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Detection of Room Cleanliness Based on Digital Image Processing using SVM and NN Algorithm

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Abstract: A clean environment can prevent us from disease and can increase productivity. A neat and clean room arrangement can affect health, avoiding the possibility of stress, lethargy, and depression. The room recognition process based on its neatness is carried out through the process of matching and comparing the images that are used as training and testing sets. The development of technology supports to detect the condition of the room through the image. Detection uses image processing by classifying images into 2 categories, clean and messy. It has been widely used in various fields, one of which is hospitality. This classification process is done by comparing the image in the database with the image that is used as input. In determining clean rooms and messy rooms, there are obstacles due to image quality, different lighting, and image comfort. This study aims to detect a clean and cluttered space by comparing the Support Vector Machine and Neural Network on a dataset of 199 images using Orange data mining software. The Support Vector Machine was chosen because it can be implemented easily while the Neural Network has a high tolerance for noise. The use of feature extraction methods was also added to improve accuracy. Based on the test, the highest accuracy classification value is 98.0% for the Neural Network method with AUC 0.999.

Keywords: Classification, Image Processing, Neural Network, Room Cleanliness, Support Vector Machine

INTRODUCTION

For some, a tidy room can be a quiet retreat. But to others, a tidy room feels unattractive. Some people feel anxious when they are in a messy room, while others feel more creative when they are in a messy room (Cherry, 2021). The spread of Covid-19 is forcing people to adapt and change at the same time. Activities that used to be in various places are now concentrated only in the house (Winarna et al., 2021). The pandemic condition that is still ongoing until now has made people limit their activities outside the home. That way to stay comfortable and productive while at home, it is necessary to pay attention to the condition of the tidiness of the house. In addition, especially for the hotel sector, cleanliness and aesthetics of hotel rooms are the most important part of service and affect the success of the hotel (Dharmali et al., 2021).

To simplify the work in determining the tidiness of space, you can use image processing. Image processing is the application of computational transformations to images, such as sharpening, contrast, and more (Wiley & Lucas, 2018). This work is done by grouping spaces by classifying them through cameras and algorithms (Shakya, 2020).

Classification is a method of grouping objects based on characteristics (Hidayat et al., 2021). Object classification is an easy task for humans but a complex problem for machines. Image classification is an important and challenging task in various application domains, including biomedical imaging, biometrics, video surveillance, vehicle navigation, industrial visual inspection, robotic navigation, and remote sensing (Kamavisdar et al., 2013). Currently image classification is developing and becoming a trend among technology developers, especially with the growth of data in various parts of the industry such as e-commerce, automotive, health care, and games (Abu et al., 2019). However, low image quality becomes an important problem in recognition and identification. Therefore, to handle this condition, a method is needed, one of which can be done

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by applying the computer vision method (Wildah et al., 2021). In this study, it is proposed to test space classification using the Support Vector Machine and Neural Network methods to compare which method has the highest accuracy for the image classification process with the help of feature extraction. This study offers the results of detecting which rooms are clean and which rooms are messy. The application of the results of this research can be used for business, especially in the field of services such as lodging and hospitality.

LITERATURE REVIEW

In this research we use a classification algorithm for image processing. This section describes the characteristics and how does the process work of the algorithms, Support Vector Machines and Neural Networks.

Some classification methods have advantages and disadvantages based on research (Wibawa et al., 2018), including: Support Vector Machines can be implemented easily, but difficult to use for large-scale problems and Neural Networks have a high tolerance for noise, but the process steps can be very long.

In general, Neural Networks can be used for troubleshooting. Each neuron in the network is used to find the relationship between input data and output features (Balaji & Lavanya, 2019). Neural Networks can use image segmentation to identify trash (Santos et al., 2020). The way Neural Network works is inspired by how the human brain processes information that is described through the human nervous cell system. Information will be processed by neurons. Each neuron will send a signal through the interconnection. Each neuron has a link with a different weight that can amplify or weaken the signal. Determination of the output is done by the activation function on each neuron for the number of weighted inputs received. The signal can be forwarded if the activation function value is strong enough.

