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Integrated Colormap and ORB detector method for feature extraction approach in augmented reality

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Abstract
Augmented Reality (AR) is a technology that addition of virtual objects into the real-world environment. AR technology uses images recognition approaches to recognize objects. The objects can be easily recognized if rich in details, have good contrast, and have no repetitive patterns. A feature-based technique called Natural Feature Tracking (NFT) system can be used to recognize physical objects in markerless AR. The features such as blob, edge, and corner in the object are extracted by the feature detector and descriptor before recognizing process. The extraction feature is the most important thing in the recognition process because it can determine accurate results. ORB detector is a feature extractor were suitable for real-time tracking in AR because it has speed, efficiency, and a high quantity of features detected and extracted. However, before detecting and describing the features, ORB detector uses the Grayscale Image Generation (GIG) process to change color images into grayscale images. We found some features extracted using the GIG process not extracted perfectly. ORB detector is influenced by the intensity of the grayscale pixel to find the candidate corner. The proposed integration of the Colormap technique and ORB detector method can enhance feature extraction for improving features detection in AR.

Keywords Image processing · ORB detector · Colormap · NFT · Augmented reality

1 Introduction

Feature extraction is a fundamental image processing approach of many computer and machine vision applications such as Robot Navigation, Object Detection, Object Tracking, Augmented Reality (AR) [31], Image Segmentation [36], Digital Watermarking [5, 46],

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Steganography [18, 19, 30], and Cryptography [48]. Image processing aims to identify and recognize the object's shape in a digital image [38]. The image-based techniques are used to capture the texture and geometry of objects in the scene [39]. Natural Feature Tracking (NFT) system is used to recognize an object in the Augmented Reality technology [37]. The feature recognition is used to extract the geometry information [34]. The markerless tracking technique uses natural features from the real environment [24]. The natural feature markers have the advantage of not designing specific ID marker to be recognized by the camera [11]. ID marker in natural feature marker comes from the process of feature detector and descriptor, which consists of a binary number. Thus, the process of feature detector and descriptor can affect the recognition of the object.

ID marker is a unique pattern to identify each different object, it must have accurate features that the camera can track and recognize the object. Sometimes the marker shows insufficient features, such as does not have a good texture, noise, and lightning, especially if the marker is taken directly using a camera and it is difficult to be detected. Image enhancement is needed to remove ambiguous noise in these resources. By removing noise, the feature extraction can extract more true positive features and less false-positive features. Thus, the inter marker confusion will be less, and in other words, the accuracy is increased.

2 Related work

Object tracking is the one most crucial issues in AR application because of the unpredictable structure of the object [3]. Vision-based approaches are used to track 2D and 3D Object [6]. Whereas, in the 3D vision part the 2D features are compared with the database of 3D models. 2D views of the 3D model are used to identify potential locations of the objects to be searched. Vision-based in AR uses two methods which are using markers and using features (Markerless) [4]. There are several techniques for tracking natural features such as SIFT (Scale Invariant Feature Transform), SURF (Speed-Up Robust Feature), and FAST (Features from Accelerated Segment Test). FAST corner shows ten times faster than the SIFT and SURF algorithms and the FAST corner is still used as the faster detector [40]. The feature extraction based ORB (Oriented FAST and Rotated BRIEF) is better than other feature detectors such as SIFT, SURF, KAZE, AKAZE, and BRISK [42]. The advantages of using ORB are based on speed, efficiency, and high quantity of features detected [42]. Referring to a particular study from [41], the classification of feature detectors such as ORB uses a template-based method to match the keypoint. Based on the summary of the feature extraction method by [28], it can be seen that the foundation of the method based on the ORB detector and FAST corner is the intensity of the image pixel. The intensity pixel belongs to the classification of the global feature group, where the global feature has the disadvantage of not being able to separate the foreground from the background and tends to mix information from both halves together [16]. Thus, the intensity dramatically affects the accuracy of the feature detector in detecting features [42]. The intensity is the foundation of some feature detectors and descriptors such as FAST corner detector which compares candidate corners with surrounding pixels to determine the location of the corner [21]. This technique is also applied to track features in AR technology. In the feature extraction to find the features from the images, the RGB image was changed into a grayscale image after comparing to every brighter and darker pixel [52]. FAST corner detector divides pixels into 7 × 7 like Bresenham circles [33], if the pixel is darker or brighter with N < 12 or N < 9 from the candidate corner, then the candidate is selected as a corner.

Several researchers have been used ORB detector as feature extraction in AR [17], and another researcher has been improved ORB detection in AR [9, 53]. Based on the improvement, other researchers agreed that the matching feature in the planar image [9] and 3D object [53] affect the recognition of the AR marker. The challenge of AR application is to recognize sufficient features in a natural environment to estimate the pose and orientation of the real-time camera [8]. For example, AR Software Development Kit (SDK) such as Vuforia uses FAST corner detection to track features [45]. The FAST corner uses darker and brighter pixels from grayscale images to find a corner [21, 52]. However, the images are oriented from RGB images are changed to grayscale images, the images can lose some details [43], and the grayscale image is included under the Histogram Stretching (HS) category. The operations will cause the pixels to be rounded into the highest or lowest grayscale values. To minimise the lack of histogram stretching methods, the researcher used the Contras Enhancement method [32]. Based on this problem, feature extraction in the AR framework, especially on tracking features using FAST corner detection with grayscale images, is not suitable because the FAST corner is comparing the brighter and darker values of images that have lost some of the details which can affect the determination of candidate corner.

