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Comparative Performance Analysis and Evaluation of Novel Techniques in Reliability for Internet of Things with RSM

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Abstract: Future smart cities are predicted to benefit significantly from the Internet of Things (IoT) in terms of sustainable development. The variety of connected things and the unreliability of related services are only two of the major problems this paper discusses that may hinder IoT from fulfilling this essential function. An intellectual management structure for IoT is proposed for solving these problems. In this framework, constantly shifting real-world objects are depicted within a virtual environment, as well as cognition, as well as closeness, are used to automatically and intelligently choose the objects that are most pertinent to a given application. Novel Analysis of different techniques of Reliability of the Internet of Things using RSM has been designed through design expert software with different parameters are runs over 13-fold cross-validation gives results of accuracy of more than 97 percent, desirability is 1.00 as compared to the J48 algorithm and SVM-RBF.

Keywords: *IoT, RSM, Reliability of Internet of Things, J48, SVM-RBF.*

1. Introduction

Reliability theories and practices initially appeared in the 1950s, long before the Internet of Things (IoT) first went live towards the end of the 20th century. But since the Internet of Things (IoT) is such a complicated and interconnected system, dependability research and teaching must now meet new challenges. In the Internet of Things, every device is linked to one another and often has the ability to speak with one another without the need for human involvement. The Internet of Things has to be very reliable since it depends on humans, gadgets, and programming. It is necessary to talk about these connections. Since data constitute an essential, integrated component of this system, a data-driven IoT system is more complicated. As a consequence, data validity must be considered. The reliability of IoT for accuracy and desirability is examined by using the conventional reliability evaluation approach of RSM. This paper will mostly discuss the reliability of data-driven IoT using RSM and their designed models.

All choices and procedures that are based on the information at hand are referred to as "data-driven" processes. When it comes to large data, this is particularly clear. It is connected to data science, data mining, as well as other complementary disciplines. The phrase "data-driven" is used often to characterize the activities of several industries, including the Internet of Things. Initially gather and analyze data if there is a requirement of data-driven organization. Therefore, some kind of communication must be used. To do this, we employ a variety of hardware, software, networks, and IoT (Internet of Things) devices, yet any of these might malfunction. Reliability is responsible for ensuring that things continue to function and for fixing them when they do. We shall quickly define the Internet of Things before we continue our discussion about dependability.

An end-to-end IoT system's heterogeneity poses problems with reliability. The interface between subsystems has to be carefully considered to guarantee compatibility and dependability. The physical system is the most important part of the IoT, and it might result in unexpected system failures. As part of the software's, accuracy and desirability of IoT engineers and mathematicians have analyzed these systems for a very long period in order to reduce accident rates and protect human life. Different Applications of IoT are given below in figure 1 showing smart farming, smart grid, smart wearables, Smart city, and smart education. All these give a clear perspective of IoT applications in Various aspects and trained designed architecture shows in Various reliability measures.

In the current work the novel Analysis of different

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techniques of Reliability of the Internet of Things using RSM has been designed through design expert software with different parameters run over 13-fold cross-validation giving results of accuracy more than 97 percent, desirability is 1.00 as compared to J48 algorithm and SVM-RBF.