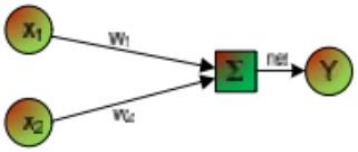

Figure 1. Neural Network work pattern

The Support Vector Machine (SVM) method is a set of related learning methods that analyze data and recognize patterns, which are then used for classification and regression analysis (Pratama, 2020). SVM works by dividing the data into two parts using a linear function on a high-dimensional feature space (Hidayat et al., 2021).

Support Vector Machine works by finding a hyperplane that separates groups of classes that tell some patterns that are members of the class. Hyperplane in SVM is a function that acts as a boundary that helps us classify data points. Data points located on both sides of the hyperplane can be interpreted as different classes. Determining the best hyperplane is done by measuring the distance of the closest pattern from each class with a hyperplane and finding the maximum point. The pattern that has the closest distance to the hyperplane is hereinafter referred to as the support vector.

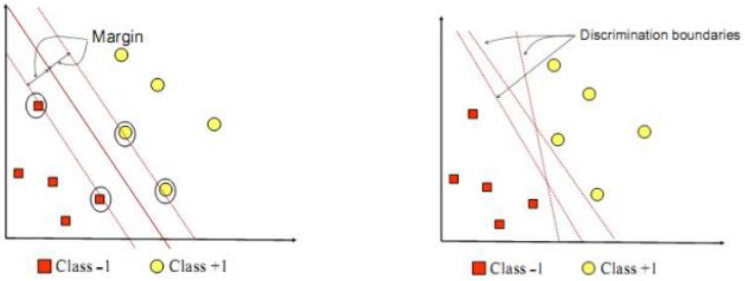

Figure 2. SVM forms a hyperplane between classes

Based on the exploration results, there are several relevant studies related to image classification that have been carried out previously. Related research conducted by (Muhathir et al., 2021) using the SVM algorithm and feature extraction of Gray Level Co-Occurrence Matrix (GLCM) with a total accuracy of 83.2%.

Other related research conducted by (Othman & Rad, 2019) with the aim of identifying each room in the house covering 5 categories using the Places dataset. The highest accuracy in this classification model reaches

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98.5% which is shown through a combination model of CNN and a multi-binary classifier called error correcting output code (ECOC).

Another study aims to identify popular foods from Indonesia using the Convolutional Neural Network approach with a standard architecture and the Inception-v4 model as a technique with Adam as the optimizer function (Giovany et al., 2019). Accuracy showed 76.3% for standard network and 95.2% for inception-v4 network. Research related to the classification of food images has also been carried out by (Islam et al., 2018) using Convolutional Neural Networks.

In this research, the application of two classification algorithms Support Vector Machine (SVM) and Neural Network aims to find the best method that can produce the highest accuracy value with a low error rate for detecting space cleanliness in the dataset used. SVM will find the closest distance between hyperplane and pattern in clean class and messy class, while neural network will classify pattern based on the messy room and clean room image input given with the help of the best parameters.

METHOD

The method used in this study starts from the image input stage, then preprocesses the image, and clustering it. Furthermore, from the results of this feature a classification process will be carried out using several classification algorithms. The steps of this research are as seen in Figure 3 start from input image until the last step with evaluation model:

