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Review Article

A SUPPLY CHAIN MANAGEMENT BASED PATIENT FORECASTING MODEL FOR DENTAL HOSPITAL

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Abstract
Management is in fact on the verge of a major breakthrough in finding out exactly how service sector success is actually determined by the interactions between the flows of information, materials, money, manpower, and capital equipment. The way these five flow principles interlock to be able to amplify one another as well as to bring about switch and fluctuation will build the grounds for anticipating the look of decisions, policies, organizational forms, and investment choices . A concept of distribution management which recognized the integrated dynamics of organizational associations since companies are so intertwined, expert argued that technique attributes can influence the general functionality of abilities as investigation, engineering, sales, and promotion. Illustrated phenomena is actually utilizing a laptop computer or perhaps computer simulation of order information flow along with the impact of its effect on development in addition to distribution general functionality for each supply chain member, in addition to the entire supply chain application. A Machine Learning based proposed model for patient forecasting is implemented to show the research analysis work for patient forecasting for the dental hospital located in Bhopal, Madhya Pradesh, India. This research paper is indicating about the use, application and implementation of Kernel based Support Vector Machine for regression analysis purpose and also select the best Kernel for the implementation of the predicted model.

Keywords: Supply Chain Management, Machine Learning, Support Vector Machine, Artificial Neural Network, Dental Hospital.

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INTRODUCTION

Today we've the fundamental requirements of a supply chain concept; let us move on to the differences between the supply chains of the manufacturing as opposed to the service business. Expert in the field states that you will find four primary disparities in the two industries in the aspects of inputs, logistics, finished products, as well as the flow of supply chains. For inputs, the big difference between service as well as manufacturing is the fact that the latter requires an input of physical labour (packaging, shipping, etc.) as well as the service business calls for feedback of labour in the kind of building relationships or even manipulating information. In logistics, companies move bodily content while in the service business, no physical item is actually moved but only information is actually exchanged through telephone, email, as well as more [1]. Some experts does point out that for service industries, new software & equipment are actually used to speed the flow of communication. Finished products are among the largest differences between the two industries. In manufacturing, a production process is actually a raw material which has been completely transformed whereas in a service business, it's a flow of services. In the class of optimization, nonetheless, both the manufacturing as well as the service industry are actually unique but similar at exactly the same time - the two of these industries work to enhance the operations of theirs such as for instance the acceleration of delivery or even decreasing costs. By cutting down bottlenecks and discovering much better rates on materials that are raw, companies better enhance the business of theirs. By creating much better partnerships to help you in the places where a service organization isn't powerful, they better enhance the business of theirs and assist eliminate virtual bottlenecks [2].

Service firms have various operations needs from manufacturers. Businesses which maintain or maybe repair things, market consulting, or perhaps provide other services or health care typically have higher labour content minimizing investments in equipment and plants because of this, a service based company's most significant asset is the employees of theirs. It's not simply the employees, but additionally the interactions with various other companies which are very critical to the continued success of a firm. A service business should work tirelessly to keep workers, business partners, along with other individuals surrounding the business satisfied. The first job of business is to get the idea of the working of a takeout business. This particular business was good at providing bonuses to the ground level workers to help keep them happy. Gift certificates, cash prizes, along with other things had been offered to keep employees motivated. This take out chain knew that workers that are happy translated into clients that are happy. Imagine a strategy to inspire the staff of yours to remain happy about the work of theirs [3].

Recently, firms have started to understand the benefits of sharing integration and information throughout the stakeholders in the supply chain. Though these kinds of initiatives lessen forecast mistakes, they're neither ubiquitous nor total and forecast mistakes still abound. Collaborative forecasting as well as replenishment permits a firm and its supplier firm to coordinate choices by exchanging complicated decision support models and strategies, thus facilitating integration of forecasting and output schedules. Nevertheless, in the lack of Collaborative forecasting as well as replenishment, firms are actually relegated to conventional forecasting as well as output scheduling. Being a result, the firm's need seems to fluctuate in a random manner even when

the last customer's demand has a predictable pattern. To forecast the manufacturer's demand under these circumstances gets a difficult process because of a popular bullwhip impact [4].

