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IMAGE STITCHING USING A-KAZE ALGORITHM FOR BOROBUDUR PANORAMIC ON BASED FEATURE

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Abstract: *Borobudur Temple is the largest Buddhist temple in Indonesia which has an area of 123 x 123 square meters consisting of 504 Buddha statues, 72 overlay stupas, and one main stupa, with 2,672 relief panels. Borobudur Temple also has nine platforms, six of which are square, and the remaining three are circular. Taking 2D images of Borobudur using a camera produces images that are far, small, and less clear. So we need a process of partial and overlapping image division. The process of combining multiple still images with overlapping fields of view to produce a segmented panoramic, resolution image. This method is widely used in object reconstruction. In this paper, we present a learning-based approach using the A-KAZE algorithm on the image merging process. The test results have been successfully carried out but the quality of the final result is highly dependent on the input image. A good input image has a fairly high intensity and has many objects in it, so it has many features found. Our approach directly estimates feature locations between image paired boundaries by maximizing the image-patch similarity metric between images. A collection of high-resolution images was collected for training and evaluation. The experimental results illustrate that the inner feature approach is better. This method can describe an image with a certain key point, where each key point has a gradient orientation (GO) and a gradient scale (GM) which is processed into features in the image registration process. The purpose of this study is to match images that have been cut off and in the process of merging they are still overlapping. The results of this study are that images that are split into two can be combined with image stitching.*

Keywords: *Image Stitching; A-KAZE Algorithm; Feature Extract; Panoramic Borobudur*

I. INTRODUCTION

Semua Borobudur Temple in Indonesia has a very beautiful and interesting and unique panoramic and natural beauty. Each staircase is square and has a beautiful relief on the walls. stone carvings carved into blocks like bricks, which are arranged to form a very sturdy wall.[1]Borobudur was built in the Mandala style which reflects the universe in Buddhist belief. The structure is square, with four entrances and a circular center point. For shooting using 2D, the process of merging two overlapping images is then combined into one, to produce a segmented panoramic image of Borobudur. The initial image resolution of objects 1 and 2 is 938 x 996 pixels [2][3]. The reconstruction of the temple panorama object uses deep learning for image stitching to produce a high-resolution image of the temple[4].

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Taking panoramic pictures of the large and spacious Borobudur temple will result in a lot of noise that follows. So we need an imaging technique so that the merging of two images becomes neat with Image stitching which produces beautiful images.

Images that have noise and are multi-line and multi-image will be more difficult to combine panoramas. This problem can be overcome by using invariant local features with a scale or sequence of image cuts from the original image so that the method of extracting Borobudur temple features can be maximized[1]. The boundaries of paired images in the matrix and the similarity of high-resolution patch images of the Borobudur temple panorama can be collected for training and evaluation. The experimental results illustrate that the inner feature approach is better [5].

Taking panoramic pictures of the Borobudur temple using an idea-screen or wide-resolution camera can be used to take panoramic pictures with a wide area. This sequence will be used to combine the overlapping images/frames that are sequenced later in the stitching process[6]. The pattern in Sweep Panorama is a limitation because the user can only take pictures vertically or horizontally. This limitation will be seen when the user takes pictures from left to right, with a slight upward or downward rotation (human hand movement)[7].

II. METHODS AND MATERIALS

2.1. Borobudur Temple

Borobudur is a Buddhist temple in the form of a stupa located in Central Java, Indonesia. This temple consists of four entrances and a circular center point, consisting of Kamadhatu (160 reliefs), Rupadhatu (328 Buddha statues and 1300 reliefs in the form of Gandhawyuha, Lalitawistara, Jataka, and Awadana), Arupadhatu (circular stupa with holes, bells, and bells). upside down, containing a Buddha statue that leads to the outside of the temple. The main stupa is located in the middle as a crown in which there is a Buddha statue 42m above the ground with a diameter of 9.9m. and around Borobudur temple, there are Pawon and Mendut temples[1][2].
Image data retrieval used to test Borobudur temple experiments with different lighting levels, feature covers, color types, and nature[8].