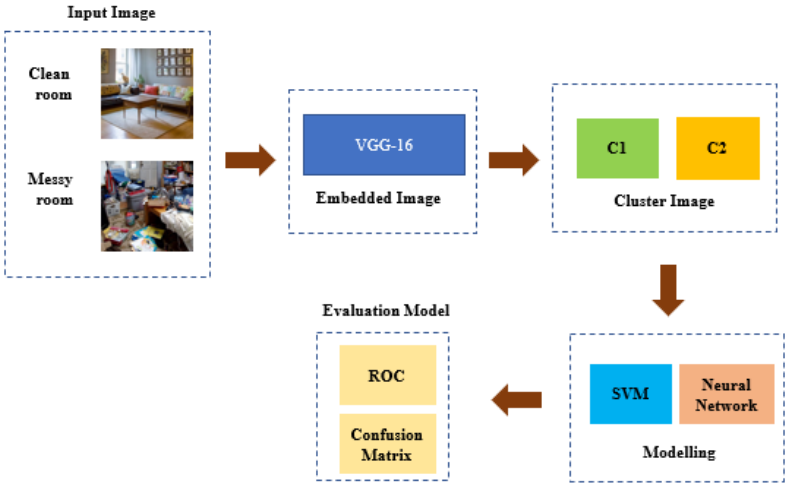

Figure 3. Stages of the Research Model

Input Image

This study uses a dataset room consisting of a clean room and a messy room totaling 199 images in PNG format. All images have been adjusted so that they have sizes between 79.2 KB to 203 KB and dimensions of 300x300 pixels. Each image is labeled clean or messy and given a serial number of the image. Then the image is divided into training sets and testing sets

Figure 4. Clean Room Image Sample

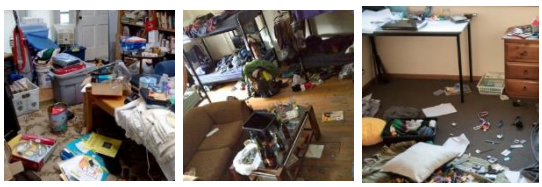

Figure 5. Messy Room Image Sample

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Based on Figure 4 and Figure 5, it can be seen the difference between clean and messy, such as the absence of pieces of garbage scattered on the floor, on the table or on the bed.

Embedded Image

The next step is to read the image and upload it to a remote server or evaluate the image locally. At this stage, a deep learning model is used to calculate the feature vector for each image. The embedder used is VGG-16 for 16-layer image recognition models trained on ImageNet.

Image Clustering

This study grouped images using the k-Means clustering algorithm. Initialization is done using KMeans++ with 10 replays and a maximum of 300 repetitions. From this stage, 2 clusters are obtained, namely C1 and C2 with 6 meta attributes, namely: image name, image, size, length, height, and silhouette score.

Modeling

The classification model used in this research is Support Vector Machine and Neural Network.

In Figure 6 we can see for Neural Network, using 100 neurons per hidden layer with the addition of ReLu as an activation function for the hidden layer for fixed linear units and the use of Adam as a solver for stochastic gradient-based weight optimization.

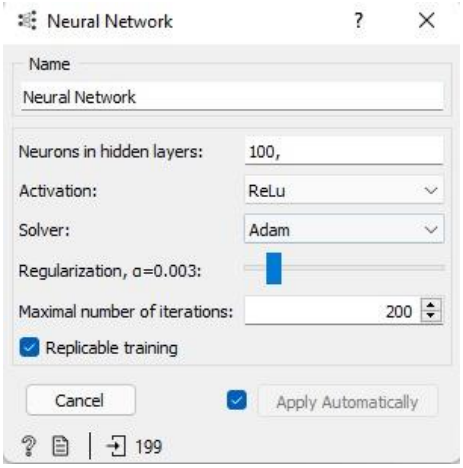

Figure 6. Image Processing Process

While in SVM, the size of the loss and applicable to the classification and regression tasks used is 100. This study uses the RBF Kernel which converts the attribute space into a new feature space to fit the hyperplane maximum margin, thus enabling the algorithm to create a model, and the maximum number of iterations is 100.

Model Evaluation

At this stage, the model evaluation of the two classification algorithms is used to see the results of accuracy, precision, recall, and F1 generated.