FORECASTING

Forecasting is an old task and is now much more advanced recently. For a while, constant measures in a time series information set, like easy trends or maybe cycles were noticed as well as extended into the future. Nevertheless, today a blend of time series, economic theory models as well as econometrics could be used to create numerous forecasts which could likewise be interpreted jointly or even put together in sensible fashions to make an excellent printer. The variable being forecast is actually a random adjustable. Initially interest was mostly directed towards the mean of this variable; later to the variance, and today to the entire marginal division. Pre-testing of the information to look for the essential capabilities of it's now vital and that has developed contemporary methods like co-integration. The horizon of which the forecast is actually attempted is likewise important, as well as longer run forecasts [5].

The question of evaluation of forecasts has additionally been significantly created. The majority of forecasts are very simple to assess though others, coming out of the Global Models are harder. Governments, global organizations, commerce, or business might discover that these designs, in case explored, might provide useful assistance for their forecasting pursuits or maybe the efforts of theirs to enhance accuracy of forecasts. As a result, forecasting is a need nearly in any operation. Nevertheless, the resources of forecasting in common business consumption continue to be primitive within view of the strides made by investigation. Hence, promoting developments in forecasting to help predictive analytics is actually deemed a worthwhile endeavour as well as would be the goal of this research paper. This kind of equipment might additionally decrease anxiety as well as volatility characteristic of worldwide trade. The connection of various business parameters that could alter as well as influence choices are very abundant that any credible efforts to run significant associations are in need by worldwide business owners [6].

Forecasting is actually studied throughout a lot of disciplines, and lots of techniques have been created for making predictions based on historical details. We don't attempt to survey all the different solutions with these, but refer the audience to one of numerous introductory texts which describe exponential smoothing, spectral studies, and neural networks, along with other popular techniques is an excellent introduction to a lot of forecasting strategies employed in the context of economic predictions as well as modelling. The proliferation of methods is in part a sign that the very best means for just about any specific issue might count on factors that are numerous, like the kind as well as amount of information available as well as the attributes of the domain name [7]. Lots of uses concentrate on comparing strategies to determine by far the most useful method for a specific issue for example, see the application of forecasting to the application or retail sales to anticipate electrical energy rates. The approach of method for cost prediction concentrates on merging predictions made utilizing distinction energy sources of strategies as well as information. Different techniques have been created for merging predictions, often driven by the issue of merging the views of professionals. Lately, predictions markets have turned out to be a favourite means for aggregating information. These strategy shares some functions with these markets, like the usage of logarithmic scoring rules to assess the quality of predictions [8].

LITERATURE REVIEW

Good need preparation as well as sales forecasting throughout the supply chain is able to provide a multitude of advantages. Precisely, it is able to help enhance labour productivity, bring down head count, cut inventories, and speed up merchandise flows, and increase revenues as well as earnings. This research work expresses the views on this crucial supply chain activity from a selection of instructive perspectives and it comes with a framework for linking business plans as well as sales forecasts both vertically and horizontally to the group and collaboratively with the supply chain partners [9-11].

Demand forecasting is an important element of the preparation activity in supply chain businesses. Probably the most typical strategy to forecasting need in these businesses entails the usage of a computerized forecasting system to create first forecasts as well as the subsequent judgmental feature of the forecasts by the company's demand planners, ostensibly to take into consideration remarkable circumstances anticipated with the preparation horizon. To make these modifications are able to involve a lot of management energy as well as time, but will they enhance accuracy, and therefore are several kinds of feature better compared to others [12]. To explore this, Authors [13] collected information on over 60,000 forecasts and results from four supply chain businesses. In three of the businesses, on average, judgmental changes increased accuracy. Nevertheless, a comprehensive analysis revealed that, even though the fairly larger changes tended to lead to greater typical advancements in accuracy, the smaller changes usually damaged precision. Additionally, good changes, which involved adjusting the forecast upwards, were less prone to enhance precision than bad changes. They were additionally produced in the wrong path more often, suggesting an overall bias towards confidence. Designs were then produced to eradicate these kinds of biases. Based on both this statistical analysis as well as organisational observation, this work moves on to analyse techniques designed to improve the usefulness of judgmental changes directly.

