
Bayesian Network	0.43	0.74	0.43
Decision Stump	0.37	0.72	0.38
Naïve Bayes	0.47	0.76	0.49
J48	0.42	0.74	0.42
Naïve Bayesian Network Updateable	0.47	0.76	0.47
Random Forest	0.43	0.75	0.43

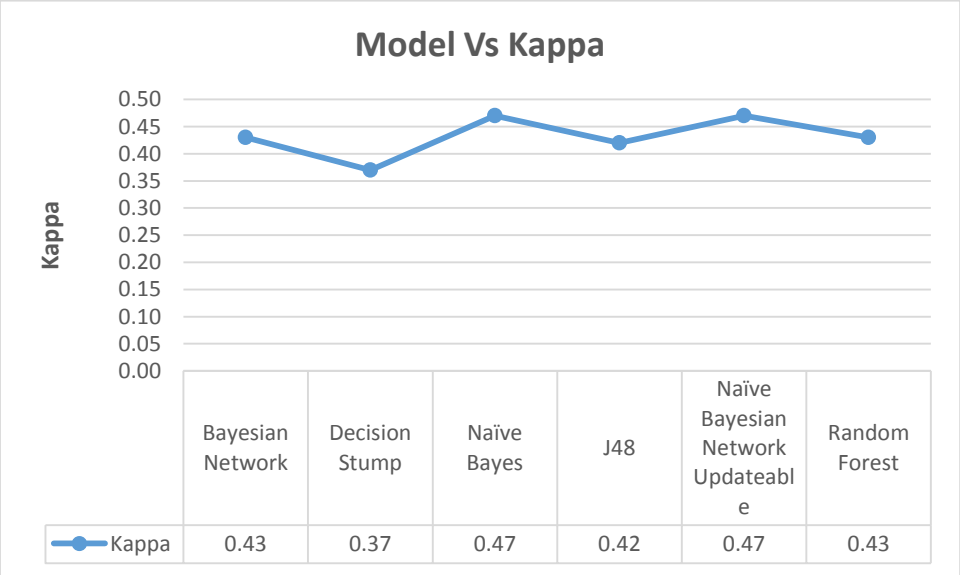

Figure 5: Model Vs Kappa

The figure 5 shows that the Naïve Bayes Network Updateable and Naïve Bayes has same kappa as well best outcome compare with others which is 0.47 kappa. The Decision stump has least outcome compare with others which is 0.37 kappa. The Bayesian Network and Random Forest has 0.43 kappa. The J48 has 0.42 kappa.

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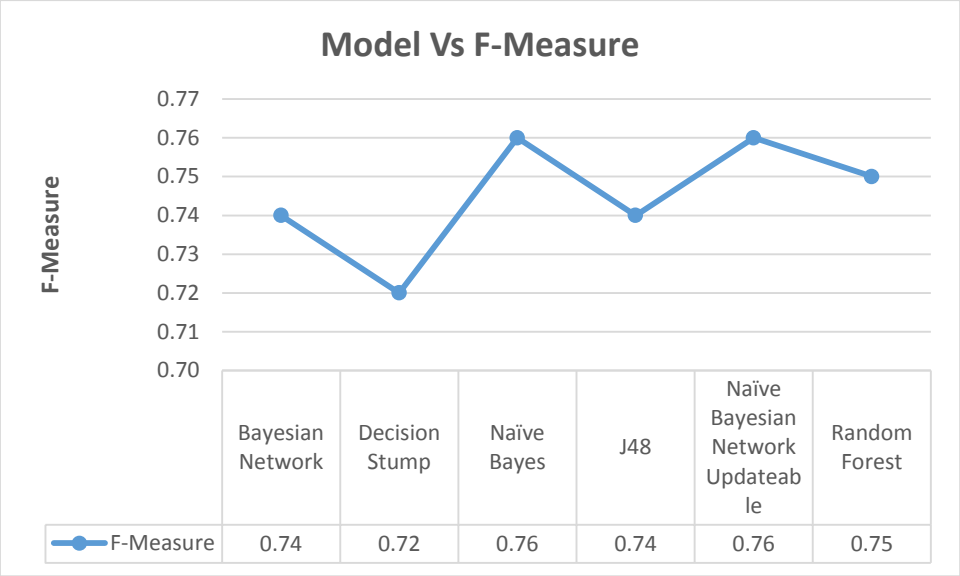

Figure 6: Model Vs F-Measure

The figure 6 shows that the Naïve Bayes and Naïve Bayes Network Updateable has best outcome compare with others which is 0.76 F-Measure. The Decision Stump has 0.72 which is least value compare with others. Bayesian Network and J48 has 0.74 F-Measure and the Random Forest has 0.75 F-Measure.

