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Design of construction material sales prediction system using the svm method on Tb. Samijaya

Ariya Putra Sejati[1], Hanifah Permatasari[2], Vihi Atina[3]
[1,2,3]Faculty of Computer Science, Universitas Duta Bangsa Surakarta, Indonesia

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ABSTRAK

TB. Sami Jaya is a construction materials provider company offering key components like sand, nails, cement, iron, heavy steel, and electronic products for infrastructure construction projects. In the era of rapid technological development, the company faces the challenge of making accurate sales predictions. This study aims to develop a sales prediction system using Support Vector Machine (SVM) to help TB. Sami Jaya optimize the supply of construction materials based on existing transaction data, collected from November to December 2023. By identifying relevant trends and patterns, the goal is to generate more reliable projections, thereby reducing the risk of inventory excess or shortage, which increases operational costs and decreases customer satisfaction. The model's performance is evaluated by comparing the prediction results with actual data using metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE). The Rational Unified Process (RUP) method is employed for information system development. The results indicate that using SVM for predicting sales of construction materials is effective and helps optimize inventory management.

Corresponding Author:

Ariya Putra Sejati,
Faculty of Computer Science,
Duta Bangsa University of Surakarta,
Faculty of Computer Science, Duta Bangsa University of Surakarta, Jl. Bhayangkara No.55, Tipes, Serengan District, Surakarta City, Central Java 57154, Indonesia
Email: 202030128@mhs.udb.ac.id

1. INTRODUCTION

TB. Sami Jaya is a construction materials provider company that provides various key components such as sand, nails, cement, iron, heavy steel, and electronic products for infrastructure construction projects. The ever-increasing demand for materials makes supply management very important to ensure the smooth running of projects without obstacles.

In the era of rapid technological development, TB. Sami Jaya faces a tough challenge in making accurate sales predictions. Factors such as new development projects affect the demand for materials significantly. Difficulties in these predictions often result in excess or shortage of material inventory, which increases operational costs and reduces customer satisfaction.

In an increasingly competitive business world, an effective information system is the key to controlling inventory well. Information systems allow companies to monitor and manage inventory in real-time, ensuring the availability of the right materials at the right time. However, relying on current data alone is not enough to anticipate future fluctuations in demand. Therefore, being equipped with sales predictions is very important. These predictions allow companies to make better decisions regarding when and how much inventory needs to be held.

Support Vector Machine (SVM) is an effective method for classification and regression, proven to be efficient in handling large and complex data with good generalization capabilities. Compared to other predictive methods such as linear regression, decision trees, or time series analysis, SVM excels in managing complex relationships within data, especially in scenarios where the demand for construction materials is influenced by multiple, interrelated factors. While methods like linear regression might be limited by their assumptions of linearity, SVM can model non-linear patterns more effectively, providing more accurate predictions in dynamic environments. This research aims to develop a sales prediction system using SVM to help TB. Samijaya in optimizing the supply of construction materials based on historical trends and other predictive variables. With this system, it is hoped that the risk of shortage or excess inventory can be reduced, operational costs are minimized, and customer satisfaction is improved

The specific objective of this research is to assist TB. Samijaya in managing their inventory over the coming months or even years, by providing accurate and reliable sales predictions. This system will enable the company to anticipate demand more effectively, ensuring that the right amount of inventory is available to meet future needs.

This research is not only beneficial for TB. Samijaya in improving its operations, but also contributing to academic literature related to the application of machine learning techniques in the construction industry. In addition, this research can be a reference for similar companies in facing the challenges of sales prediction and inventory management.

2. RESEARCH METHOD

Inception

At this stage, the focus is directed to the goals and scope of the system. The steps taken include identifying needs, studying literature, and setting goals for creating a system. Since TB. Sami Jaya has not previously implemented any system for inventory management, this prediction system will be their first. Additionally, this stage involves determining the sources of historical data and predictive variables, which are obtained directly from the company's transaction records and any relevant external data sources.

Elaboration

This stage aims to analyze and design the system in detail. The first step is to gather the necessary data for the prediction system, which includes both historical transaction data from TB. Sami Jaya and any relevant external predictive variables. The data is then processed to ensure it is in optimal condition for use in the SVM method. Following data processing, a Use Case Diagram is created to show how the system's users specifically the admin and owner will interact with it. A Class Diagram is then developed to illustrate the class structure and relationships within the system. Finally, the data is divided into Training data and Testing data.

