Comparison of Speeded-Up Robust Feature (SURF) and Oriented FAST and Rotated BRIEF (ORB) Methods in Identifying Museum Objects Using Low Light Intensity Images

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Abstract. Museum is a place of education and learning in the field of culture and history for all levels of society. As one of the first and largest museums in Lampung, Museum Lampung presents a variety of collections that are conditional on cultural values and are very useful if they can be identified through digital media. Speeded-Up Robust Feature (SURF) and Oriented FAST and Rotated BRIEF (ORB) methods are two examples of feature extraction methods that are relatively robust for object recognition in images by finding key points. Digital media determined by the value of key points in this study are images that are classified as having low intensity with an intensity value of <2250 Lux. This study compares the two methods using the digital object media of museum objects. The image of the museum object is given treatment in terms of rotation, scaling, and cropping to test the durability of the image matching process. In terms of feature matching time, the best time is achieved by SURF with 0.16 seconds in testing of 1/3 image region. Meanwhile, the highest matching percentage was also obtained by SURF method from rotational distortion at an angle of 90 degrees which is 76.79% instead of to 63.79% of the percentage obtained by ORB.

1. Introduction

A museum is part of the cultural and entertainment environment that presents as a service in the community with the aim of preserving, exhibiting, and conveying human relics for educational, learning, and recreational purposes [1]. As one of the provinces rich in historical heritage, Lampung has a place to capture its history and culture, i.e., the Lampung Museum. Museum Lampung keeps many collections related to the culture, history and origin of the community ranging from pre-historic relics, traditional weapons, musical instruments, traditional ceremonies, and so on [2]. The need for object recognition through digital objects is increasingly becoming a field highlighted by many people, one of its applications is through images. Some of the things that underlie these needs are applying marketing techniques as a tool for the survival of the museum as a liaison between museums and visitors, besides the imbalance of the number of tourists and tour guides that cause inadequate information so that it can be accepted by tourists [3]. Introduction to digital objects through digital devices can be a solution.

One area of science related to object recognition based on shape and features is feature matching. Matching images that apply these techniques has been widely applied to the introduction of image-based objects or digital images. Among these can be applied to mobile devices to help tourists...
translate information and messages contained in images of temple reliefs [4]. The information extraction method applied is Speeded-Up Robust Feature (SURF) which contributes to an excellent recognition compared to Scale Invariant Feature Transform (SIFT) method [5]. In addition, the Oriented FAST and Rotated BRIEF (ORB) methods provide excellent performance in terms of process speed as an alternative to SIFT and SURF in terms of efficiency [6]. Several types of distortion compare image matching methods such as scaling, intensity, rotation, noise, eyelets, and sheared by calculating evaluation parameters such as the number of key points, image matching levels, and execution time on one image type [7].

This study combines several concepts from previous studies by comparing the SURF and ORB methods from several pictures of museum objects from the Lampung Museum. The comparison process is conducted through several types of tests in the form of distortions that may occur and are carried out by tourists in the museum, namely in the aspect of rotation, scale, and cropping. This research is expected to help in determining the best method for recognizing museum objects. The best method is also expected to attract tourists by providing adequate information through digital images from museum collections.

2. Related Works

Several studies have been carried out in implementing similar methods and techniques in recent years. Among those conducted by Bay, et al. [6] who introduced museum objects with the SURF method to develop a prototype of an interactive mobile museum guide, this study found excellent results for the speed of the SURF method. Another study that applied the SURF method was carried out by Yunmar and Harjoko [4] who identified relief objects in temples with various conditions, such as rotation, distance and object cutting with recognition accuracy of 93.30% with an average computing time of 59.55 seconds. However, research conducted by Yunmar and Harjoko [4] has not paid attention to the lighting aspect if the object is in a low-light room.

Furthermore, the SURF method can also be applied well to the signature identification system [8] and is also very powerful according to his theory for point detection of image features [6]. Besides SURF, another method that has also been implemented well is ORB. Research that has used this method is carried out on an implementation that can improve and perfect the SURF method in feature extraction activities with a high degree of accuracy [8] [9].

3. Methodology

3.1. Image Acquisition

The process of sampling image data is carried out on objects that are in the room of the Lampung Museum. The image is taken using an 8-megapixel resolution camera that is saved in JPEG format. Images acquisition was carried out under low light conditions from the environment with a value of <2250 Lux.