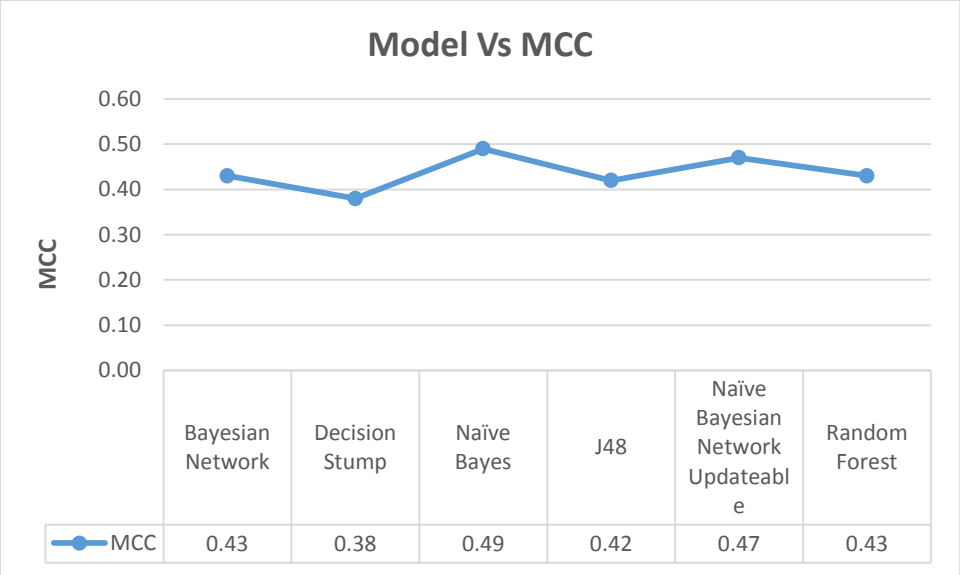

Figure 7: Model Vs MCC

The figure 7 shows that the Naïve Bayes has best outcome compare with others which is 0.49 MCC. The Decision stump has least outcome compare with others which is 0.38 MCC. The Naïve Bayes Updateable has 0.47 MCC value. The Bayesian Network and Random Forest has 0.43 MCC. The J48 has 0.42 MCC value.

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Table 3: ROC and PRC Outcome of selected ML algorithms

Classifier	ROC	PRC
Bayesian Network	0.81	0.81
Decision Stump	0.68	0.68
Naïve Bayes	0.82	0.82
J48	0.76	0.72
Naïve Bayesian Network Updateable	0.82	0.82
Random Forest	0.82	0.82