Our previous research [2] compared three Contrast Enhancement methods such as Histogram Equalization (HE), Contrast Limited Adaptive Histogram (CLAHE), and Colormap for enhancing the grayscale image and tracked the corner feature using FAST corner detector. As a result, the Colormap method is better than HE and CLAHE in terms of noise, distributed histogram, and accuracy of corner detected by using the FAST corner detector. Because ORB uses oriented FAST as a feature detector, we proposed the integrated Colormap and ORB detector method.

3 Feature extraction

Feature extraction involves reducing the number of resources is required to classify large data sets. The ORB detector has been used as feature extraction in AR [9, 17, 53]. The feature extraction process is about finding the Interest Points or features from the image or the video, detecting the descriptors from the interest point, and then comparing the descriptors with the data in the database [35]. Feature extraction involves descriptor computation, which is typically performed around the central region of the feature detected by the feature detector. Descriptors use image processing to transform local pixel environments into representations vector. This representation can make comparisons between existing environments that are being changed from scale or orientation. Descriptors, such as Scale Invariant Feature Transform (SIFT), Speeded up robust features (SURF), and Harris corner, use local gradients to find the features. The binary descriptors, such as Features from Accelerated Segment Test (FAST), Binary Robust Invariant Scalable Keypoints (BRISK), Binary Robust Independent Elementary Features (BRIEF), Fast Retina Keypoint (FREAK), and oriented FAST and rotated Brief (ORB), used local intensity to find the candidate features, then descriptor changed into binary vectors. ORB detector is more suitable for real-time tracking based on computational efficiency, quantity, and speed than BRISK, SURF, SIFT, AKAZE, and KAZE [42].

Accurate features detection is very important to recognize an object fast and robustly in Augmented Reality. Therefore, image processing is necessary to identify and recognize the object or marker on a digital image [38]. Sometimes, the marker does not use good features, such as lack of a good texture and noise and lighting problems, especially if it is directly captured using a camera. This makes the features difficult to detect or encounter mismatches [8]. Sufficient features are needed to detect specific objects such as problems that occur by [8]. Hence, such feature extraction, which can extract many features accurately is needed. Features detection is mainly aimed to produce features for robust object detection. With specific features in the images, hidden information can be added, such as steganography techniques [48] and watermarking techniques [5]. ORB detector using oriented FAST as a corner detector enables the intensity of grayscale images to influence the detection of candidate corners. In the AR framework, Features Extraction, which uses Grayscale Image Generation (GIG) process [27, 35] where RGB image converts into the grayscale image, the process can lose some features and details of the image [2]. The features cannot extract precisely during the features extraction process due to noise and image quality. So that, to enhance the grayscale image, the Colormap method will be used. The more features can be detected, the more robust the markers can be tracked and recognized [8].

3.1 The enhancement of feature extraction method

NFT in AR basically uses an image that will be captured using a camera, and the image is converted into a grayscale image [50]. Based on the AR framework using the GIG process to change RGB images into grayscale images before tracking the features in the marker, the process of converting the grayscale image is included in the Histogram Stretching (HS) category. These operations cause the pixels to be rounded to the highest or lowest grayscale values. This process can make some extracted features in the database by using GIG not extract well because of lack of details. According to [27], feature extraction in AR has six steps: Grayscale Image Generation (GIG), Integral Image Generation (IIG), Response Map Generation, Interest Point Detection (IPD), Orientation Assignment (OA), Description Extraction (DE). According to [35], the process of feature extraction is based on SURF. This paper examined oriented FAST as a feature detector and rotated BRIEF as a feature descriptor or called ORB detector for real-time tracking. According to [47], ORB consists of interest point detection (Keypoint Detection & Non Max-Suppression), Orientation assignment (Orientation Estimation), and description extractor (descriptor generation).

The GIG process as aforementioned above affects the ORB detector result because the FAST corner works as a feature detector. The integrated Colormap and ORB detector can enhance feature extraction, and this method has five main steps, which are image acquisition, GIG process, enhance grayscale using Colormap technique and detect and describe the feature using ORB detector. This framework is illustrated in Fig. 1. We proposed to use the Colormap technique at feature extraction based on ORB detector. Therefore, this research proposed the new method with integrated Colormap and ORB detector as illustrated in Fig. 1.

The proposed enhancement of feature extraction method consists of four main processes: image acquisition, Grayscale Image Generation (GIG), Colormap technique, and ORB detector. **First**: acquisition of the dataset image before doing image enhancement techniques. **Second:** convert the image into a grayscale image to make effective color modifications. **Third:** The Colormap technique improves details of corner boundary in the marker and reduces the conversion effect on the colored image. **Fourth:** The Oriented FAST and Rotated BRIEF (ORB) is used as a feature detector-descriptor to extract keypoint into a binary vector. That includes three steps: Interest Point Detection (IPD), Orientation Assignment (OA), and Descriptor Extractor (DE). The following subsections will describe the Fig. 1 in further details.