2.2. Feature based techniques

Tracking and detection features for matching panoramic images using stitching techniques, this method can automatically stitch together a collection of images through points, lines, edges, corners, or other shapes[9][8][10][11]. The main characteristics of this detector include invariance to image noise, scale invariance, translational invariance, and rotational. transformation[11]. In the feature-based technique, all the main feature points in an image pair are compared with all the features in another image using one of the local descriptors. For image stitching based on feature-based techniques, feature extraction, registration, and blending are the different steps required to perform image stitching[5]. Feature-based techniques aim to determine the relationship between images through the different features extracted from the processed images[6]. This approach has the advantage of being stronger against scene motion, being faster, and having the ability to automatically find overlapping relationships among non-consecutive sets of images. The way feature detection works is to process through special points of an image that is not seen as a whole, but the points are taken separately. In detecting features, several image displays are then calculated in real-time, described, and matched as quickly as possible[9][10][5].
To match the features of a paired image, it must have two criteria, namely:

1. feature points of the same scene in different perspectives, viewing angles, or lighting conditions must be the same
2. The points must have a sufficient amount of information to match each other

2.3. Image Stitching

Image merging is combining two or more images of the same scene into a high-resolution image, which is called a panoramic image[5][10]. Image stitching technology directly compares the intensity of all image pixels with each other. Feature-based technology aims to determine the relationship between images through various features extracted from the processed image.

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Image stitching is the process of combining data from multiple images to form a larger composite or mosaic image. All types of cameras can be used to create panoramic photos. This is done by taking several photos of the object at different angles. If the panoramic image to be created is 360°, the camera position when taking the photo is rotated on the 360° axis[12].

Every photo taken must always overlap or overlap so that each photo can be assembled into a panorama. The collection of photos that have been taken is then continued in the stitching process, making the image an integral part of the panorama. In this study, the image mosaic process uses the RANSAC (Random Sample Consensus) method to find the homograph matrix. The homograph matrix is used to project one image to another based on the feature matching found..

2.4. A-Kaze

Accelerated KAZE (AKAZE) is a recently proposed multi-scale 2D feature detection and description algorithm in nonlinear scale space[13]. This paper presents an image stitching algorithm that uses a feature detection and description algorithm,[14][9] AKAZE and image blending algorithms; weighted average mix. The whole process is divided into the following steps: First of all, detect the feature point on the image and then get the feature descriptor of the detected point using AKAZE[5][10][11].

The use of the RANSAC (Random Sample Consensus) algorithm in calculating the homograph matrix for image blending using a weighted average blending algorithm. The use of the proposed AKAZE based algorithm minimizes stitches and produces perfect stitch images, and also this algorithm is faster than the previous algorithm[13].

2.5. Method-Image Stitching Algorithm

The proposed image stitching algorithm is shown in Fig. 1. a match is known as a true or inlier match. A true match is defined as the selection of a successful conjugate feature point in the second image for each corresponding feature point in the first image. Furthermore, these inlier points are used to estimate the homograph (transformation) between the two images[15].

Image registration is the process of matching multiple, usually overlapping images, of a sample scene into the same coordinate system[12]. The spatial relationships between these images can be rigid transformations, affines, homographs, or complex deformation models. In this study, we focused on improving accuracy in situations of rigid transformation (translation and rotation), which supports producing high-resolution panoramic images. The general architecture for sewing multiple drawings is presented in Fig. 1. The fundamental combination based on the traditional approach is to follow the algorithm[13].

The process of creating a panoramic image consists of the following steps:
1. Keypoint detection and descriptor
2. Detects a set of matching points that exist in both images (overlapping areas)
3. Apply the RANSAC method to improve the detection of the matching process
4. Apply a perspective transformation to one image using another image as a frame of reference
5. Merge pictures

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The flowchart can be seen in Figure 1.