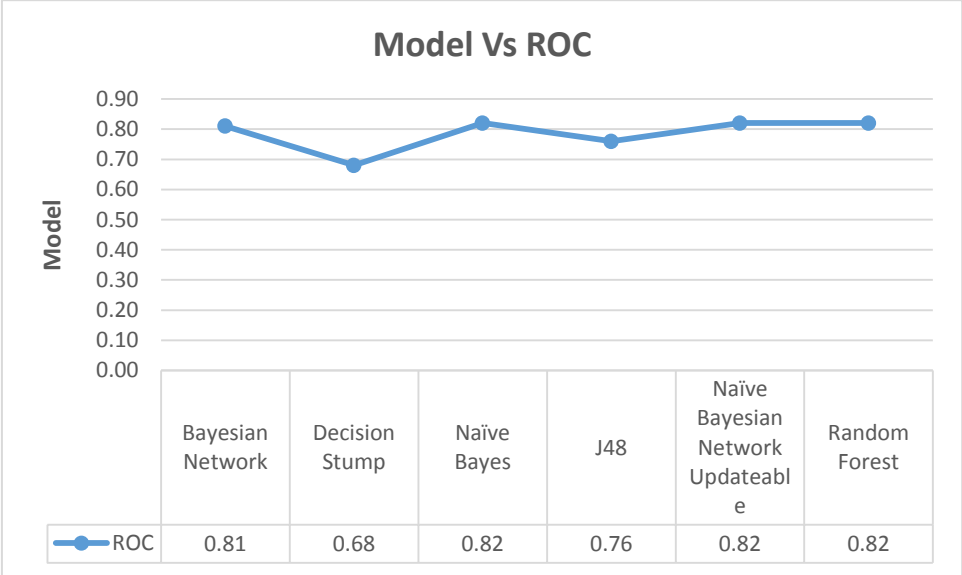

Figure 8: Model Vs ROC

The figure 8 shows that the Naïve Bayes, Naïve Bayes Network Updateable and Random Forest has same as well best outcome compare with others which is 0.82 ROC. The Decision Stump has 0.68 ROC which is least value compare with others. The Bayesian Network has 0.81 ROC and J48 has 0.76 ROC.

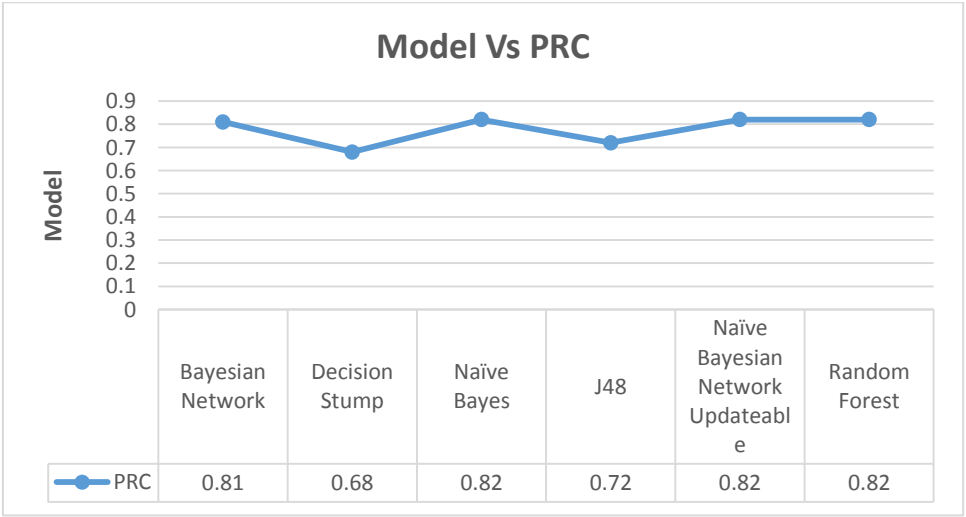

Figure 9: Model Vs PRC

The figure 9 shows that the Naïve Bayes, Naïve Bayes Network Updateable and Random Forest has same as well best outcome compare with others which is 0.82 PRC. The Decision Stump has 0.68 PRC which is least value compare with others. The Bayesian Network has 0.81 PRC and J48 has 0.72 PRC.

Table 4: Deviations of selected ML algorithms

Classifier	Mean Absolute Error	Root Mean Square Error	Relative Absolute Error	Root Relative Squared Error
Bayesian Network	0.3	0.42	65.72%	88.28%
Decision Stump	0.38	0.44	83.64%	92.69%
Naïve Bayes	0.28	0.42	62.50%	87.43%
J48	0.31	0.44	69.48%	93.63%
Naïve Bayesian Network Updateable	0.28	0.41	62.50%	87.43%
Random Forest	0.31	0.4	68.59%	84.65%