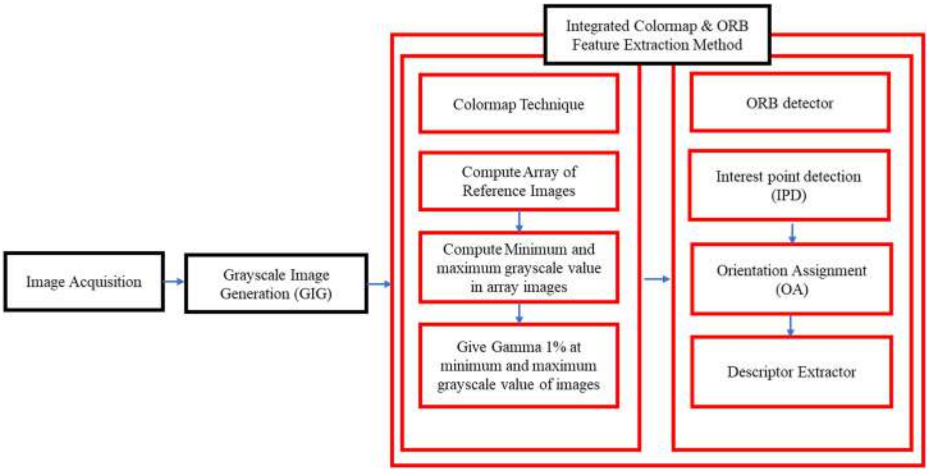

Fig. 1 The enhancement of feature extraction method

3.1.1 Image acquisition

The first step is acquiring the image which mainly aims to transform an optical image in Real-World data into an array of numerical data that could be manipulated with a computer or smart devices. The image should be collected by the cameras and converted into a manageable entity before any processing of video or image is carried out. The feature matching used in AR has two image acquisitions. The first is used as reference images or database images, and the second is used as real-time tracking to recognize the object. Many factors can affect detection in tracking objects such as light intensity, Light Marker Camera (LMC) angle, surface smoothness, and physical movement camera in real-time tracking. This factor is a part of the marker placement factors that can affect the quality of the marker [25].

3.1.2 Grayscale image generator

The second step is converting the marker into a grayscale image or called Grayscale Image Generation (GIG) process. GIG is a process that converts the image into a grayscale pixel value, which aims to make it effective for color modification [27]. In the grayscale image type, there is no influence from other colors such as red, green, or blue. Each pixel is a grayish image, typically 0 (black) to 255 (white). The grayscale image not only increases the image processing method, but also prevents unwanted noise from a colored image. Therefore, an RGB to grayscale conversion is performed as a foundation of FAST corner detection to determine candidate corners.

3.1.3 Grayscale image enhancement method using Colormap technique

The third step uses the Colormap technique to enhance the grayscale image. The grayscale image enhancement method using Colormap technique consist of three steps are involved: first, get an array of the image; second compute the minimum and maximum grayscale values in array images; and last give gamma = 1 at the minimum and maximum grayscale values (low_in high_in, low_out high_out). Instead, gamma is less than one makes the image is mapping to a higher (brighter) output value. Otherwise, if the gamma greater than one makes the image is mapped with the lower (darker) output value. Gamma = 1 is given at the minimum and maximum grayscale values 1% gamma, which is also called linear mapping.

Colormap is one of the contrast stretching techniques [44]. Linear contrast enhancement is also called contrast stretching. Basically, contrast stretching uses for grayscale medical images to improve the quality of the image. Contrast stretching can expand the intensity value of an image. This is called contrast stretching because the bright pixels in the image will be brighter and dark pixels will be darker. Extending the original digital value linearly into a new distribution. In other words, the image has a higher contrast. By expanding the original input value of the image, the sensitivity range can provide the determination of the appropriate intensity value to increase the details of grayscale image. Linear contrast enhancement using the minimum-maximum linear contrast range, the original minimum and maximum values of the data are set to a newly defined set of values using the range of available brightness values. This process creates an even histogram by stretching the minimum values and maximum value of the intensity pixel. An illustration of the contrast distribution by contrast stretching using Colormap can be seen in Fig. 2.

Linear contrast stretching is the best contrast stretching algorithm. The gray values between the original image and the modified image follow a linear relationship throughout this algorithm. That unclear features or details in the original image are obvious different in the stretched image [15]. To produce the best contrast, color variation combines small variations of the gray values in each band stretches to the full brightness range of the output or display unit. The algorithm can match the old maximum value to the new maximum value and the old minimum value to the new minimum value. All old intermediate values are scaled proportionally between the new maximum and minimum values. The proposed colormap technique uses linear mapping with three processes: first, compute an array of the reference image; second, compute maximum and minimum grayscale value on the image, and third, gamma 1% is given at the minimum and maximum grayscale value of the image. This process can be seen in Fig. 3.