3.2. Preprocessing

The preprocessing stage involves a process to reduce computational complexity, namely by the process of cropping, resizing and grayscaling. The cropping process is performed to extract only the part of the object that is intended to be observed. On the other hand, the resizing process is carried out with the aim to reduce the spatial size of the image. Furthermore, changing the image into grayscale is performed with the aim to speed up the runtime process of the algorithm [1].

3.3. Feature Extraction

At this stage the feature extraction process is carried out from the two methods to be compared, the two methods are SURF and ORB.
3.3.1 SURF (Speeded-Up Robust Feature)
This method is the development of Scale Invariant Feature Transform (SIFT) which has already appeared. SIFT algorithm has weaknesses in terms of computational time and robustness of performance matching features [5]. SURF appears with the ability to overcome the weaknesses of SIFT by utilizing the speed of computational filtering using an integral image based on the determinant values of the Hessian matrix [10]. For orientation problems, SURF uses wavelet responses in the vertical and horizontal directions by applying Gaussian Weights. SURF uses wavelet responses to select key points by dividing the image into several sub regions, then from the sub regions response wavelets are taken and represented to get the feature descriptors.

3.3.2 ORB (Oriented FAST and Rotated BRIEF)
ORB is a fusion of the FAST key point detector and BRIEF descriptor with some modifications [11]. Initially to determine the key points, it uses FAST. Then a Harris corner measure is applied to find top N points. FAST does not compute the orientation and is rotation variant. It computes the intensity weighted centroid of the patch with located corner at center. The direction of the vector from this corner point to centroid gives the orientation. Moments are computed to improve the rotation invariance. The descriptor BRIEF poorly performs if there is an in-plane rotation. In ORB, a rotation matrix is computed using the orientation of patch and then the BRIEF descriptors.

3.4. Feature Matching and Testing
This stage is done by comparing the preprocessed image with the image that is subject to a distortion process such as scaling, rotation and cropping of the image. Preprocessed images are compared with each distorted image separated into two groups, namely SURF and ORB. The feature matching testing process using key points was carried out with several experiments in order to get the best information and characteristics of the method between the two methods that were compared. The accuracy of the detection and matching process using key points can be used as a reference for the implementation process for subsequent application applications [12].

3.4.1 Rotation
In the process of image rotation, carried out several treatments based on the angle. Several types of image rotation are applied to determine the resistance of the method to the angle of image capture. The rotation types applied in this study are 45 degrees, 90 degrees, 135 degrees, and 180 degrees.

3.4.2 Scaling
Image scale testing applied in this study is based on the process of enlarging and reducing the size of the image of the museum object. The scale used in this testing phase is 0.5 times and 2 times the original image, respectively.

3.4.3 Cropping
Image cropping is done based on the whole image region. In this process, the cropped image can be divided into 2 types, i.e., 1/3 region and 2/3 image region from the Y axis or pixel line of the image. Testing of image cropping is performed to determine the ability of the method to recognize incomplete object images.

4. Result and Discussions
4.1 Image Acquisition
Image samples used in this study are Red, Green, and Blue (RGB) images taken indoors with relatively low light intensity. The low intensity of the light causes the lack of appearance of the object. The original image processed in this study can be seen in Figure 1.
4.2 Preprocessing

The result of the preprocessing stage is an image that has a smaller pixel size than the original image with size reduced by 1/3 times the actual size. In addition, the image to be processed has a simpler color space obtained from the grayscaling process. Preprocessing results from the original image can be seen in Figure 2.

4.3 Feature Extraction

This stage is done to get the features of each method of grayscale image. The features extracted at this stage for both methods, SURF and ORB, are in numerical form with the term key points. Each key points value shows the features according to the characteristics of the extracted object.

4.4 Feature Matching and Testing

This stage is carried out to test the sensitivity of the SURF and ORB methods to the effects of distortion in the form of image rotation, scale and cropping. Testing is performed by comparing the image of the results of preprocessing with various images that have been subjected to various types of distortion.