The need forecasting method is modelled by artificial intelligence methods by using artificial neural networks. The consumer product causers the issues in forecasting the upcoming need as well as the precision of the forecast In overall performance of the artificial neural community a benefit in a continuously changing demand and business environment forecasting a company to make right choices about manufacturing or inventory control. The learning algorithm of the prediction is imposed to better prediction of time sequence in upcoming. The prediction functionality of recurrent neural networks a simulated time series information along with sensible product sales information are used. This's due to influence of a few aspects on needing perform in list trading feature. It was additionally found that as forecasting period gets smaller, the artificial neural network strategy offers much more precision in forecast [14-16].

This research work [17] evaluates the effect of forecasting premature order commitment and designs in a supply chain with one capacitated supplier as well as four retailers beneath demand uncertainty. Personal computer simulation models have been used to simulate need forecasting and inventory replenishment choices by the retailers in addition to production choices by the producer under a bunch of need patterns as well as capacity tightness scenarios. This research study discovered that early order commitments as compared to the overall costs as well as service levels, to different degrees, because the retailers and also the producer, hinting that the advantages of early order commitment might be utilized by a mix of forecasting designs, need patterns as well as capacity tightness.

In this research work, a bit of investigation continues to be accomplished on managing the political and organizational dimensions of producing as well as improving forecasts in corporate ways. Authors [18] look at the implementation of a supply chain planning activity at a consumer electronics business, focusing on the forecasting strategy around which the procedure revolves. The examination of this model focuses on the forecasting progression and just how it mediates as well as accommodates the purposeful biases which could impair the forecast accuracy. Authors [18] categorize the sources of purposeful bias into intentional, driven by misalignment of bonuses as well as the disposition of strength to the business,

and unintentional, resulting from informational as well as procedural blind spots. Authors [18] show that the forecasting procedure, combined with the supporting systems of elicitation and information exchange of assumptions, is actually able to coping with the possible political struggle and also the procedural and informational shortcomings. Authors [18] show that the development of an unbiased team in charge of dealing with the forecasting procedure, an approach that we distinguish from generating forecasts immediately, can strengthen the political dimension adequately to allow procedure improvement to be steered. Last but not least, Authors [18] discover that while a coordination process - the appropriate tasks, responsibilities and roles, and system - may be created to deal with existing functional and individual biases of the business, the brand new coordination structure will in turn create brand new person as well as purposeful biases. The released framework of purposeful biases, the evaluation of the political dimension of the forecasting procedure, as well as the thought of a coordination structure are actually brand new constructs to better understand the interface in between various other features and operations control.

Supply chains are actually networks of firms that pool their materials as well as capabilities to be able to deliver value to the end customer. Firms are not in the position to own or even handle total supply chains. Modern logistics as well as information technology abilities have produced a worldwide market where businesses are able to make the most of the chance to source internationally. Businesses have so specialized and partnered around the world with other businesses. These businesses have then to progressively concentrate on logistics and supply chain coordination. This kind of coordination is currently an important business process. Modern-day Supply Chain Management (SCM) begins with the premise that supply chain participants are mainly interested in optimizing the own goals of theirs and this self serving emphasis typically leads to performance that is very poor. One other way of thinking this by considering a sequence of regional optimum policies doesn't bring about a worldwide maximum answer [19-21]. Authors [22] summarize it as follows when each part of a team tries to maximize his or maybe the personal advantage of her with no regard to the effect on various other members of the team, the complete strength might suffer. This kind of inefficiencies frequently creeps in when logical members of supply chains optimize separately rather than coordinating their efforts. A recognized example of that inefficiency is actually the bullwhip impact. This particular influence refers to the tendency of replenishment orders to rise in variability as one move up the supply chain from retailer to manufacturer. A disintegrated content flow mixed with distorted need info along with an absence of replenishment rule alignment predictably results in bad source chain dynamics. This type of absence of coordination might even outweigh the benefits from economies as well as specialization of scale. With this assessment Authors [22] concentrate on supply control and make use of the bullwhip result as the major example of supply chain inefficiency. Authors [22] highlight the managerial relevance of the bullwhip result as well as the methodological problems so that both supervisors as well as researchers may benefit.