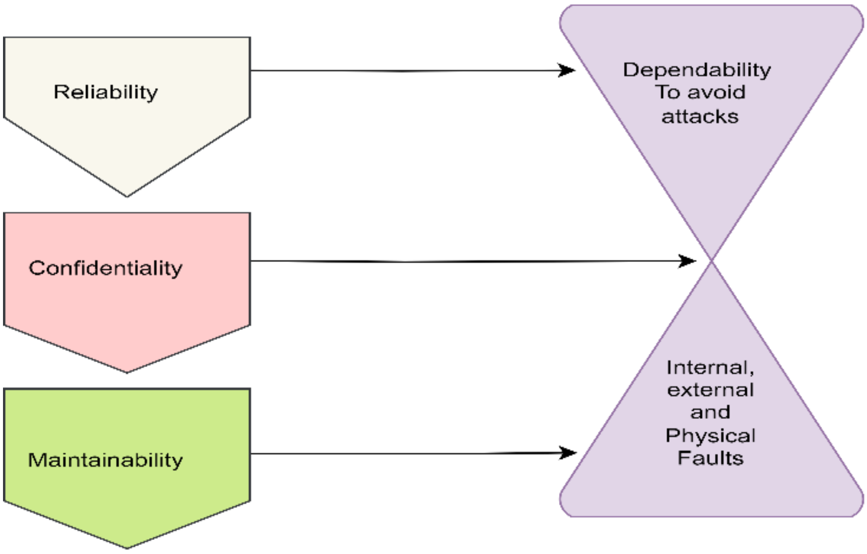

Fig. 1. IoT Reliability Measures

2. Literature Review

Organizations also consider performance to be one of the most crucial real-time device dependability factors. IoT design must provide a specific degree of availability and performance, according to Roman et al. (2013), and it must have a consumer-friendly solution [1]. When attempting to increase IoT performance, the communication network is a crucial element to consider. Due to the amount of data, there is a chance that the network may get crowded. According to Gubbi et al. (2013), the inclusion of IoT devices may result in network congestion and latency problems [2]. To guarantee that IoT network performance is adequate and dependability concerns are handled, enterprises may devise a plan. It is the need for a dependability plan. Organizations exploring a novel breakthrough like IoT can overlook reliability. Manufacturers of IoT devices often do not prioritize dependability (Peppet, 2014)[3]. However, for the majority of enterprises to profit from IoT, dependability is required (Cheng et al., 2014) [4]. Therefore, in order to address dependability, especially high availability, and performance, companies need a plan. For systems that need large availability, high availability is one technique to handle availability difficulties.

IoT is similar in that many customers anticipate it to be a fault-tolerant system. Eliminating single-point failures and incorporating redundancy into the system is one technique to achieve high availability such that in the event of a hardware failure, requests would be handled by the backup hardware (Suarez-Tangil et al., 2013)[5]. The utilization of single hardware user devices is an issue for IoT. A single point of failure is often created when a customer utilizes only one IoT device to send data. However, middleware servers that may be set up for high availability are used by IoT devices to interact (Kanso, Toeroe, & Khendek, 2014) [6]. The middleware servers save the data that the IoT devices have collected and will keep the data even if the IoT device is broken (Franke et al., 2014)[7]. As a result, while developing a plan, firms may think about using high availability. Another crucial concern that has to be addressed in a dependability plan is network performance. Because it will boost processing effectiveness and availability, reducing network complexity is crucial (Patil et al., 2014)[8]. As a result of the inconvenience it causes for users of IoT devices, lowering complexity will also aid in the prevention of data loss. Businesses may avoid network performance difficulties by scaling IoT devices and the network to avoid congestion (Atzori et al., 2010)[9]. The complexity of the network will be reduced and possible latency problems will be addressed by limiting the number of devices on each network segment. Additionally, enterprises may increase network resilience by using software design. The relevance of testing software and finding flaws was discussed by Chatterjee et al. (2021) as a way to raise the caliber and dependability of the program [10]. Even if it may not be a functional need, network speed is nevertheless crucial to the IoT ecosystem since it will assist to lower reliability concerns (Jacobsson et al., 2015)[11]. As a result, to resolve network performance concerns, a remediation strategy is required for various types of IoT ecosystems [12-18].

3. Proposed Methodology

It takes several stages for developing a Reliability that can avoid obstacles in the IoT space, which includes an algorithmic evaluation as well as the meticulous choice of appropriate gadgets for ensuing In this response, we'll pay special focus on the design of the algorithm as well as evaluation phases.

3.1 Process Parameters

For New Methodology, we have taken two major factors One is the Confidence interval parameter (C.I.) for J48 Classifier and the other one is the Confidence interval parameter (C.I.) for SVM-RBF is considered with type Numeric and Continuous sub-type on Design Expert Software used for Novel techniques in Reliability of IoT using RSM that is Response Surface[19-25]. Methodology runs over 13-fold cross-validation and shows results of many actual parameters of the Reliability of the Internet of Things. After these process parameters, we get to set the occurrence of Mean and standard deviation from the minimum and maximum values. Table 1 shows the J48 Classifier and SVM- RBF response occurs Y1 with the accuracy of 13-fold cross-validation analysis of Polynomial type and Quadratic Model.

Table 1. 13-fold cross validation for analysis of two factors

Run	Factor 1 (C.I. Parameter for J48 Classifier)	Factor 2 (C.I. for SVM-RBF)
1	.10	8.00
2	.30	8.00
3	.30	5.00
4	.50	2.00
5	.30	5.00
6	.10	5.00
7	.30	5.00
8	.30	5.00
9	.50	5.00
10	.10	2.00
11	.30	5.00
12	.50	8.00
13	.30	2.00

This Standard deviation and Mean depend upon the Coded Values that response finds the solution through Ration and designed model type. These primitive findings through parameters will lead to the design of a new model of Reliability which will be discussed in a further paper.