4.4.1 Rotation

The results of tests that have been carried out on a distorted image with a 45 degrees rotation are given in Figure 3 and Table 1. Figure 3 (a) shows the results of feature matching with the SURF method. On the other hand, Figure 3 (b) shows the results of feature matching with the ORB method.

![Figure 1. Original Image](image1.png) ![Figure 2. Preprocessed Image](image2.png)

**Figure 1. Original Image**  **Figure 2. Preprocessed Image**

![Figure 3. The results of feature matching at 45 degrees rotation](image3.png)

**Figure 3. The results of feature matching at 45 degrees rotation**
Table 1. Details of the test at an angle of 45 degrees

| Methods | Key points 1 (Original Image) | Key points 2 (45 degrees) | Matches | Average Match Rate | Time (sec) |
|---------|-------------------------------|---------------------------|---------|-------------------|------------|
| SURF    | 554                           | 392                       | 149     | 32.45%            | 00.26      |
| ORB     | 7233                          | 5525                      | 1528    | 24.39%            | 01.12      |

Figure 4. The results of feature matching at 90 degrees rotation

Table 2. Details of the test at an angle of 90 degrees

| Methods | Key points 1 (Original Image) | Key points 2 (90 degrees) | Matches | Average Match Rate | Time (sec) |
|---------|-------------------------------|---------------------------|---------|-------------------|------------|
| SURF    | 554                           | 535                       | 418     | 76.79%            | 00.23      |
| ORB     | 7233                          | 6559                      | 4369    | 63.51%            | 01.29      |

From the test results of Table 1, the obtained results show the number of key points produced by each SURF and ORB methods. In terms of the number of key points, the SURF method provides fewer results compared to the ORB method. However, the average introduction and processing time of SURF shows better performance.

Test results that have been carried out on distorted images with 90 degrees rotation are given in Figure 4 and Table 2. Figure 4 (a) shows the results of feature matching with the SURF method, while Figure 4 (b) shows the feature matching results from the ORB method. From the test results obtained in Table 2, the results show that the number of key points from the ORB at the term of processing time. The average match rate result of the introduction was generally better than the first test, with 76.79% and 63.51% from SURF and ORB respectively.

The results of tests that have been carried out on a distorted image with a 135 degrees rotation are given in Figure 5 and Table 3. The results shown in Table 3 are almost the same as that of 45 degrees rotation. When viewed in terms of the number of key points, the SURF method provides fewer results compared to the ORB method, but with a better average introduction and processing time. The average match rate shows a small difference between the two methods, which is only 1.4%.

The results of tests performed on a distorted image with 180 degrees rotation are given in Figure 6 and Table 4. The results shown in Table 4 are almost the same as the test at a 90 degrees rotation. SURF method gives fewer number of key points compared to ORB method, but with better result of introduction and processing time. The average result of the general recognition success was almost the same as the image rotation test of 45 degrees, but with a slightly smaller percentage value, namely with 76.79% and 63.51% from SURF and ORB respectively.
Figure 5. The results of feature matching at 135 degrees rotation.

**Table 3.** Details of the test at an angle of 135 degrees.

| Methods | Key points 1 (Original Image) | Key points 2 (135 degrees) | Matches | Average Match Rate | Time (sec) |
|---------|-----------------------------|-----------------------------|---------|-------------------|------------|
| SURF    | 554                         | 375                         | 115     | 25.71%            | 00.25      |
| ORB     | 7233                        | 5463                        | 1513    | 24.31%            | 1.36       |

Figure 6. The results of feature matching at 180 degrees rotation.

**Table 4.** Details of the test at an angle of 180 degrees.

| Methods | Key points 1 (Original Image) | Key points 2 (180 degrees) | Matches | Average Match Rate | Time (sec) |
|---------|-----------------------------|-----------------------------|---------|-------------------|------------|
| SURF    | 554                         | 563                         | 410     | 73.42%            | 00.24      |
| ORB     | 7233                        | 6382                        | 4152    | 61.23%            | 01.22      |