PROPOSED FORECASTING METHODOLOGY

One of the leading functions of SCM is actually enhancing the accuracy of forecasts. Because total effort might not be possible, it's essential to take a look at the feasibility of forecasting need in the lack of considerable info from many other partners. The cause of the need distortion in the lengthy SCM simulation is actually because of demand signal processing by the participants in the SCM [23-24]. Based on projection, need signal processing means that each party at the SCM does a bit of processing on the need signal, therefore changing it prior to passing it along to the subsequent member. As the end-customer's demand signal moves up the SCM, it gets increasingly distorted. This happens whether or not the need signal processing functionality is the same in all of people of the lengthy SCM. For instance, even when all supply chain members work with a six month pattern to forecast demand, distortion will still appear. Figure 1 describes the process of forecasting model applied to build the proposed model based on machine learning technique.

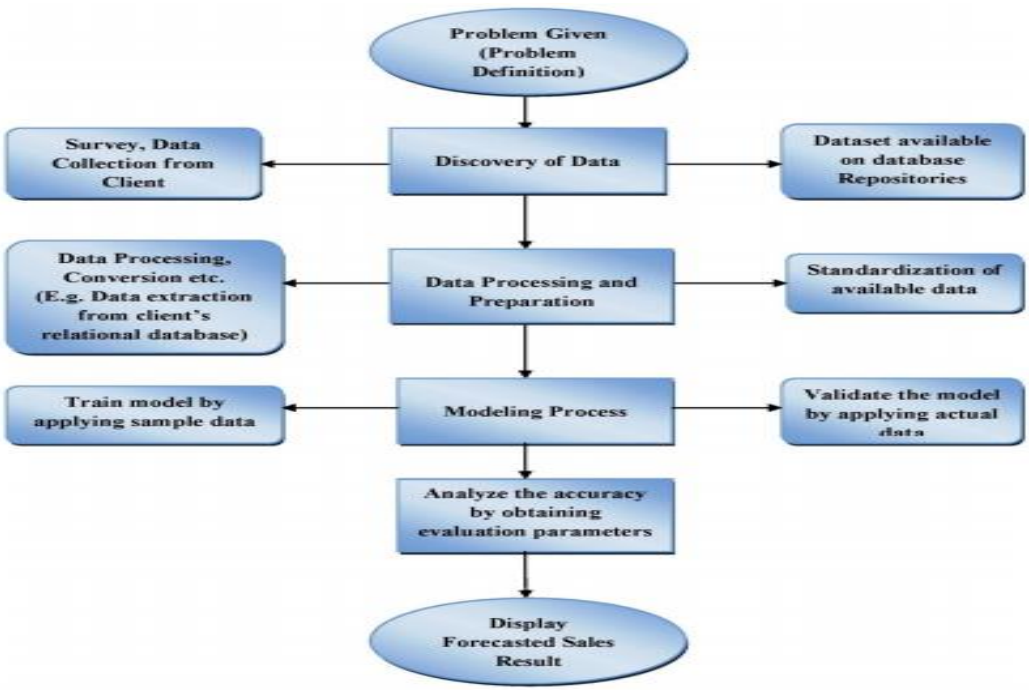

Figure 1: Machine Learning Based Forecasting Model

The implementation details for forecasting model is described below:

- Analysis of the problem domain and its description is completed as well as required information for the problem definition.