3.2 Design Matrix Value

The decision tree is a categorizing technique. It is based on the principle of "divide and conquer." Leaf nodes and decision nodes make up a decision tree, where a leaf node represents the class value and a decision node specifies a test against one of the attributes. Every path is controlled, from the root node to the leaf node. Classification error is the main aspect of performance for decision trees. The percentage of cases that are incorrectly categorized is what constitutes a classification error. In practice, large training data sets are often employed, which increases the number of levels and branches in the resultant decision tree. The categorization accuracy of a decision tree is drastically reduced when there are extra class categories. Several methods, including ID3, J48, FT, BFTree, and LMT, among many more, may be used to create decision trees. Because the J48 algorithm has a good accuracy rate, we employ it for our inquiry. The J48 algorithm was initially presented by Quinlan in 1993. SVMs sometimes referred to as support vector networks, assess the accuracy of the data used in regression and classification. Supervised learning models, or SVMs, use associated learning techniques. An SVM training method takes a set of training samples, each of which is labeled as belonging to one of two categories, and builds a no-probabilistic binary linear classifier from them. It constructs a model that places new instances in one of the two categories. An SVM model maps instances as points in space with as much room as possible separating examples of the different categories. Then, additional samples are mapped into that same region and predicted to belong to a group based on which side of the gap they fall. By implicitly converting their inputs into high-dimensional feature spaces, SVMs may successfully do non-linear classification in addition to linear classification. The kernel trick is the name of this tactic. When data are unlabeled, unsupervised learning is required since supervised learning cannot be done since there is no natural categorization of the data. Then, new data is mapped to these. created groups. Support vector clustering is a clustering approach that improves support vector machines. It is often used in industrial applications where data are not labeled or when just partial data are labeled as a pretreatment step before a classification run. Table 2 shows the minimum and maximum range values for taken input parameters.

Step 1: Define the problem

The problematic statement requires the 13-fold cross-validation values to be mentioned.

Step 2: Formulate the problem mathematically

To begin this work, we must clearly define the issue for two factors that have to be used to run over Response Surface Methodology.

Table 2. Mini mum and maximum rage value for taken input parameters

Factor	**Name**	**Type**	**Subtype**	**Min**	**Max**	**Coded**	**Values**	**Mean**	**S.D.**
A	C.I. Parameter for J48 Classifier	Numeric	Continuous	0.10	0.50	0.10	0.50	0.30	0.14
B	C.I. Parameter for SVM-RBF	Numeric	Continuous	2.00	8.00	2.00	8.00	5.00	2.04
Response	Name	Observation	Analysis			Mean	S.D.	Ratio	Model
Y1	Accuracy	13	Polynomial	93.2	95.45	94.378	.74662	1.02	Quadratic

3.3 Development of RSM Model for process parameters

Response Surface Methodology (RSM) is a collection of statistical as well as mathematical methods used for the study and modeling of certain issue elements. In RSM, the optimization is accomplished by using a linear or square polynomial function to consider the impact of output variables on the intended answer. The impact of linear, quadratic, cubic, and cross-product models of four process parameters was studied using a five-level central composite design, which was also utilized to create an experimental design matrix. To create the mathematical model in this study and demonstrate the relationship between the input process parameters with magnitude precise-ness, a second-order quadratic model was applied to each response value.

4. Comparative Analysis of New Models with RSM for Reliability of IoT

The reliability of the Internet of Things (IoT) is an important consideration for its widespread adoption and successful implementation. While IoT offers numerous benefits and opportunities, several factors can influence its reliability [26-30]. Here are some key points to consider:

Connectivity: Reliable connectivity is crucial for IoT devices to function properly. If devices cannot establish or maintain a stable connection to the internet or a local network, their reliability can be compromised. Factors like signal strength, network congestion, and interference can impact connectivity.

Security: IoT devices are vulnerable to security threats, including hacking, data breaches, and unauthorized access. Weak security measures can compromise the reliability and integrity of IoT systems [31-32]. It's important to implement robust security protocols, encryption, and authentication mechanisms to protect against potential threats [33-35].

Interoperability: IoT devices from different manufacturers often use different communication protocols and standards, which can hinder interoperability. Lack of interoperability can lead to compatibility issues and challenges in integrating devices into a cohesive IoT ecosystem. Adopting widely accepted standards and protocols can enhance reliability and ease of integration.

Device Management: Managing a large number of IoT devices can be complex. Proper device management practices, including remote monitoring, software updates, and devices can be complex. Proper device management practices, including remote monitoring, software updates, and effective management, devices may experience software bugs, outdated firmware, or performance issues.

Power Management: Many IoT devices are battery-powered or rely on limited power sources. Efficient power management is crucial to ensure reliable operation over extended periods. Devices should be designed to optimize power consumption and provide notifications or backup options when power levels are low.

Data Quality and Processing: IoT devices generate vast amounts of data, and the reliability of the data collected and processed is crucial for making informed decisions. Data integrity, accuracy, and real-time processing capabilities impact the reliability of IoT applications and services.