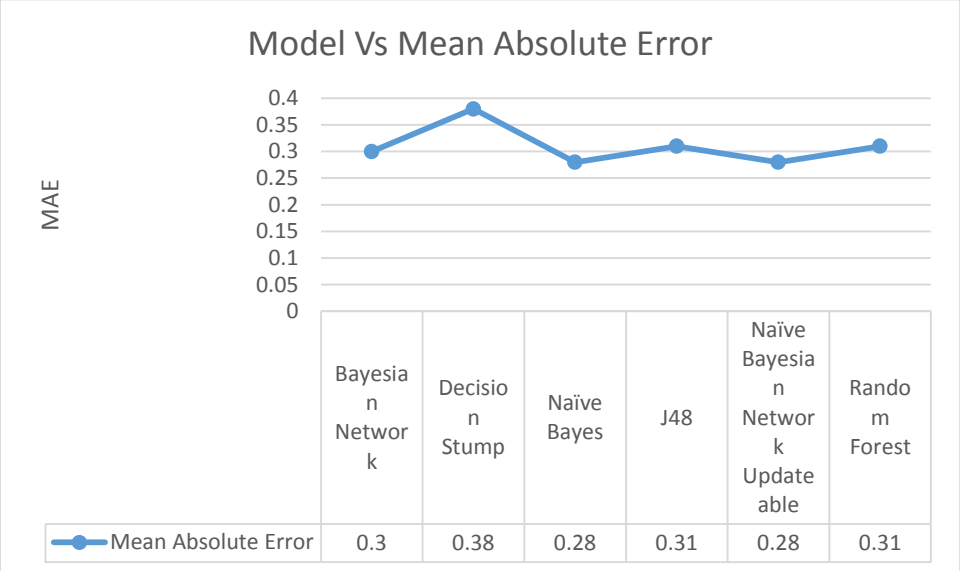

Figure 10: Model Vs MAE

The figure 10 shows that the Naïve Bayes and Naïve Bayes Network Updateable has best outcome which is 0.28 deviations(MAE). The Decision Stump has worst result(0.38). The J48 and Random Forest has 0.31 MAE and Bayesian Network has 0.3 MAE deviations.

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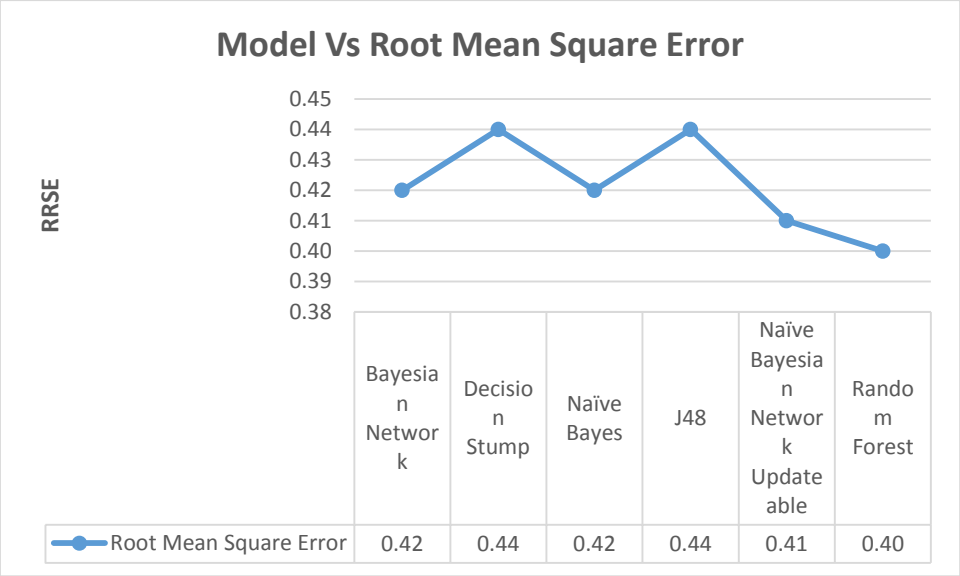

Figure 11: Model Vs RMSE

The figure 11 shows that the Random Forest has best outcome which is 0.28 deviations (0.40 MAE). The Decision Stump and J48 has same as well worst result(0.44). The Bayesian Network has 0.42 MAE deviations and Naïve Bayes Updateable has 0.41 MAE.