Image enhancement is an active area of study that has produced a large number of papers on contrast enhancement. The contrast of an image is the most important factor that influences the quality of images [12]. The grayscale image contrast indicates how easily object can be identified in the picture. Many distinct intensity values indicate that the image has high contrast. Contrary, low contrast has low intensity values. GIG operations cause the pixels to be rounded to the highest or lowest grayscale values to make the image lack details. Meanwhile, ORB and FAST corner detector are greatly influenced by the grayscale pixel intensity to determine the candidate corner.

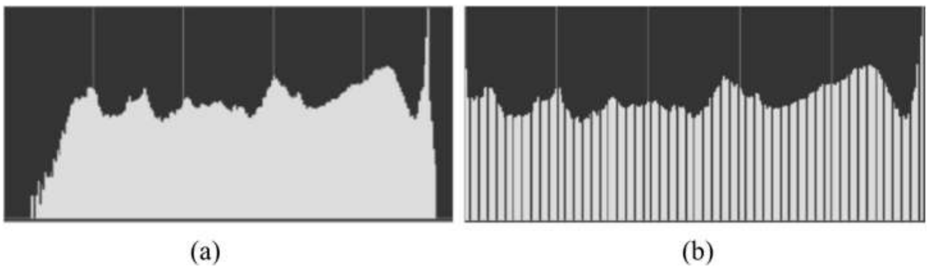

Fig. 2 Illustration of Contrast Stretching. (**a**) Original distribute histogram. (**b**) using Colormap)

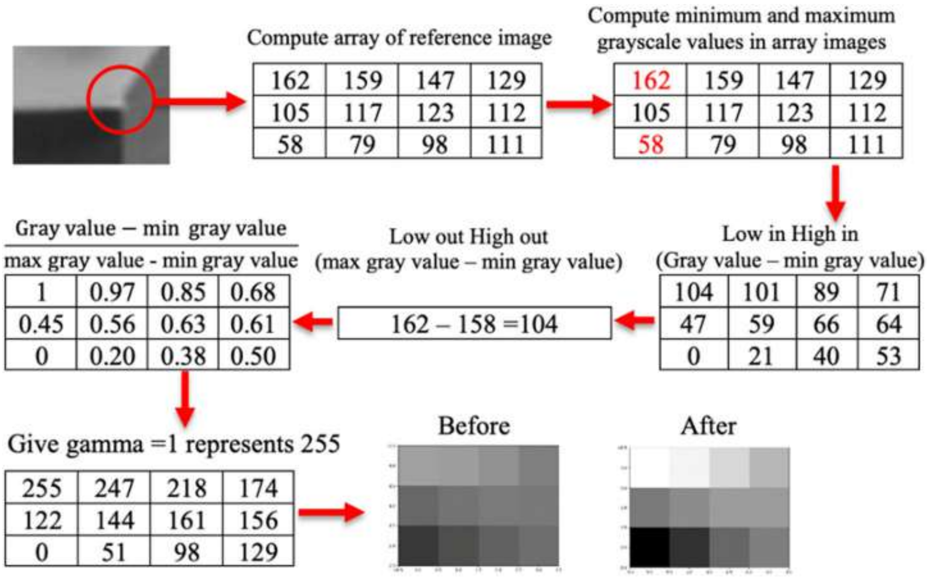

Fig. 3 The process of Colormap technique

3.1.4 ORB detector method

In the fourth step, the ORB detector method is used to detect the interest point. Based on the literature, interest points were called as keypoints. ORB detector method has three steps, which are Interest Point Detection (IPD), Orientation Assignment (OA), and Description Extraction (DE). Interest point detection in ORB using oriented FAST, then the keypoint is used to measure orientation assignment by using a pyramid scheme scale for detecting keypoint in scale-invariant and rotation, then rotated BRIEF is used to describe the keypoint into a binary number, the binary number is used as ID marker in Augmented Reality.

Interest point detection (IPD) The main process for obtaining interest point is measured with the color components as well as grayscale luminance. The algorithms which are used to find the interest point, called feature detectors, and the descriptors are the algorithms that used to describe the features. The interest point is the anchor point, which also gives the invariance attributes of the scale, rotation, and illumination invariant for the descriptor, while the descriptor adds details and more invariance attributes [26]. The algorithm for interest point detector such as FAST comer detector has been used to find the key point in the input image. Moreover, by this FAST corner detector, the number of corners is likely to become keypoint. It also uses an image pyramid to produce multiscale features. It is categorized as a keypoint if the corner candidate score is more than 8 pixels from the related neighbour [47].

Orientation assignment (OA) After determining the keypoint, then orientation to each keypoint like determine neighbour keypoint rotation and multiscale depending on how the intensity level changes around the keypoint. An image rotation function is supplied with a reproducible orientation at each interest point to get orientation by intensity centroid. In this step, the centroid's intensity is obtained from the value of the patch with the corner located in the middle. Therefore, the vector direction from this vertex to the centroid forms the orientation. For obtaining the rotation invariance, the moments are computed within a circular region of a defined radius on which radius is defined by the size of the patch [14]. The pyramid scheme scale is used to detect features on different scales, whereas the intensity centroid technique is assigned to the orientation, with assuming a general equation for the patch's moment.