Construction

The selection of the appropriate kernel based on the existing data is an important step in the application of the SVM method. Once the kernel is selected, the authors proceed to train the model using predefined parameters, aiming to maximize the accuracy of predictions. The last step is hyperparameter tuning, where the C and Gamma parameters are optimized through cross-validation techniques. This process is carried out to ensure that the resulting model has the best performance, avoids overfitting and underfitting, and is ready for practical application as the first inventory management system at TB. Sami Jaya.

User Interface Design

Given that this system is the first to be used at TB. Sami Jaya, the user interface is specifically designed for the admin and owner. The UI focuses on simplicity and clarity, ensuring that these key users can easily access and interpret the sales predictions and other system outputs. This design consideration is crucial to support the adoption and effective use of the system in daily operations.

3. RESULTS AND DISCUSSION

3.1. Inception

To understand the system needed, the first step is to conduct interviews with interested sources. After that, conduct a literature study to review existing research and understand the SVM method in similar case studies. Finally, set clear system goals to overcome existing problems.

3.2. Elaboration

3.2.1. Data Collection

Transaction data that has been collected from the TB. Samijaya transaction memo in November-December 2023 is shown in table 2 below:

Table 1. Transaction data for november-december 2023

	Code	Date	Clock	Goods	Amount	Price	Total
0	PK001	Wednesday, 01 November 2023	8:10	Nail	1.0	22000.0	22000.0
1	EM034	Wednesday, 01 November 2023	8:10	Bucket	5.0	8500.0	42500.0
2	BN004	Wednesday, 01 November 2023	8:10	Thread	4.0	2500.0	10000.0
3	SM002	Wednesday, 01 November 2023	9:10	Cement	25.0	55000.0	1375000.0
4	PK001	Wednesday, 01 November 2023	9:23	Nail	1.0	22000.0	22000.0
….	….	….	….	….	….	….	….
331	EM034	Saturday, 30 December 2023	9:39	Bucket	4.0	8500.0	34000.0
332	PK001	Saturday, 30 December 2023	9:39	Nail	2.0	22000.0	44000.0
333	SM002	Saturday, 30 December 2023	10:40	Cement	3.0	55000.0	165000.0
334	SK008	Saturday, 30 December 2023	10:40	Scrap K	5.0	2500.0	17500.0
335	SK009	Saturday, 30 December 2023	10:40	Scrap B	2.0	8500.0	17000.0

3.2.2. Preprocessing Data

Data preprocessing is an important step in data analysis and machine learning. The goal is to prepare the raw data so that it is ready for use in the model (Karim et al., 2023).

a) Normalization

Table 2. Data normalization

	Date	Goods	Amount	Price	Total
0	2023-11-01	1	1.0	22000.0	22000.0
1	2023-11-01	2	5.0	8500.0	42500.0
2	2023-11-01	3	4.0	2500.0	10000.0
3	2023-11-01	4	25.0	55000.0	1375000.0
4	2023-11-01	1	1.0	22000.0	22000.0
….	….	...	...	...	...
331	2023-12-30	2	4.0	8500.0	34000.0
332	2023-12-30	1	2.0	22000.0	44000.0
333	2023-12-30	4	3.0	55000.0	165000.0
334	2023-12-30	5	5.0	3500.0	17500.0
335	2023-12-30	6	2.0	8500.0	17000.0

b) Data Sharing, the division of data into two sets, namely data training and data testing is a critical step in the model development process. This division is important for evaluating the model's performance by using data that was not used during training. Here the author divides the author's dataset into 80:20, with 80% Training data and 20% Testing data. Of the 335 transaction data, the author divided 265 as training data and 68 as testing data (Karim et al., 2023).

c) Use Case Diagram, the following is a Use Case Diagram used in the development of the TB Construction Material Prediction System. Samijaya.