Redundancy and Failover Mechanisms: Building redundancy and failover mechanisms into IoT systems can enhance reliability. This involves implementing backup systems, redundant data pathways, and failover protocols to ensure continuity of operations in the event of device failures or network disruptions.

Environmental Factors: IoT devices may be deployed in various environments, including harsh or remote locations. Extreme temperatures, humidity, vibrations, and other environmental factors can affect the reliability of IoT devices. Ensuring devices are designed to withstand such conditions and regularly testing their performance in different environments is important.

Overall, the reliability of IoT systems depends on robust connectivity, security measures, interoperability, effective device management, power management, data quality, and redundancy mechanisms. Addressing these factors can enhance the reliability and performance of IoT solutions, making them more dependable for various applications.

4.1 Accuracy

A set of 13 different J48 and SVM-RBF gives how much accuracy is to occur, by these factors, both algorithms give a clear factor-based analysis of the modular approach and enhance the accuracy in the Reliability of Internet of Things systems. Table 3 depicts the accuracy in quadratic, polynomial designing techniques.

Table 3. 13 -fold cross-validation of two factors and their accuracy

Run	Factor 1 (C.I. Parameter for J48 Classifier)	Factor 2 (C.I. for SVM-RBF)	Accuracy
1	.10	8.00	94.15
2	.30	8.00	95.18
3	.30	5.00	94.16
4	.50	2.00	95.3
5	.30	5.00	94.16
6	.10	5.00	93.3
7	.30	5.00	94.16
8	.30	5.00	94.16
9	.50	5.00	95.4
10	.10	2.00	93.2
11	.30	5.00	94.16
12	.50	8.00	95.45
13	.30	2.00	94.14

4.2 Effect of process parameters for J48 and SVM-RBF Algorithm

The effect of different process parameters on percentage variation in accuracy is revealed in Fig. 2 & 3. Figure 2 showsthe effect of factor coding with increment in both parameters and figure 3 shows the standard error of design First, using CV Parameter Selection and the feature matrix in Weka, the values of the confidence interval parameter (C) for the J48 classifier, the complexity parameter C for SVM-RBF, were optimized. The ranges in which classifiers were assessed. Two distinct setups of each classifier were used to run them

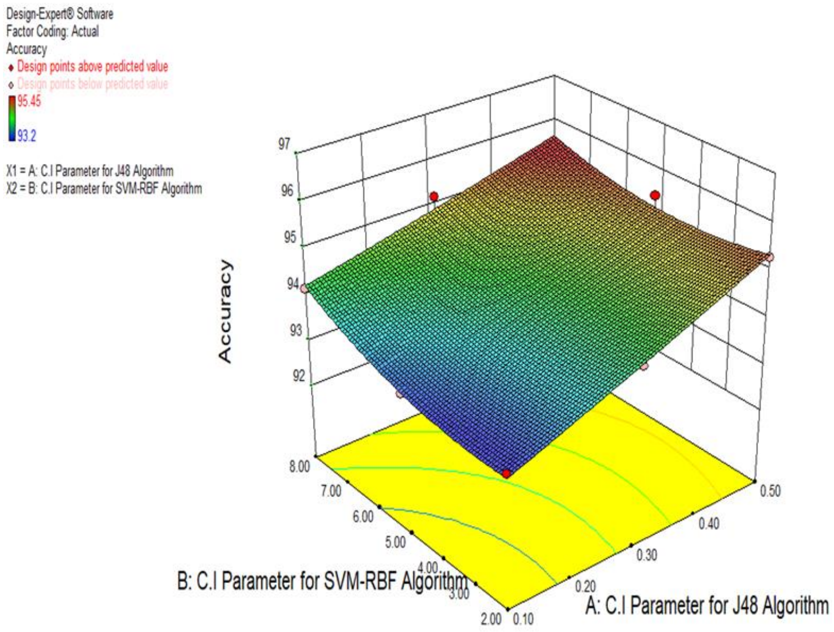

Fig. 2 Effect of Confidence interval Parameter on J48 Algorithm and SVM RBF on Accuracy