- After that, we are implementing Data Discovery phase. Data Discovery includes collection of data from different available sources. These sources are described as data collection from survey data and data collection from different stakeholders of the dental hospital as well as dataset gathered from different available data repositories.
- Information gathered in previous step is used to pre-processing of the gathered data. Pre-processing of data used to discard outliers and noise present in the gathered data. Finally, the model specific data is chosen for further analysis. Information change in format that is essential, Data standardization might be a part of this phase.
- An additional move is modelling of forecasting technique. Knowledge as well as validation is the sub things of this phase.
- Design of forecasting model and its training is performed based on test dataset. In this phase education and learning of information and data is completed after that, forecasting model is actually validated.
- Accuracy of forecasting model is actually examined by obtaining evaluation parameters including Mean Absolute Percentage Error (MAPE), Mean Squared Error (MSE) and Mean Absolute Deviation (MAD) [25].
- Final forecasted outcomes of patient reporting are displayed.

DESIGN AND DEVELOPMENT OF PROPOSED FORECASTING MODEL

Implementation of Kernel based Support Vector Machine (SVM) [26] technique is actually shown and described through Figure 2. This Kernel based SVM technique provides a lot of measures including processing of training dataset, selection of Kernel based on its capabilities and performance, dataset is divided in three sets i.e. first set used for training purpose of the proposed model, second set of dataset is used for validation purpose of the proposed model and third set of dataset used for testing and performance analysis of the proposed model.

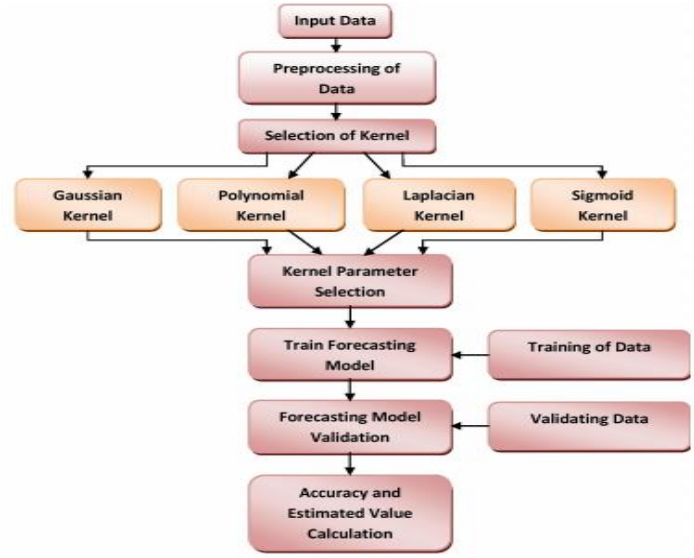

Figure 2: Flow of Kernel Based SVM Technique

The working and flow of Kernel based SVM technique which includes training of proposed model, validation test of the model for model parameters tuning and last step includes the testing of the proposed model. These steps are presented as follows:

- Pre-processing of the gathered dataset is performed after that appropriate parameters and features are chosen and finally scaling is performed in the range [-1, 1] and dataset is also checked for possible outliers and these outliers removed for dataset.

The selection of Kernel and regularization parameters is performed by optimizing a cross-validation based model selection.

- Appropriate Kernel function selected by observing the solution space to get the decision by applying the regression analysis.
- After choosing the appropriate values for desired Kernel, we will build and train the proposed model for training dataset.
- Validation of Forecasting model is performed on validation data for tuning the model.
- To get the performance as per expectation, we will select the excepted accuracy through proposing loss function and imposed penalty.
- In the last step, the accuracy and performance of proposed model is measured through the implementation of Mean Absolute Percentage Error (MAPE), Mean Squared Error (MSE) and Mean Absolute Deviation (MAD).

The process applied in the development of the proposed model i.e. in the training of the model and for the testing of built model by the use of Kernel based SVM technique as elaborated and showed through Figure 2.

DATA PREPARATION

A comprehensive data collected through performing survey. This survey is conducted at dental hospital place, which is located in Bhopal, Madhya Pradesh, India [27] and data gathered as per the actual patient reporting in the dental hospital on the basis of monthly, quarterly and annual reporting of patient in the dental hospital located at Bhopal, Madhya Pradesh, India. The patients are broadly divided in to three categories of patients based on gender as well as age criteria. These categories are defined as: Kids patient, Male patient and Female patient.