RESULT

Research for detecting the cleanliness of the room by classifying the room into 2 categories, namely clean room and messy room. The classification algorithm used is Support Vector Machine and Neural Network. This research uses Orange tools to facilitate image processing. The processing of image can be seen in figure 7

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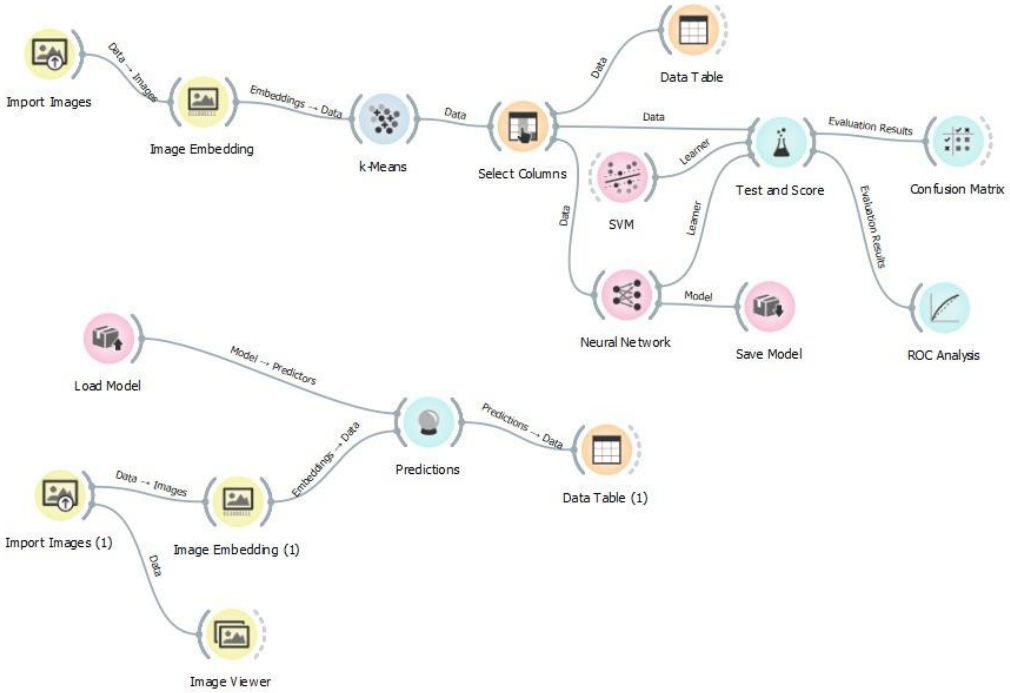

Figure 7. Image Processing Process

From the processing that has been done, the test results obtained for each classification algorithm used. Support Vector Machine algorithm test results:

Table 1.
SVM Algorithm Testing Table

Accuracy	0.945
AUC	0.993
Precision	0.949
Recall	0.945
F1	0.945

From the results of table 1, it is shown that the correct prediction ratio (accuracy) for the use of the SVM algorithm is 0.945 or 94.5%. AUC is the area under the Receiver Operating Characteristics (ROC) curve which is a tool to measure classification performance in determining the threshold of a model, the AUC value in this result is 0.993. Precision is the ratio of true positive predictions to all positive predicted results with a magnitude of 94.9%. Recall or sensitivity is the ratio of true positive predictions to the overall data that is true positive of 94.5%. F1 score is the average comparison between the recall value and the weighted precision value. For SVM results, the F1 value is 94.5%.

Rsults of accuracy, AUC, precision, recall and F1 values for testing the Neural Network algorithm as written in table 2:

Table 2.
Table of Neural Network Algorithm Testing

Accuracy	0.980
AUC	0.999
Precision	0.980
Recall	0.980
F1	0.980

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The conclusions that can be drawn from the test results above are: AUC shows the area under the ROC curve. Because the AUC values of the two algorithms are close to 1, it can be concluded that the model obtained is accurate and falls into the Excellent Classification category.