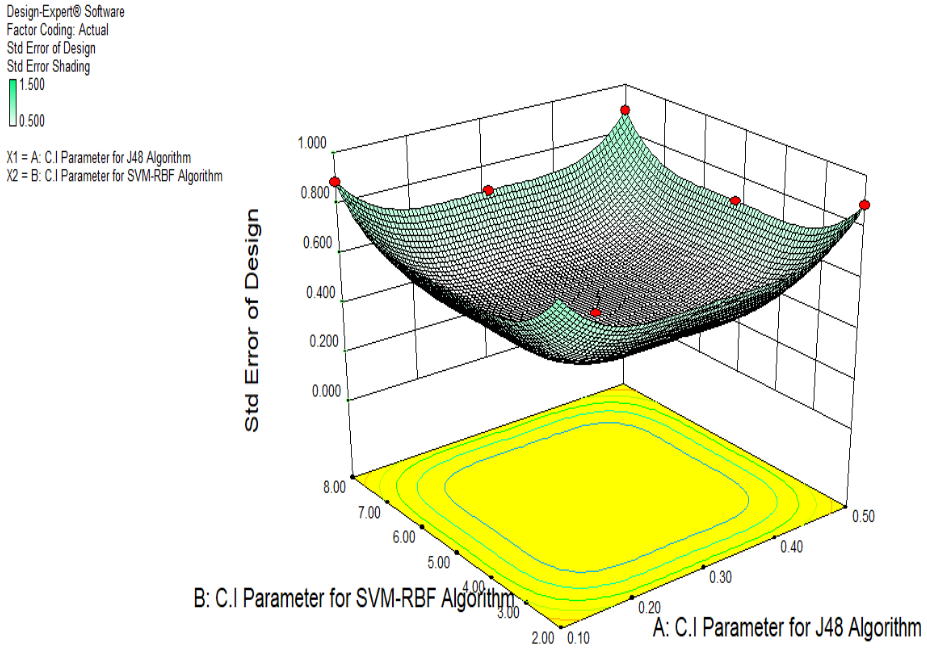

Fig. 3 Effect of Confidence interval Parameter on J48 Algorithm and SVM-RBF on Standard error of Design

4.3 ANOVA Model

ANOVA model is frequently used for the statistical analysis of designing structures. Table 4. depicts the ANOVA Model for the Response Surface Quadratic Model which gives for Sum of the Square value, the difference between values, and the F value showing the significant value of P i.e. Probability value. This Model gives the Significant Value for Two C.I. parameters for the J48 algorithm and SVM-RBF algorithm. This shows this model is quite accurate for our data that is used to evaluate for Reliability parameters. Equations (1) and (2) provide an accurate mathematical equation of RSM in the Reliability of IoT, which has A, B, and their square values with C.I. Parameters for J48 and SVM-RBF provided after we evaluate and did the analysis of these parameters. Figure 4 demonstrates the evaluated accuracy for both the Algorithms which is quite higher above 95.45 percent and the model is significant for reliability parameters. The mathematical equation of RSM for calculating accuracy for Reliability of IoT in terms of coded factors and actual factors can be represented by equations (1) and (2) as

Final Equation in Terms of Coded Factors:

$$Accuracy=+94.20+ (0.92*A) + (0.36*B)-(0.20*A*B) + (0.033*A2)+(0.34*B2) \quad (1)$$

Final Equation in Terms of Actual Factors:

$$Accuracy = +92.76293 + (5.75345*C.I\ Parameter\ for\ J48\ Algorithm)–(0.16234*C.I\ Parameter\ for\ SVM\text{-}RBF\ Algorithm)-(0.3333*C.I\ Parameter\ for\ J48\ Algorithm*C.I\ Parameter\ for\ SVM\text{-}RBF\ Algorithm) +(0.82759*\ C.I\ Parameter\ for\ J48\ Algorithm^2)+(0.038123*C.I\ Parameter\ for\ SVM\text{-}RBF\ Algorithm^2) \quad (2)$$

Table 4. ANOVA for Response Surface Quadratic Model

ANOVA for Response Surface Quadratic Model Source	**Sum of Squares**	**df**	**Mean Square**	**F Values**	**P Value Prob >F**	**Remarks**
Model	6.38	5	1.26	43.29	<.0001	Significant
A- C.I.P for J48	5.04	1	5.04	171.14	<.0001	
B- C.I.P. for SVM-RBF	0.76	1	0.76	25.91	.00014	
AB	0.16	1	0.16	5.43	0.0526	
A^2	3.027E-003	1	3.027E-003	0.10	0.7579	
B^2	0.33	1	0.33	11.04	0.0127	
Residual	0.21	7	0.029			
Lack of Fit	0.21	3	0.069			
Pure Error	0.0000	4	0.0000			
Cor Total	6.58	12				