Description extraction (DE) There are many natural feature algorithms already used in modern computer vision applications. Each algorithm applies different methods for calculations keypoint detection and keypoint descriptor. Apart from the different keypoint detector can divide natural feature algorithms into two main groups by the types of calculated descriptors used: floating and binary type descriptors [10]. The feature exaction is all about finding the interest point on video /picture, finding the descriptors, and comparing it with the interest points within the database or reference image. The keypoint descriptors have such characteristics that they can be found from an image and distinguished it from other keypoints, and most importantly, the features match with the features it selves in different image transformations such as translation, scaling and rotation can be determined [10]. To get descriptor rBRIEF (rotation BRIEF), where BRIEF (Binary Robust Independent Elementary Features) is weak at rotation, rBRIEF was developed to cover the weakness. The rBRIEF determines a test point which is strong at rotational changes.

A feature point is typically represented by a number of descriptors. The rotated BRIEF algorithm for calculating the feature point descriptors is used in the ORB detector Algorithm. The details of the rotated BRIEF algorithm are described as following. Firstly, consider the oFAST circular patch, then pick M pairs of Gaussian distribution points in a patch. Secondly, rotate this pair of points at the corner is defined by an Eq. 2 to ensure the rotation invariant. Thus, after rotation, the M pairs of points can be classified as $D1(IA1,\ IB1), D2(IA2,\ IB2), D3(IA3,\ IB3)\ \ldots\ DM\ (IAM,\ IBM),$ where Ai and Bi are the two points of a pair, IAi and IBi are intensity values of the point [13]. Thirdly, an operator is defined as follows:

$$T(Di(IAi, I\,Bi)) = \begin{cases} 1 & if\ IAi\ \geq\ IBi \\ 0 & if\ IAi < IBi \end{cases}, \tag{1}$$

The operator is T, giving a result one bit for each corner pair. The M pair generates a $M\text{-}length$ vector for operator T. For example, T produces the following results, $T(D1(IA1,\ IB1)) = 1,\ T(D2(IA2,\ IB2)) = 1,\ T(D3(IA3,\ IB3)) = 0 \ldots T(DM(IAM,\ IBM)) = 1$, then the descriptor of the feature point P is 110...1. The bit vector is a descriptor of the feature points and as ID Marker in AR application.

3.1.5 The proposed algorithm

The proposed enhancement of feature extraction method consists of four main processes: image acquisition, Grayscale Image Generation (GIG), Colormap technique, and ORB detector. **First**: acquisition of the dataset image before doing image enhancement techniques. **Second:** converts the image into a grayscale image to make effective color modifications. **Third:** The Colormap technique is used to improves details of corner boundary in the marker and reduces the conversion effect on the colored image. The Colormap have five process, which are compute array of reference image, compute minimum and maximum grayscale values in array images, compute low in high in, compute low out high out, and last is give gamma = 1. **Fourth:** The Oriented FAST and Rotated BRIEF (ORB) is used as a feature detector-descriptor to extract keypoint into a binary vector. That includes three steps: Interest Point Detection (IPD), Orientation Assignment (OA), and Descriptor Extractor (DE). The proposed Algorithm for enhancing feature extraction with the integrated Colormap and ORB detector is shown as following:

Algorithm 1 Integrated Colormap technique and ORB detector Method

Input:	Dataset image
Output:	Detect Features
Goal:	Enhance Feature Extraction
Step 1:	Read Reference image
Step 2:	Reference image convert into grayscale (Grayscale Image Generation)
Step 3.1:	Compute array of reference images
Step 3.2:	Compute minimum and maximum grayscale values in array images
Step 3.3:	Compute low in high in (Gray value – *Min* Gray value)
Step 3.4:	Compute low out high out (*Max* Gray value – *Min* Gray value)
Step 3.5:	Give gamma=1 (255) at [low in high in]/[low out high out]
Step 4.1:	Interest Point Detection (IPD) using FAST corner detection
Step 4.2:	Orientation Assignment (OA) using Pyramid Scheme
Step 4.3:	Descript corner features using rBRIEF Eq.(1)

4 Experiment results

The tricolor box image is used to see the effect of color conversion were affecting corner detection, and it can easily get the accuracy of the corner position. The robustness of image recognition techniques can be measure in terms of accuracy of recognition between two frames corresponding points [49].