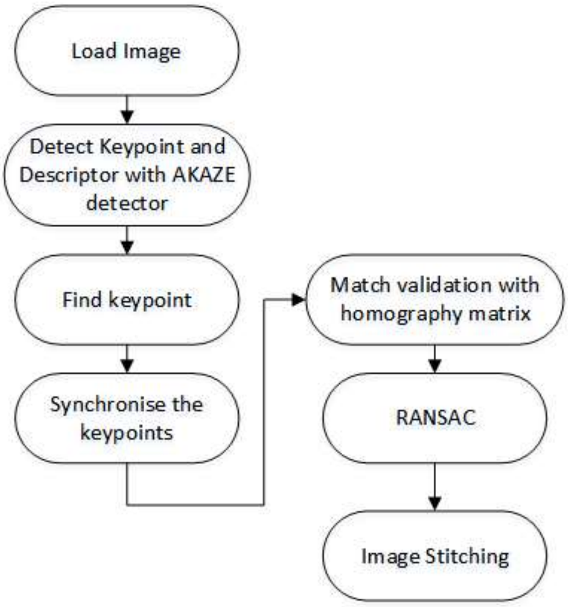

Figure 1. Flowchart Models

2.6. Homography Estimation using RANSAC

RANSAC (Random Sample Consensus) is a method used to find the Homograph Matrix and at the same time serves to remove outliers from the features that have been found. Outliers are features that have values that deviate from most other features. Homography Matrix is a transformation matrix that is useful for projecting one image on another image according to the feature match found. By multiplying the image with the Homograph Matrix, the image will undergo geometric transformations such as translation, rotation, scaling, skew, shear, and others[12].

Ransac's ability to estimate model parameters is that it can estimate parameters with a high degree of accuracy even when a large number of outliers are present in the data. While the weakness is having a time limit needed to calculate the inlier parameters. When the number of iterations is small at the time of calculation, then the solution may not be optimal and may not even fit the data in a good way. This algorithm produces results with probabilities that have many iterations. The data used consists of inliers, distributed data can then be explained by several sets of model parameters. The verified model can be compared with the probabilities of producing an inlier set at the correct image fit or an outlier set generated by an incorrect image match.

$$\begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = H \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

Where (u v 1) T is X2, (x y 1)T , is X and is a Homograph Matrix in the form of a 3 x 3 matrix.
This homography matrix is used to unite the two interconnected images. The output of this method is a Homograph Matrix. To unite the two images, the first image only needs to be multiplied by the matrix[15].
The purpose of the RANSAC algorithm is to iteratively select a random subset of the original data, where a set of observed data values and model parameters can be described in pairs. Following are the steps of the RANSAC Algorithm[8][7][5]:

1. Random selection of the minimum number of points is required to detect the model parameters.
2. Determine how many key points from the set according to the level of match

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3. estimate the model parameters that have been identified and end in inlier, if the fraction of the number of inliers is above the total number of points in the set, it will exceed the maximum threshold value that has been determined
4. Otherwise, this process can be repeated several times, so that each time it produces a model with few points, it is rejected as an inlier or a perfect model

III. DISCUSSION AND RESULT

This research presents a sewing approach to produce high-resolution panoramic images of beautiful places. This system is an important approach in computer vision for estimating the homographic matrix of each image pair based on deep feature selection. In this approach, multiscale keypoint detection and feature description match and select the appropriate point between each pair of images. To retrain the detection model. The experimental results illustrate that deep feature extraction is suitable for extracting key points for estimating transformation parameters, which significantly supports image registration, wrapping, and stitching. The plan further focuses on investigating the architecture more deeply and training on a larger benchmark data set for better performance and improvements to multiscale feature detection and description.

3.1. Load Image

The dataset used for this analysis is a personal dataset uploaded to the kaggle.com website (https://www.kaggle.com/faruqaziz/puzzlessd) with data collected from various sources (the images collected are original photographs without any effects any computation).

Figure 2. Example of object 1 used

Figure 3. Example of object 2 used

Figures 1 and 2 are the objects used in this analysis, where they are the object of the photo of the temple which is split into two and then the images are merged

3.2. Keypoint detection with AKAZE detector

In this analysis, the akaze detector is used to find keypoints and descriptors for each image

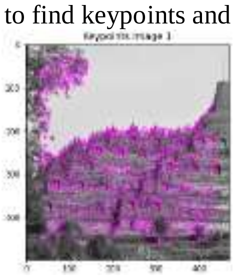

Figure 4. Keypoint on object 1

Figure 4 shows the results of the keypoint after detection with the AKAZE algorithm, it can be seen that every keypoint that exists leads to each object in the image.

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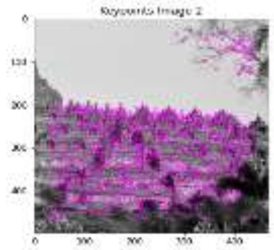


Figure 5. Keypoint on object 2

Figure 5 keypoint results from the second object which also shows that every keypoint detected is an object

3.3. Looking for the best match

At this stage, after the keypoint is found on the object, image matching is performed. If the closest match distance is significantly lower than the second closest distance, then the match is correct (unambiguous match), the results can be seen in Figure 6.