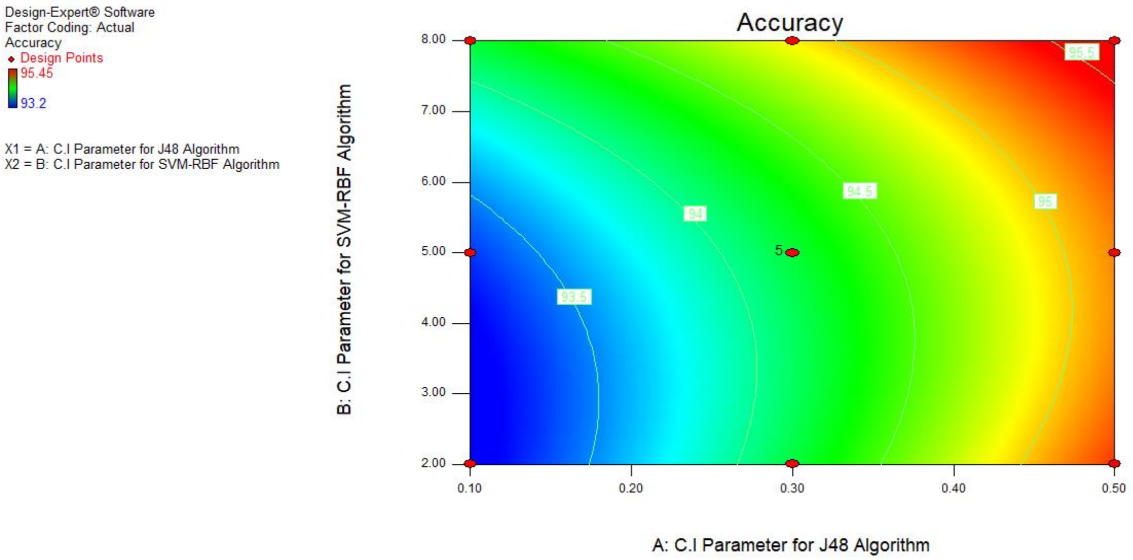

Fig. 4 Accuracy for Confidence Interval for J48 and SVM-RBF Algorithms

4.4 Parameter optimization with RSM

Parametric optimization with RSM gives the data analysis plot using their accuracy and desirability based upon the two algorithms and their optimization percentage is higher than 96 percent which means it shows the correct formulated approach through RSM for the Reliability of IoT data. Figure 5 shows the 3-D surface plot for accuracy with respect to J48 Classifier and SVM-RBF which gives the significant results and optimized plot as well. Table 5 depicts the regression coefficient value used to evaluate for prediction of statistical solutions. In figure 6 3 D surface plot for Desirability with respect to J48 Classifier and SVM-RBF which gives the significant results and optimized plot shown below:

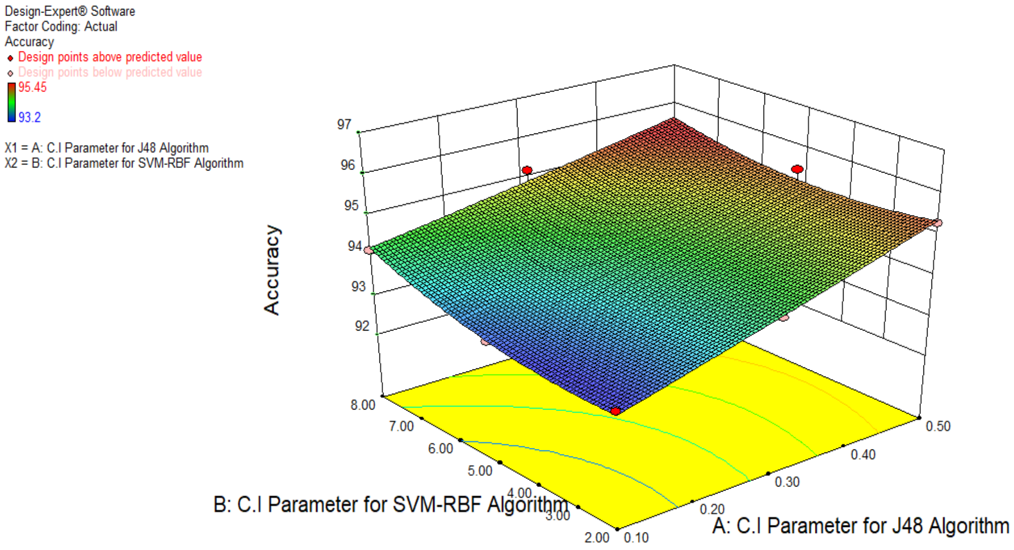

Fig. 5 shows the 3 D surface plot for accuracy with respect to J48 Classifier and SVM-RBF