The proposed forecasting model created and implemented with the help of Python [28] and Scikit-learn [29] software. The hardware system of computer utilised with windows 10 operating system and 8 GB of RAM is used to implement the experiments and for the analysis of proposed forecasting model results. To get the view of comparative results, all the performed experiments were again run to get the best of accuracy.

Interviews and questionnaires process conducted as per the requirement of forecasting in the SCM process of the dental hospital by inducing appropriate questions to the stakeholders. The observation during the interviews and questionnaires process indicates that there is urgent requirement of effective and efficient forecasting system in the

dental hospital for betterment of decision making process, optimized management of inventory storage and finally for betterment of hospital management and its process.

EVALUATION OF FORECASTING MODEL

Performance evaluation and analysis of forecasting mode is conducted based on following evaluation criteria i.e. Mean Absolute Percentage Error (MAPE), Mean Squared Error (MSE) and Mean Absolute Deviation (MAD). During the performance evaluation phase of different built models, the model with the minimum Mean Absolute Percentage Error (MAPE) value is selected because minimum Mean Absolute Percentage Error (MAPE) value indicates about the best prediction performance for the forecasting model [30]. Forecasting error indicates about the gap of value between actual value and the forecasted value given and calculated by the forecasting model for the period selected for the forecasting [31].

Where, E denotes predicted error of the model at duration t, A is the actual value of the output at duration t and p is the predicted values of the model during time t shown in Equation 1.

$$E(t) = y(t) - p(t) \quad (1)$$

Mean Absolute Percentage Error (MAPE) defined through Equation 2, where D stand for total number of data in the training dataset and equation is defined as:

$$\text{Mean Absolute Percentage Error (MAPE)} = \frac{\sum_{t=1}^{D} \frac{E(t)}{A(t)}}{D} \quad (2)$$

Mean Absolute Deviation (MAD) defined through Equation 3, where D stand for total number of data in the training set and equation is defined as:

$$\text{Mean Absolute Deviation (MAD)} = \frac{\sum_{t=1}^{D} E(t)}{D} \quad (3)$$

Mean Squared Error (MSE) defined through Equation 4, where D stand for total number of data in the training set and equation is defined as:

$$\text{Mean Squared Error (MSE)} = \frac{\sum_{t=1}^{D} E^2(t)}{D} \quad (4)$$

RESULTS

Data related to actual patients reporting to dental hospital is gathered from SCM departments of dental hospital and this data is being used for testing of proposed model. The actual count of patients those are visiting to dental hospital based on monthly criteria, based on quarterly criteria and based on yearly criteria for the selected time duration, on the basis of the patient and the category of the patient required to assess and calculated for selected time duration. Data represented in terms of time series manner, showed in terms of monthly basis, quarterly basis and yearly basis for the period which runs from July 2018-July 2019 has been collected, processed and evaluated through proposed model. Each and every proposed model has been analyzed and evaluated for same set of data with the same set of parameters for proposed model.

Results presented in tabular manner, where Tables 1 shows observed value of Mean Absolute Percentage Error (MAPE) for Kernel based SVM in comparison to other techniques and the value for Kernel based SVM observed less as compared to the value of other techniques. Table 2 denotes the value of Mean Absolute Deviation (MAD) and we can observe that somehow similar value is seen for Mean Absolute Deviation (MAD) value.

Table 1: MAPE For MEN PATIENTS

Patient	Kernel based SVM	Simple Moving Average	Support Vector Machine	Weighted Moving Average	Artificial Neural Network	Exponential Smoothing	Naïve Bayes	Adaptive Rate Smoothing
1	0.093	0.093	0.075	0.085	0.098	0.096	0.080	0.098
2	0.070	0.087	0.080	0.089	0.076	0.075	0.066	0.097
3	0.089	0.098	0.097	0.099	0.099	0.097	0.098	0.093
4	0.084	0.093	0.090	0.093	0.091	0.089	0.092	0.094
5	0.075	0.092	0.088	0.089	0.073	0.084	0.088	0.098
6	0.083	0.085	0.090	0.083	0.098	0.090	0.096	0.097
Average	0.082	0.091	0.086	0.089	0.089	0.088	0.086	0.096