Detector AKAZE: 1 keypoint

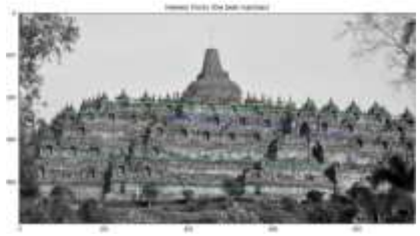
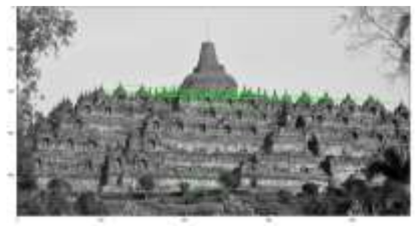


Figure 6. Image match with akaze detector

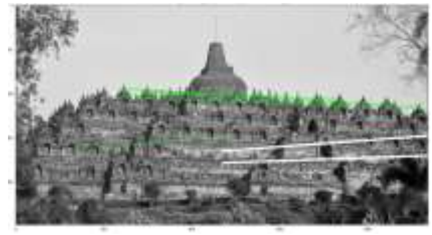
Figure 6 is the result of combining with the akaze detector.

SIFT Detector: 6 Keypoint



We also analyzed by comparing other algorithms, as shown in the picture above with the SIFT keypoint algorithm, it looks a bit more but not directed at this object, namely the temple.

Detector KAZE: 4 keypoint



Meanwhile, the KAZE algorithm shows that the key points are pointing in the same direction but not more key points than AKAZE

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ORB detector: 0 keypoint

We also detect with the ORB algorithm and this algorithm cannot detect key points on temple objects.

3.4. Improve keypoint match with RANSAC

$$\begin{matrix} x \\ y \\ 1 \end{matrix} = H \begin{matrix} x \\ y \\ 1 \end{matrix} = \begin{matrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{matrix} \times \begin{matrix} x \\ y \\ 1 \end{matrix}$$

It is important to note that when we match feature points between two images, we only receive matches that fall on the corresponding epipolar line. We need this good match to estimate the homograph matrix. We detected a large number of key points and we need to reject some of them to keep the best. Now, we need to calculate the homographs. We implement the cv2.warpImages() function which consists of the parameters img1, img2, and H. The first and second parameters are our two images and H is the homograph matrix. As we already explained this3×3matrix will be used to convert the second image to have the same perspective as the first which will be saved as a reference frame. Then, we will extract information about the transformation of the second image and use that information to align the second image with the first. To find this transformation matrix, we need to extract the coordinates of at least 4 points in the first image and the corresponding 4 points in the second image. These points are connected by homographs so we can apply a transformation to change the perspective of the second image using the first image as the reference frame. The previous objects were merged and then matched the keypoint with RANSAC, the results can be seen in Figure 7.

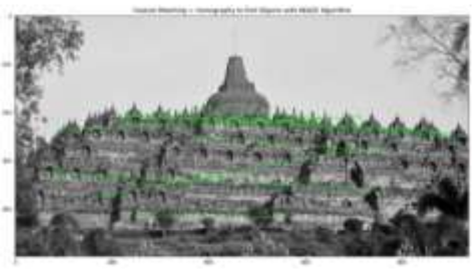

Figure 7. Object after RANSAC

After a comparison with a similar algorithm, in this study, more key points were detected with AKAZE, but to optimize and it is hoped that more key points were found, the RANSAC method was used to optimize key points from AKAZE

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3.5 Show result image

The resulting image can be seen in Figure 8

After the object's keypoint is detected later and RANSAC has been proven to be able to optimize this AKAZE method, the last stage is merging objects and looks like Figure 8 above.

IV. CONCLUSION

The panoramic depiction of the Borobudur temple is one of the most important research areas in the field of image processing, matching the image with a very wide and wide image. Presentation of basic and basic image stitching techniques using the feature-based A-KAZE algorithm. AKAZE algorithm and RANSAC algorithm can remove outliers from the two images. A review of the literature on image stitching shows that there is room to improve the stitching process with various other techniques as well. Several factors can cause errors in the stitching process. Taking pictures that are not by the movement of the camera's eyes, resulting in many unresolved effects such as parallax that is too high. Then there is movement in the captured object which can cause ghosting effects or the failure of feature matching.

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