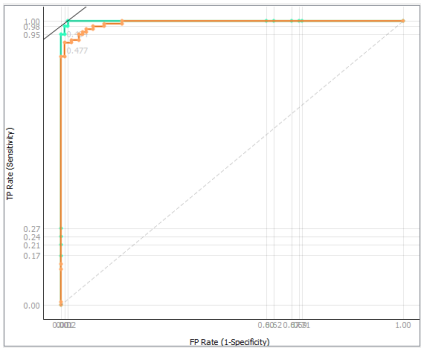


Figure 8. Area Under Cover

In figure 6 the green line represents the AUC of the neural network while other line represents the AUC of SVM. The classification accuracy of the two algorithms shows the amount of data that has been classified correctly. Neural Network shows greater accuracy with a value of 98% compared to the SVM accuracy value which is only 94.5%.

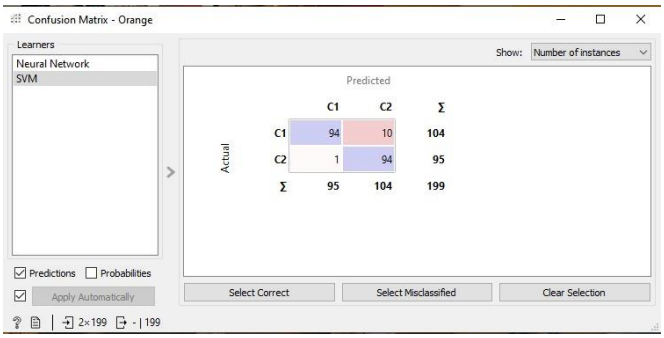
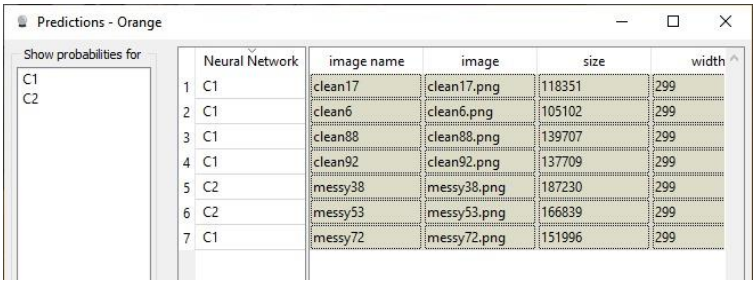


Figure 9. Confusion Matrix

The confusion matrix of the classification results from this study can be seen in Figure 9 where the True Positive (TP) value is 94, False Negative (FN) 10, True Negative (TN) 94, and False Positive (FP) 1. Positive class is described with C1 which shows clean room data, while negative class is described with C2 for messy room. TP shows the data that is predicted to be correctly entered into the clean room is 94. FN is data that should go into the clean room but is predicted to be a messy room is 10. TN is data that is predicted to be correctly classified into the messy room is 94 and FP is data that should classified into messy room but was predicted to be a clean room is 1. The FP description can be seen in Figure 10.



	Neural Network	image name	image	size	width
1	C1	clean17	clean17.png	118351	299
2	C1	clean6	clean6.png	105102	299
3	C1	clean88	clean88.png	139707	299
4	C1	clean92	clean92.png	137709	299
5	C2	messy38	messy38.png	187230	299
6	C2	messy53	messy53.png	166839	299
7	C1	messy72	messy72.png	151996	299

Figure 10. Prediction Image

Figure 10 shows a prediction image result where the seventh line of testing for the messy72.png image should be included in the messy room class represented by C2, but the prediction output goes into the clean room class or C1.

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CONCLUSION

This study identifies the condition of the room based on the image by classifying the clean room and messy room. The methods used for classification are Support Vector Machine and Neural Network. The evaluation results show an accuracy of 94.5% and an AUC value of 0.993 for the Support Vector Machine method while for the Neural Network method the accuracy is 98.0% and the AUC value is 0.999. For the research that has been done, we recommend the use of other methods for image processing with different formats. We also suggest research for making applications with the application of artificial intelligence so that the detection of the cleanliness of this space can be directly utilized by the public

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