Table 2 shows that except the some cases, the calculated value of Mean Absolute Deviation (MAD) in Kernel based SVM is less as compared to other applied methods. Table 3 presents the performance of different techniques in terms of error generated for accuracy calculation. These errors calculate for in terms of Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Error (MSE) for test data and based on the results of test data, we are predicting patient reporting in six departments in the dental hospital based on the category of the patient. The calculated results of each technique shown in Table 3 and the desired results for each department patient are marked for desired performance evaluation. For representation and reference criteria, the calculated values of Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Error (MSE) are showed for Male patients.

Table 2: MAD For MEN PATIENTS

Patient	Kernel based SVM	Simple Moving Average	Support Vector Machine	Weighted Moving Average	Artificial Neural Network	Exponential Smoothing	Naïve Bayes	Adaptive Rate Smoothing
1	77.40	112.87	80.50	128.38	100.58	134.13	111.68	131.80
2	72.44	122.11	78.11	128.64	89.23	128.86	106.39	130.42
3	87.67	114.73	90.84	127.89	83.63	127.58	109.83	123.56
4	79.39	98.60	83.73	96.73	88.20	89.99	102.79	110.15
5	79.73	103.18	81.97	110.95	86.45	110.79	91.53	119.38
6	86.75	100.27	84.64	106.90	88.40	101.48	89.44	92.79
Average	80.56	108.62	83.29	116.58	89.41	115.47	101.94	118.01

A per the Table 3, the calculated value of Mean Squared Error (MSE) for Kernel based SVM is less as compared to rest classical methods as well as less as compared to artificial neural network, but exception exist for some cases. The calculated values are opposing in few patients. The average value of error levels of different techniques indicating about the dominance in terms of performance of the applied Kernel based SVM model in comparison to artificial neural network and rest of the classical methods values. Three error calculation methods i.e. Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Error (MSE) indicates about the performance and ability of the Kernel based SVM forecasting model for predicting the best and desired results.

Table 3: MSE For MEN PATIENTS

Patient	Kernel based SVM	Simple Moving Average	Support Vector Machine	Weighted Moving Average	Artificial Neural Network	Exponential Smoothing	Naïve Bayes	Adaptive Rate Smoothing
1	147.73	177.76	154.42	294.92	160.57	260.66	188.22	190.12
2	105.92	195.66	119.69	274.46	128.69	245.46	171.22	228.42
3	143.37	193.99	140.94	279.10	152.18	249.09	186.98	219.42
4	141.84	190.74	149.59	213.56	150.37	256.77	139.22	227.42
5	165.73	191.86	169.76	234.92	163.66	289.10	188.22	200.89
6	126.49	190.12	138.76	286.14	143.92	269.65	190.22	239.42
Average	144.61	190.02	156.91	263.85	149.89	260.28	177.34	217.61

CONCLUSION

In the study and analysis of this research paper, we've found that Kernel based SVM showed best results as compared to other applied techniques. Other method shows less accuracy for different accuracy calculation methods and criteria i.e. Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Error (MSE). Kernel based SVM showed shorter time to learn and shows much better consistency as well as produces better results that are more correct in comparison to other applied techniques because we have optimized threshold functions in a better way. Although artificial neural network provides better results in case amounts of iterations are more and showed some improvements in prediction errors. In machine learning, pre-processing as well as cleaning of dataset is a key process to enhancing the performance of applied techniques just before applying and implementing the model. Accurate knowledge as well as solution of the problem domain is needed before selecting a strategy and implementing technique to anticipate dataset, as various forecasting techniques are available, but as per the requirement of the problem domain. By means of cleaning of dataset and pre-processing of time series related dataset, we can improve the effectiveness and efficiency of proposed model. It's been found that each forecasting design has its own significance; one could be utilised for specific issue and problem however, not for all problems and domains. The appropriate forecasting design which can provide desired solution for the problem domain must be selected and detailed understanding of the knowledge of the problem domain can advantageous.

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