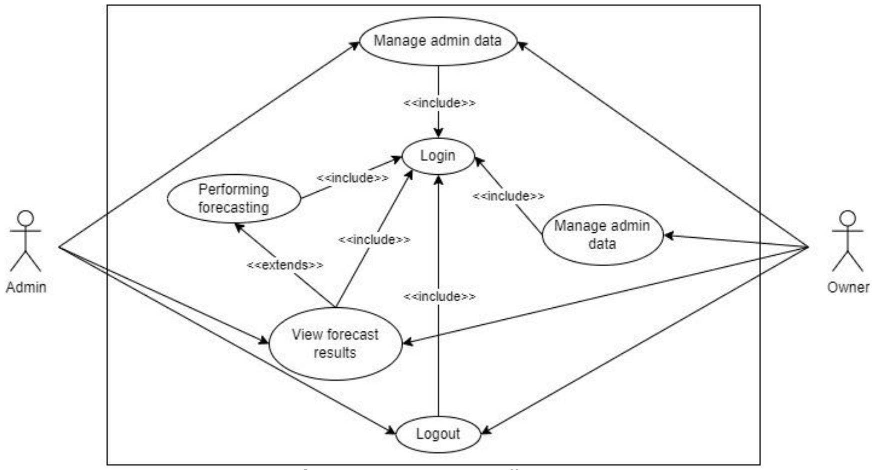

Figure 1. Use case diagram

d) Class Diagram, the following is a class diagram of the Construction Material Sales Prediction System in TB. Samijaya :

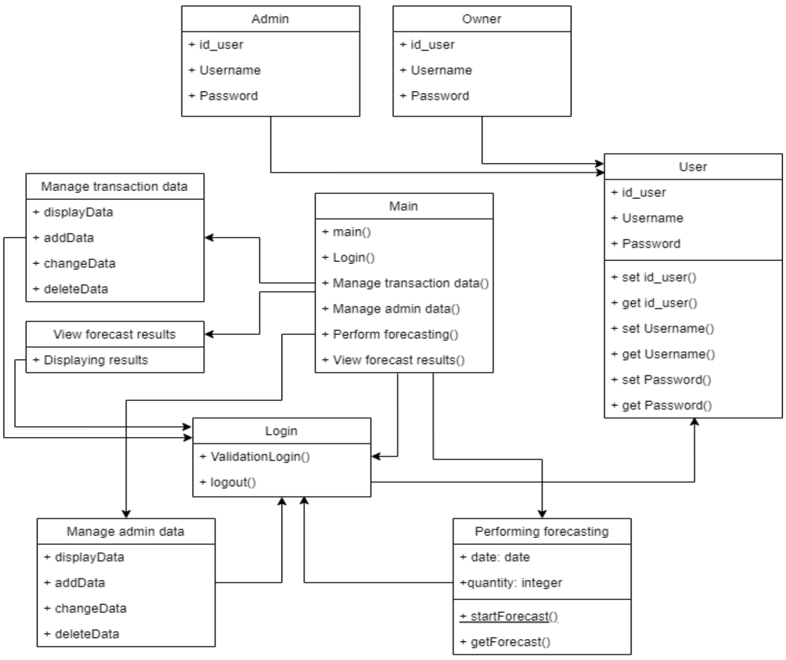

Figure 2. Class diagram

e) Designing Wareframe Design, the interface design is used to provide an overview of the system that is designed in such a way that it is easy for users to understand when providing data input and when viewing the results of the data input.

(a) Login Page, the login page serves as a prevention of other features from being accessed by unauthorized users. Users are given a form to enter their username and password. Here's what the login page looks like:

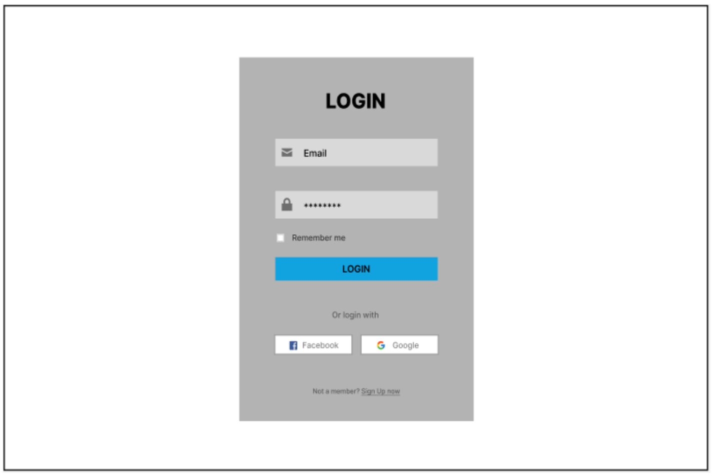

Figure 3. Login page

(b) Dashboard Page, the page accessed by the user when successfully logging into the system. On this page, a summary of the latest transactions and the number of transactions per day will be displayed. The following is the main page plan:

Figure 4. Dashboard page

(c) Sales Data Page, a page that contains all sales data that has been entered by actors presented in the form of a pagination table. On this page, actors can modify the data or add new sales data. If the Owner actor accesses this page, the option to delete data will be provided. The following is a design of the sales data management page:

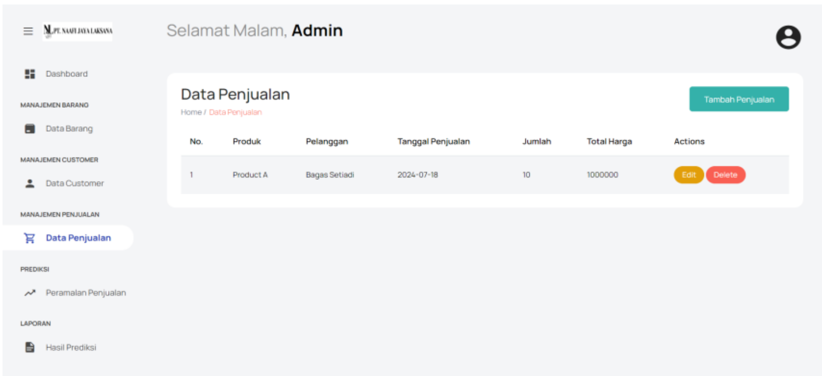

Figure 5. Sales data page

(d) Admin Manage Page, the admin management page is only accessed by the owner actor, on this page the owner can see all admin data presented in the form of a table and can make changes, add and delete admins. The following is the design of the admin management page display:

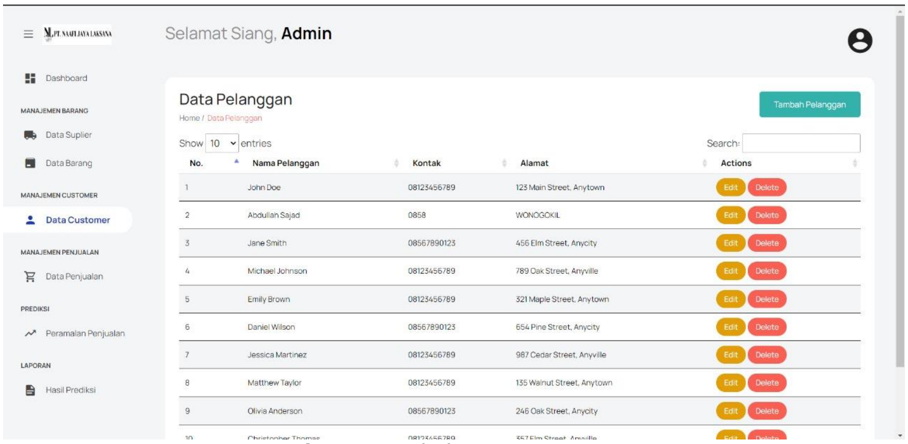

Figure 6. Admin manage page

(e) Prediction Page, this prediction page can be accessed by all actors who have successfully logged in, on this page actors can see the data of the forecasts that have been carried out which are presented in the form of a table. Here's how the forecast page looks like:

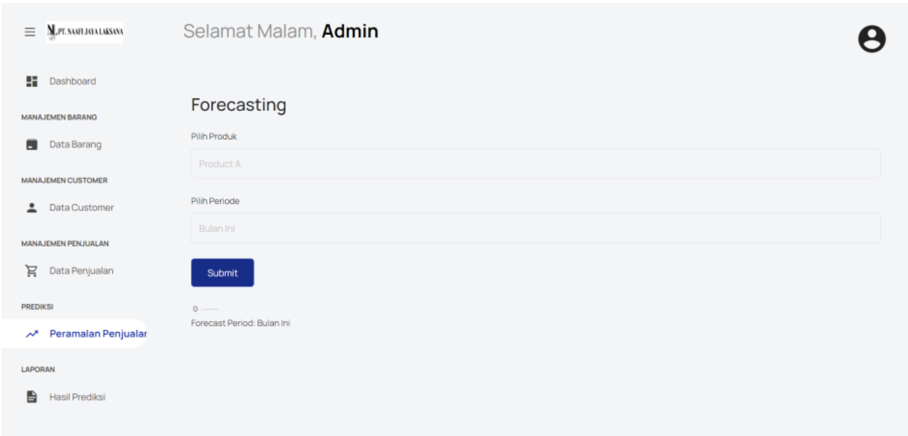

Figure 7. Prediction page

3.3. Construction

3.3.1. Kernel Selection

The RBF (Radial Basic Function) kernel is one of the types of kernels that are often used in the SVM method. This kernel is very effective for handling data that cannot be separated linearly. As in the transaction data above.