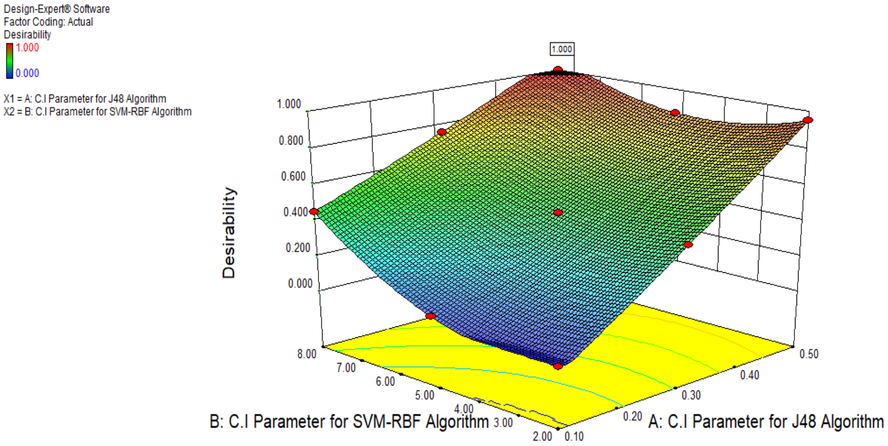

Fig. 6 shows the 3-D surface plot for desirability with respect to J48 Classifier and SVM-RBF

Table 5. Regression Coefficient Value used to evaluate for Predication of Statistical Solutions

Standard Deviation	0.17	R-squared	0.9687
Mean	94.38	Adj R-Squared	0.9463
C.V. %	0.18	Pred. R-Squared	0.7183
Press	1.85	Adequate Precision	21.840

4.5 Residuals and Predicated Value analysis using Plots

For statistical analysis of the model various input and output parameters have been taken for residual and histogram plots. Figure 7 shows the Normal Percent Probability using Internally Studentized Residuals and Color points showing the accuracy of different intervals given below. **Figure 8** shows the difference axis predicted value and Actual Value difference while working for accuracy. The slight difference in the values suggests that it evaluates closer value from the Prediction of accuracy. Figure 9 Shows the Combined feature, Accuracy, Confidence Interval Parameter for J48 Algorithm and Confidence Interval Parameter for SVM-RBF Algorithm with respect to desirability at 0.000, 0.250, 0.500, 0.750, and 1.000 values. This figure shows accuracy towards all the parameters for this approach. Table 6 shows the constraints table for a range of parameters. Table 7 represents the comparison of the values of input and output parameters for predicted and desirable accuracy