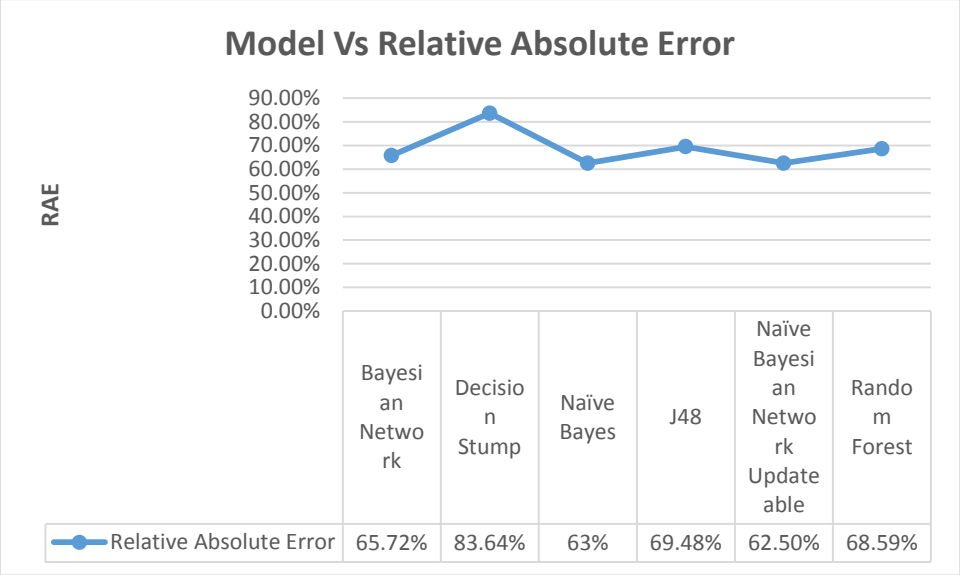

Figure 12: Model Vs RAE

The figure 12 shows that the Naïve Bayes Network Updateable has best outcome 63% RAE and Decision Stump has worst result(83.64% RAE). The others are showing in between 63% RAE to 68.59% RAE.

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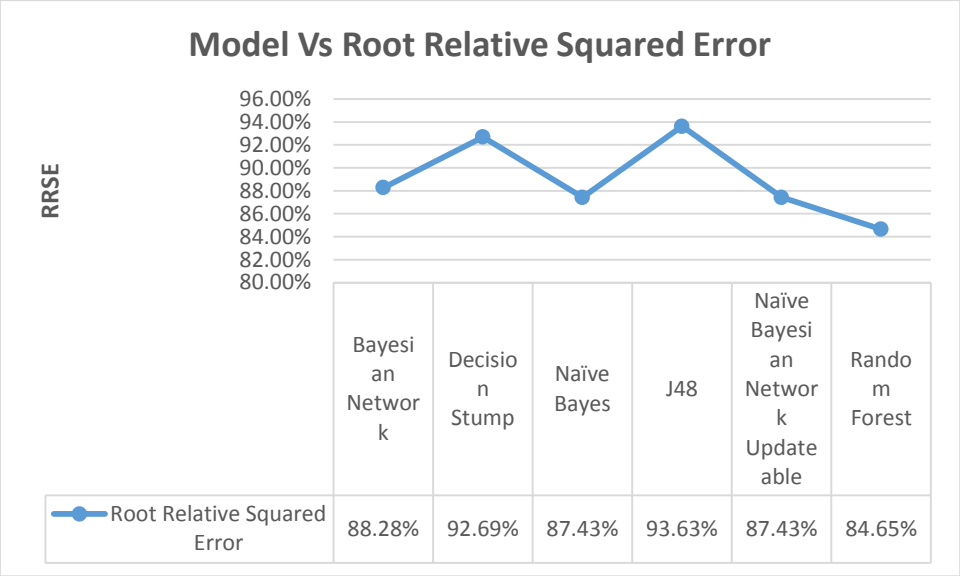

Figure 13: Model Vs RRSE

The figure 13 shows that the Random Forest has 84.65% RRSE which is the best outcome. The J48 has worst result 93.63%. The others are showing in between 87.43% RRSE to 92.69% RRSE.