A Kernel function is defined as:

$K(x, x') = \exp(-y||x - x'||^2)$

where:

- $K(x, x')$ is a kernel function
- (x) dan (x') are two data factors

3.3.2. Model Training

```
Akurasi: 0.9558823529411765
Laporan Klasifikasi:
              precision    recall  f1-score   support

         1.0       1.00      1.00      1.00        29
         2.0       0.85      1.00      0.92        17
         3.0       1.00      1.00      1.00         5
         4.0       1.00      1.00      1.00         5
         5.0       1.00      1.00      1.00         2
         6.0       1.00      0.60      0.75         5
         8.0       1.00      0.50      0.67         2
        10.0       1.00      1.00      1.00         2
        25.0       1.00      1.00      1.00         1

    accuracy                           0.96        68
   macro avg       0.98      0.90      0.93        68
weighted avg       0.96      0.96      0.95        68
```

Figure 8. Model training results

3.3.3. Hyperparameter Tunning

At this stage, the optimal parameters for the Support Vector Machine (SVM) are adjusted to the training data to generate a prediction model. This step is applied to each subset of features that have been selected using the variable selection method. The SVM prediction process is carried out using MATLAB software. The performance evaluation method used is 10-fold cross-validation.

K-fold cross-validation was chosen because it provides more accurate performance estimates. Cross-validation is an evaluation method that divides data into two segments: one for model training and the other for model validation. The data is divided into K partitions stratified randomly, with each partition having the same size. Then, as many iterations as K. In each iteration, one partition is used for testing, while the other K-1 partition is used for model training. This process is done to ensure the model is tested on all available pieces of data.

This helps to avoid bias that may arise from one particular piece of data and ensures that the model is thoroughly evaluated. This method is useful in measuring how well an SVM model can generalize from training data to test data, resulting in more reliable estimates of the model's performance on previously unseen data. The results of Hyperparamater Tuning can be seen from the image below:

	Metric	Value
0	Mean Squared Error	4.544118
1	R2 Score	0.624377
0	Mean Squared Error (Tuned)	4.676471
1	R2 Score (Tuned)	0.613436
0	Akurasi	0.955882
1	Akurasi (Tuned)	0.955882
0	Cross-Validation Scores	[0.9558823529411765, 0.9552238805970149, 0.970...
1	Mean Cross-Validation Score	0.964311

Figure 9. Hyperparamater tunning results

4. CONCLUSION

This research develops a sales prediction system using the Support Vector Machine (SVM) to help TB. Sami Jaya in managing the supply of construction materials. TB. Sami Jaya has difficulty predicting sales due to external factors such as economic conditions and seasonality, which lead to excess or shortage of inventory. Sales transaction data in November-December 2023 was used to train and test the SVM model. The data is separated into 80% for training and 20% for testing. The model performance evaluation is carried out by comparing the prediction results with actual data using accuracy metrics such as MAE, MSE, and RMSE. The results show that SVM is effective in predicting sales, helping to optimize inventory management, reduce operational costs, and increase customer satisfaction.

The implementation of an SVM-based sales prediction system in TB. Sami Jaya could potentially transform the way inventory management is handled within the construction materials industry. By improving prediction accuracy, the company can make more informed decisions, which may lead to a significant reduction in operational costs and enhanced customer satisfaction. Moreover, this system can serve as a model for other companies in similar industries, indicating the broader applicability of SVM in inventory management across various sectors. The success of this system also underscores the importance of integrating advanced machine learning techniques into traditional business operations, signaling a shift towards more data-driven decision-making processes in the industry.

Researchers are further advised to expand the data collection period and explore other machine learning algorithms such as Random Forest and Neural Networks. Adding predictive variables such as market trends and weather data can improve the accuracy of the model. Test the model with data from other companies to ensure common applications, and implement prediction systems in daily operations with regular monitoring. The development of a web-based decision support system or mobile application is also recommended. With these recommendations, further research is expected to be more in-depth and make a significant contribution to construction material inventory management.

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