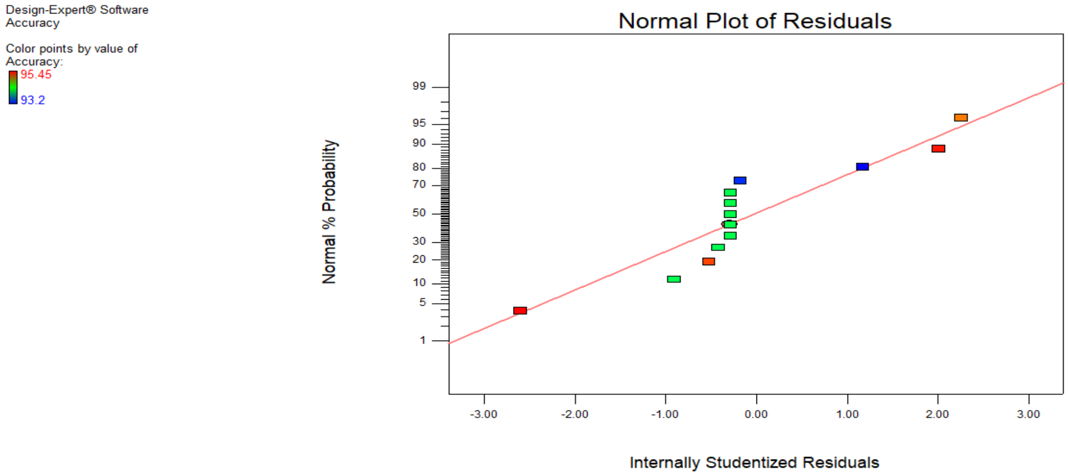

Fig. 7 Normal percentage probability plot w.r.t residuals

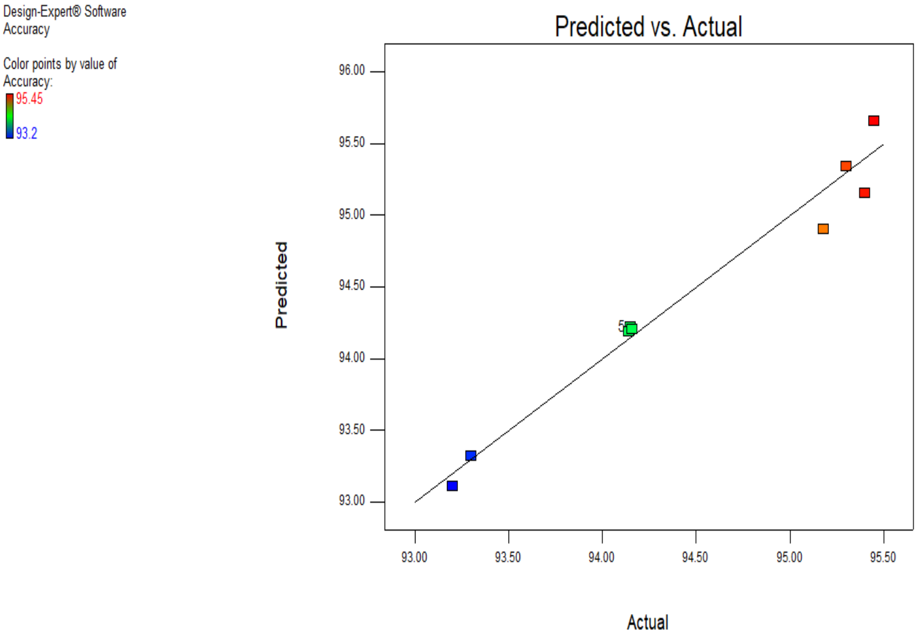

Fig. 8 Analysis of predicted and actual value with RSM

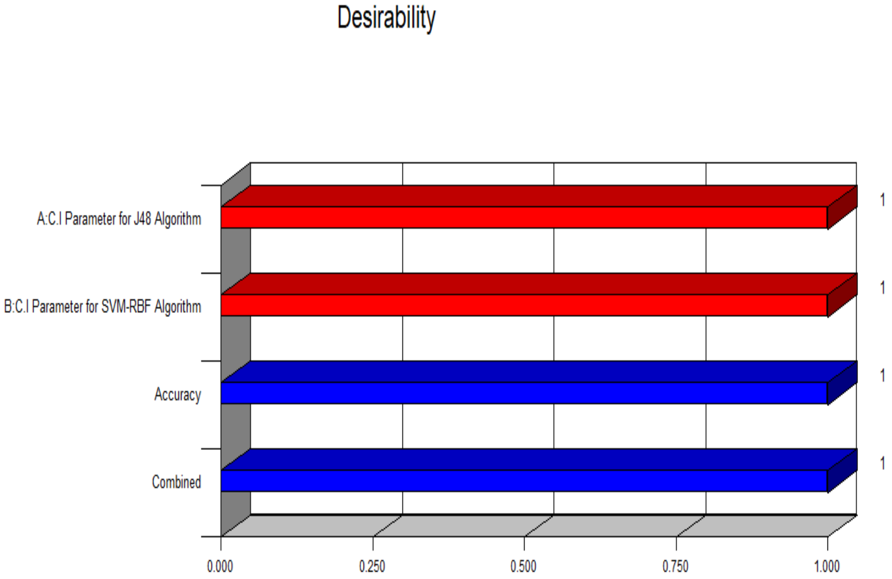

Fig. 9 Histogram plot among input and output parameters

Table 6. Constraints Table

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight
A:C.I.Parameter for J48 Algorithm	Within range	0.1	0.5	1	1
B:C.I. Parameter for SVM-RBF Algorithm	Within range	2	8	1	1
Accuracy	Maximize	93.2	95.45	1	1

Table 7. Comparison for the values of input and output parameters for predicted and desirable accuracy

Number	C.I. Parameter for J48 Algorithm	C.I. Parameter for SVM-RBF Algorithm	Accuracy	Desirability
1	.50	7.57	95.5389	1.000
2	.50	8.00	95.6544	1.000
3	.47	7.86	95.5051	1.000
4	.50	7.90	95.6233	1.000
5	.50	7.87	95.6107	1.000
6	.47	7.94	95.5311	1.000
7	.50	7.82	95.5951	1.000
8	.50	7.48	95.5073	1.000
9	.49	7.67	95.5285	1.000
10	.47	7.94	95.5207	1.000
11	.48	7.60	95.4778	1.000
12	.49	7.48	95.4898	1.000
13	.48	7.62	95.4565	1.000
14	.46	8.00	95.5063	1.000
15	.49	7.95	95.611	1.000

5. Conclusion

The Analysis of Various Models for Reliability of IoT describes the different values as R-squared 0.9687, Adj R-Squared 0.9463, Predicted R-Squared 0.7183 and Adequate Precision 21.840 Comparative analysis of ANOVA Model to other designed models for Confidence Interval Parameter for J48 Classifier and SVM-RBF for accuracy and desirability shows 95.539 percent and 1.000 in above as constraint Plot after the occurrence of results as desired as well as Selected. This RSM technique across 13-fold cross-validation to find whether in Quadratic Model shows the highest Validation in 3D designed Models has high excess and newest technique for IoT Reliability Solutions. The possibility of enabling Reliable Values could finally be explored.

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