4.1 Configuration of the experimental system

The configuration of AR recognition framework is based on the Natural Feature Tracking method (NFT) and consisted of image acquisition, feature extraction, feature matching, geometric verification, and information retrieval [35]. The feature matching is used in AR has two image acquisitions. The first is used as reference images or database images, and the second is used for real-time tracking to recognize the object. Then, the GIG process that converted the image into a grayscale pixel value, which aims to make color modification easier is used in reference image. Then, the Colormap technique uses linear mapping with three processes are used, which are: First, get an array of the image. Second, compute the minimum and maximum grayscale values in array images. Third, give gamma = 1 at the minimum and maximum grayscale values (low_in high_in, low_out high_out). Then, Features matching is used to validate the proposed method to get accuracy for the identification rate of the template and target keypoints [20, 42, 51]. This method was chosen to see the effectiveness enhancement process of feature extraction that affecting tracking results. This method measures the similarity of the features extraction in sources and environment. The brute-force matching method with k-Nearest Neighbors algorithm is used for features matching in two images. The two closet neighboars features in the test image are found for each descriptor in the reference image. Nearest Neighbor Distance Ratio (NNDR) with 0.8 threshold value is used. This threshold value is effective as stated by [7, 22, 29], it can remove 90% of incorrect matches and remove around 5% of correct matches. To achieve correct matching Random Sample Consensus (RANSAC) algorithm is used. RANSAC method can improve elimination of incorrect matches and estimate of image transformation is homographed [23].

4.2 Corner detection

An integrated Colormap and ORB detector is suitable to detect more features. ORB is using oriented FAST as a detector, although the intensity of grayscale pixel values can affect the selection of candidate corners. Yet, feature extraction is integrated of Colormap and ORB detector method provides additional features that can be detected in each dataset used. The GIG process causes the pixels to be rounded to the highest or lowest grayscale values. Figure 4 reveals the effect of converting a color image into a grayscale image in the GIG process, while Fig. 4(a) is the original image, Fig. 4(b) shows feature detector using Original ORB, and Fig. 4(c) illustrates the proposed method.

4.3 Effect color conversion

The result shows the conversion of the GIG process from a color image into a grayscale image makes some feature corners undetectable. It can be seen in Fig. 5.

The experiment aims to get more features detected, and then there are more features to be matched, and potentially affect feature matching. The robustness feature matching can be further improved by using feature points that can be detected reliably. This method can be used as feature extraction based on ORB detector in the Augmented Reality recognition to get more features matched.

4.4 Feature matching

The matching result of original ORB shown in Fig. 6, and the proposed method shown in Fig. 7 The result showed the proposed method more feature matches.

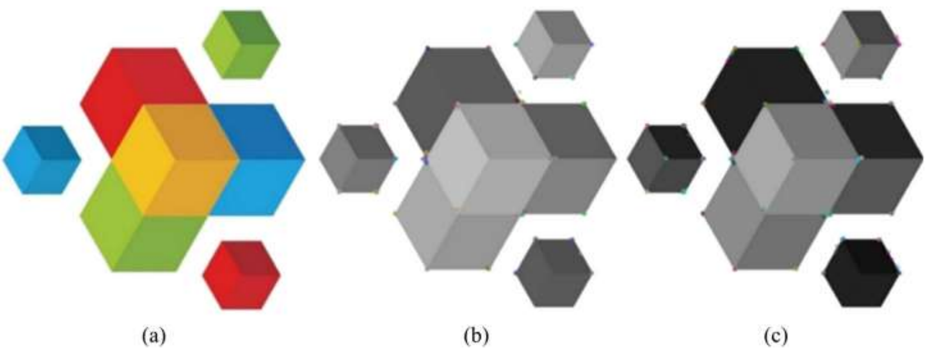

Fig. 4 Comparison accuracy of feature detection

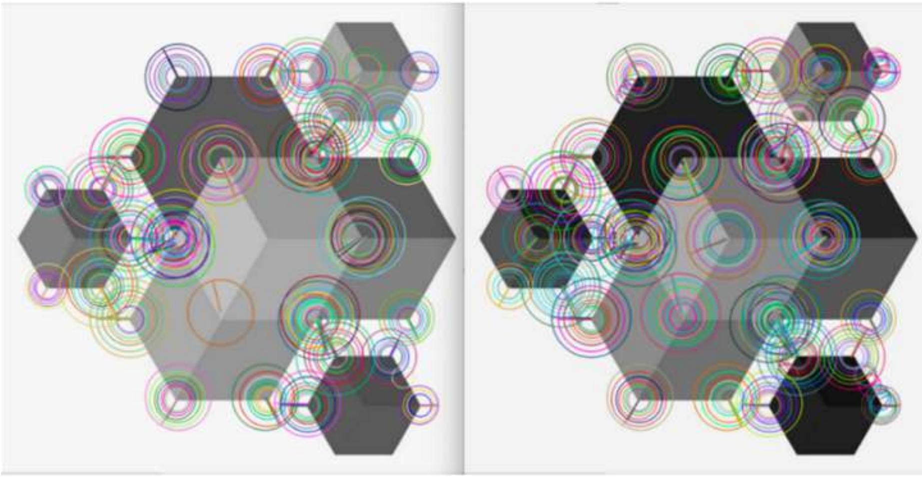

Fig. 5 The comparison of feature detection on RGB color conversion

4.5 The accuracy of the corner

Accuracy is another term frequently used to describe the robustness of image recognition techniques [49]. The accuracy percentage can be calculated with Eq. 2:

$$\text{Accuracy Percentage} = \frac{Number\ of\ correct\ matches}{Number\ of\ mateches} \times 100\% \tag{2}$$

The number of matches is a number obtained by brute-force matches. Whereas, the number of correct matches is the matched feature after running Random Sample Consensus (RANSAC) algorithm. The results in Table 1 show the accuracy increased on the proposed method.