Table 5: Time Consumption for evolving models of selected ML algorithms

Classifier	Time
Bayesian Network	0.08
Decision Stump	0
Naïve Bayes	0.02
J48	0.09
Naïve Bayesian Network Updateable	0
Random Forest	0.83

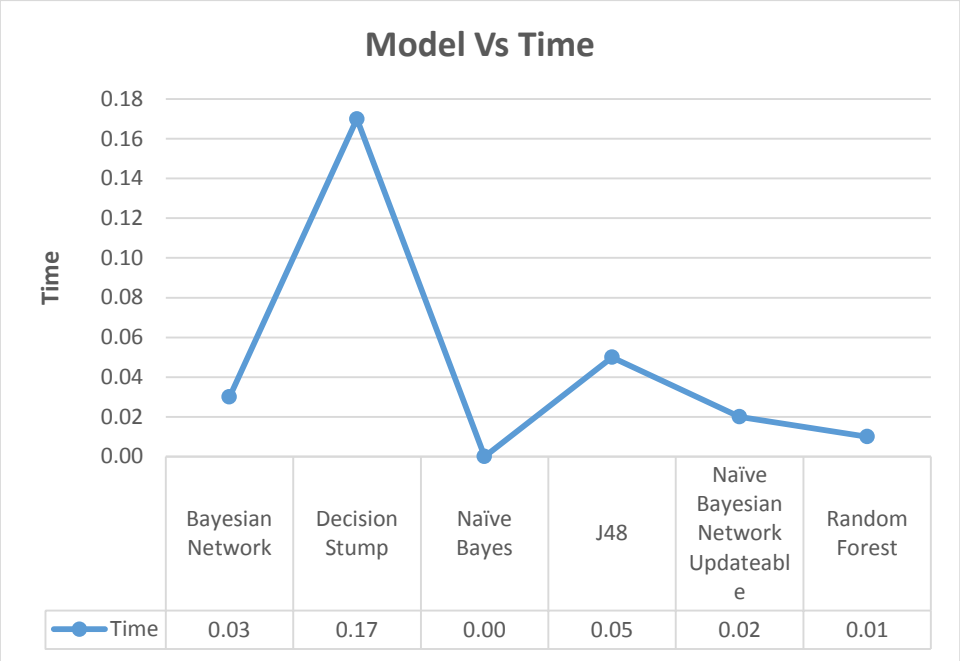

Figure 14: Model Vs Time(In Seconds)

The figure 14 shows that the Naïve Bayes takes minimum time consumption 0 seconds. The Decision stump takes more time for making its model which is 0.17 seconds. Others are showing in between 0.01 seconds to 0.05 seconds.

2. Conclusion

This work finds that the When compared to other methods, the Naive Bayes Network Updateable and Naive Bayes have the same accuracy, which is 76.30%. The Decision stump has the least accurate results (71.88%) compared to the others. The best result for both the Naive Bayes Network Updateable and the Naive Bayes has the same accuracy, which is 0.76. When compared to the other stumps, the Decision stump has the least amount of accuracy, which is 0.72. that the Naive Bayes Network Updateable and Naive Bayes have the same recall as well as the best result compared to others, which is 0.76 recall. When compared to the other stumps, the Decision stump has the least amount of memory, which is 0.72. The best result for the Naive Bayes Network Updateable and Naive Bayes is 0.47 kappa, which is the same as the best result for the Naive Bayes. The 0.37 kappa value for the Decision stump is the lowest of all the stumps. When compared to other methods, Naive Bayes and Naive Bayes Network Updateable have the best result, which is 0.76 F-Measure. The Decision Stump has a score of 0.72, which is the lowest among the others. The Naive Bayes method has the best result, which is 0.49 MCC. Compared to the other stumps, the Decision stump has the least result, which is 0.38 MCC. The MCC value of the Naive Bayes Updateable is 0.47. The best result for Naive Bayes, Naive Bayes Network Updateable, and Random Forest is 0.82 ROC, the same as for the others. The Decision Stump has a ROC of 0.68, which is the lowest of all the others. The best result for Naive Bayes, Naive Bayes Network Updateable, and Random Forest is the same as for others: 0.82 PRC. The Decision Stump has the least amount of PRC, which is 0.68. The best result is 0.28 differences (MAE) for Naive Bayes and Naive Bayes Network Updateable. The worst score is 0.38 for the Decision Stump. The best result is 0.28 differences (0.40 MAE) for the Random Forest. The worst score for both The Decision Stump and J48 is 0.44. The best result is 63% RAE for the Naive

Bayes Network Updateable. The worst result is 83.64% RAE for the Decision Stump. The Random Forest has the best RRSE, which is 84.65%. The J48 did the worst (93.63%). This work recommends that the statistical learning approach gives better result compare with trees approach based on their outcomes.

3. References

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