4.4.2 Scaling

A summary of the test results on a scale distortion of 2 times the original image is shown in Figure 7 and Table 5. The first test on scale distortion is magnification of 0.5 times the size of the original image. The results obtained in the comparison of images on a scale of 0.5 times show that the differences in the time of feature matching process from the SURF and ORB methods are not so significant, which is equal to 0.071 seconds. While on the average matching results the difference in the results of the two methods is quite significant with a result of 44.21% and 7.86% from SURF and ORB respectively.
Figure 7. Feature matching results on a scale of 0.5 times

| Methods | Key points 1 (Original Image) | Key points 2 (Scale of 0.5 times) | Matches | Average Match Rate | Time (sec) |
|---------|-------------------------------|----------------------------------|---------|--------------------|------------|
| SURF    | 554                           | 153                              | 106     | 44.21%             | 00.26      |
| ORB     | 7233                          | 1290                             | 172     | 7.86%              | 00.34      |

Figure 8. Feature matching results on a scale of 2 times

| Methods | Key points 1 (Original Image) | Key points 2 (Scale of 2 times) | Matches | Average Match Rate | Time (sec) |
|---------|-------------------------------|---------------------------------|---------|--------------------|------------|
| SURF    | 554                           | 1217                            | 298     | 39.14%             | 00.49      |
| ORB     | 7233                          | 1754                            | 1096    | 38.82%             | 03.27      |

A summary of the test results on a scale distortion of 2 times the original image is shown in Figure 8 and Table 6. The test results show that the average matching results between the two methods do not show a large difference. However, if you look at the number of key points produced from the magnified image 2 times, the increase in the number of points looks very significant. Likewise for the processing time, the SURF method requires 0.49 seconds of processing time, while the ORB method requires a longer time of 3.27 seconds.
4.4.3 Cropping

A summary of the test results on a crop distortion of 1/3 regions of original image is shown in Figure 9 and Table 7. The results of experiments with cropping of 1/3 pixel line region of the original image found that the ORB method processing time is shorter than SURF. But on the other hand, an error matching was obtained on the SURF method. The error obtained is due to an error in the matching process where the number of key points that match from the 1/3 regions image is greater than 134 compared to the number of original key points before matching the original image. The source of the error that occurs is because the kpoints2 are defined the same as other points outside the region that are as similar as the original image.

![Figure 9. The result of feature matching on 1/3 regions cropping](image)

| Methods | Key points 1 (Original Image) | Key points 2 (1/3 regions) | Matches | Average Match Rate | Time (sec) |
|---------|------------------------------|----------------------------|---------|--------------------|------------|
| SURF    | 554                          | 98                         | 134     |                    | 00.16      |
| ORB     | 7233                         | 775                        | 705     | 50.36%             | 00.37      |

![Figure 9. The result of feature matching on 1/3 regions cropping](image)

A summary of the test results on a crop distortion of 2/3 regions of original image is shown in Figure 10 and Table 8. The results of experiments with cropping 2/3 regions of the original image pixel row found that the ORB method processing time is shorter compared to SURF with a difference.

![Figure 10. The result of feature matching on 2/3 regions cropping](image)

| Methods | Key points 1 (Original Image) | Key points 2 (2/3 regions) | Matches | Average Match Rate | Time (sec) |
|---------|------------------------------|---------------------------|---------|--------------------|------------|
| SURF    | 554                          | 352                       | 366     |                    | 00.19      |
| ORB     | 7233                         | 3536                      | 3056    | 64.34%             | 0.0541667  |
of 0.57 seconds. Similar to the first cropping test, in 2/3 regions there were errors in the number of key points, but with a difference in the error of smaller key points, namely as many as 14 key points. On the processing time, the ORB method requires more that is 0.78 seconds compared to the SURF method that successfully processes 0.19 seconds.

5. Conclusions
In this study, a comparison was made on the image of museum objects that had relatively low light intensity. Experiments to determine the best method achieved by the testing of rotation, scaling and cropping distortion. The results obtained are the ORB method can extract more points than the SURF method. However, it requires a relatively longer extraction and matching time. In terms of feature matching time, the best time is achieved by 0.16 seconds and 0.37 seconds with SURF and ORB respectively. In testing of 1/3 image regions. Meanwhile, the highest matching percentage is obtained from rotational distortion at an angle of 90 degrees, which is 76.79% and 63.79% in SURF and ORB methods respectively. In addition, the results of testing on the SURF method on the distortion of 2 types of image cropping, there was a matching error caused by the number of matching points more than the extracted results. This is caused by misidentification of points that lead to other points that are not in their proper position

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