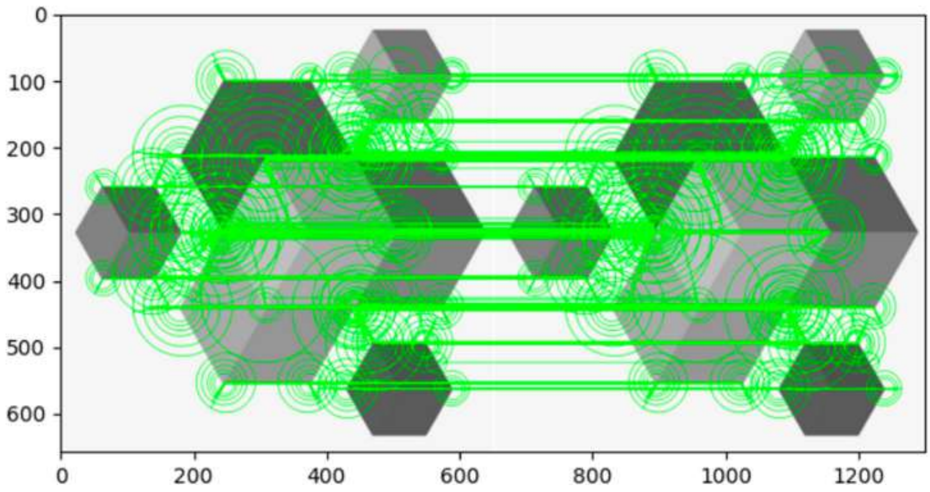

Fig. 6 Matching result of the original ORB

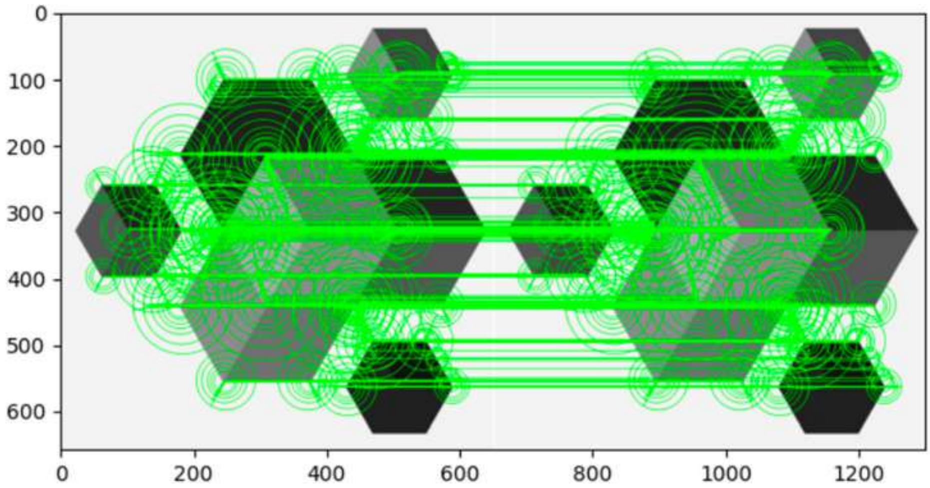

Fig. 7 Matching result of the proposed method

4.6 More feature extracted

Reference image from the Oxford dataset by Mikolajczyk (bark, boat, graffiti, wall, trees, bikes, Leuven, and UBC) and two Heinly's dataset (Venice and semper) were used to evaluate the feature extraction. The reference image is the first image (img1) each dataset. The experiment is using matching criteria with how ORB can extract maximum features from the dataset with number of features = 100,000 or more. The experiment aimed to detect more features to find out more potentially matched features [1]. The robustness feature matching can be further improved by using feature points that can be detected more reliably [54]. Figure 8 shows the maximum feature extracted between the original ORB detector and the proposed method. The proposed feature extraction with the integration Colormap and feature extraction method can extract more features so that there are more features to potentially match

4.7 Augmented reality testing

The homography of the marker is used to overlay the object to show the Augmented Reality object. The masking technique is created based on the location of homography by RANSAC and then used the inverted method to find the negative outside homography. Adding an inverse mask in the webcam can get a new overlay image in which all the webcam images and information are displayed except where the homography is located. The testing results showed the proposed framework has more features detected so that the objects can maintain their position and can be detected easily in Fig. 10 than original ORB in Fig. 9 where Fig. 10 is proposed method.

Table 1 Comparison of the features extraction & features matching result

Variable	Original ORB	The proposed method
Number of Correct matches	228	284
Number of matches	230	286
Accuracy percentage	99.13%	99.30%

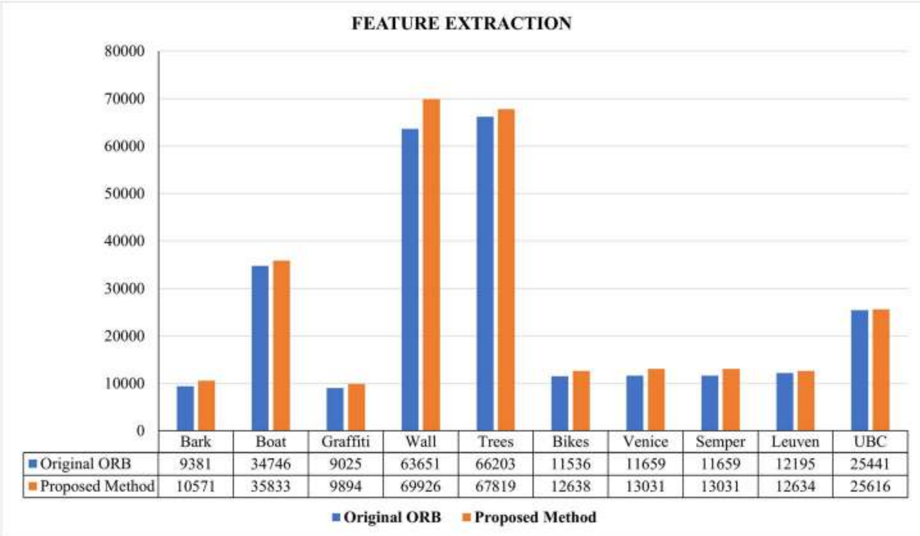

Fig. 8 Comparison of feature extraction each reference image datasets

5 Conclusion and future work

The intensity of the grayscale pixel in the image strongly influences the ORB detector to extract the feature. The determination of the candidate corner is determined by grayscale pixel value around the candidate corners and is caused by a feature detector based on the FAST corner as a feature detector in ORB. This algorithm detects the pixel value on the circle formed around the candidate point. Neighbours of the pixel must have at least nine pixels to be identified as a corner, all should be brighter or darker than the threshold. The GIG process can eliminate grayscale pixel details so that oriented FAST on ORB detector cannot detect the corner. Besides that, Colormap can enhance details of grayscale images. The Colormap algorithm gives a 1% gamma value in the image to get linear mapping. If gamma in Colormap is less than 1, the mapping is weighted toward higher (brighter) output values. If gamma is greater than 1, the mapping is weighted toward lower (darker) output values. By doing linear mapping, details on the image can be maintained so that corner detection is more accurate.

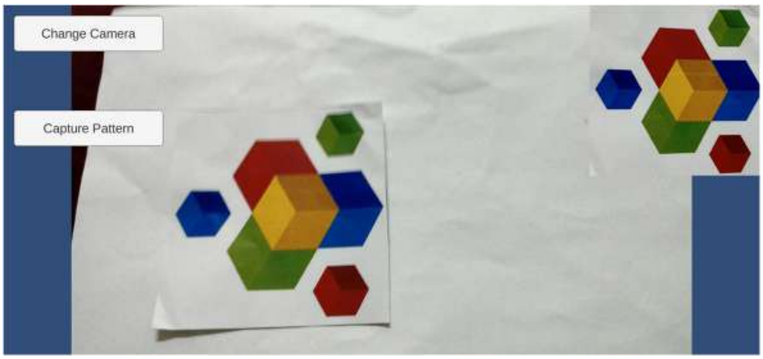

Fig. 9 Augmented Reality Testing using original ORB

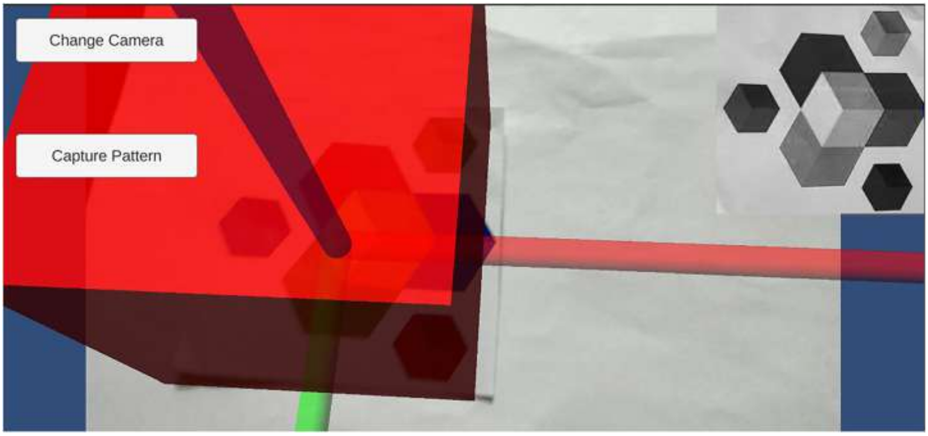

Fig. 10 Augmented Reality Testing using proposed method

This proposed method is get better matching features so that tracking is more accurate and robust. Thus, the virtual object can be easily overlay on the marker. This experiment only use several dataset to find the accuracy. In feature works, we plan to test recognition on real environment that includes all image conditions such as image rotation, scale changes, combination of rotation and scale changes, blur effects, JPEG Compression, and illumination changes.

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Declarations

Conflict of interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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