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The Performance Evaluation of Image Matching Techniques within UAV Images

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ABSTRACT

It was aimed that the images were acquired with two different types of UAV by feature-based transformation algorithms such as SURF (Speeded Up Robust Features), FAST (Features from Accelerated Segment Test) and BRISK (Binary Robust Invariant Scalable Keypoints) in this study. Images (acquired by both UAV types) grouped by inclination. This classification is based on the wing type of the UAV (Rotary-Wing UAV" and "Fixed-Wing UAV). Images with different characteristics were used to produce mosaics from the algorithms. The first performance preferred a flight height of 30 m (Ground Sample Distance, 0.82 cm/pixel) with the frontal overlap of 80%, and the second performance preferred a flight height of 60 m (GSD, 1.64 cm/pixel) and same overlap. Ten images from both performances were combined in all algorithms. Mismatches have been observed, and the mosaics produced after a very long process are not found satisfactory. According to the results, for rotary-wing UAV (SURF, BRISK and FAST), the algorithm run times were determined as 76.5 minutes, 11 minutes and 1839 minutes. Also, for fixed-wing UAV (SURF, BRISK and FAST), algorithm run times of 238 minutes, 95 minutes and 3350 minutes were determined.

1. INTRODUCTION

The process of producing the orthomosaic image can be done in two different ways: image mosaicing and image stitching. In image stitching, there are small overlaps between images in which the images are put together. In contrast, image mosaic requires extended overlaps and a blending of several images. The feature is a piece of information that has the task of solving computational problems in the process. The features can be specific structures in the image, such as points, edges, or objects (Aslan et. al., 2019). The features may also be the result of a general neighborhood operation or feature detection applied to the image. Features can be divided into two main categories:

- Features found in specific areas of the image, such as mountain peaks, building corners, doors, or interesting shaped points. Such positioned properties are often referred to as key point properties and are often identified by groups of pixels encircling the point position (Juan and Oubong, 2010).
- Properties that can be matched according to their orientation and appearance within the image are called sharp edges, and they can also be very well representative of the boundaries of objects in overlapping images and the matching lines of images (Durdu, and Korkmaz, 2019).

Key Point is the point that can be interpreted meaningfully in images. The point at which the boundary direction of the object suddenly changes or the intersection point between multiple edge segments (Figure 3).

In this study, it is aimed to acquire the outdoor images proper for the study taken with an unmanned aerial vehicle and mosaicing the images with feature-based transformation algorithms such as SURF

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(Speeded Up Robust Features), FAST (Features from Accelerated Segment Test) and BRISK (Binary Robust Invariant Scalable Keypoints) (Cen et al., 2019; Greengard, and Rokhlin, 1986; Rublee et al., 2011).

In this study, the image mosaic theory has been adopted because the overlapping areas of the images are considerably larger than aerial photogrammetry. The comparison of the algorithms researched in the literature such as SURF, FAST and BRISK was performed in the research. The advantages and disadvantages of the algorithms will be investigated by evaluating the results obtained in the study (Tareen et al., 2018). It is aimed to define the last version of this study as the most efficient method of these systems and to find the most appropriate one.

2. MATERIALS AND METHODS

SURF, FAST and BRISK algorithms were used on Unmanned Aerial Vehicle (UAV) images in this research (Makineci, 2016). Mosaics were constructed on two different models of UAV images and process times were recorded. Rotary-wing UAV and fixed-wing UAV are divided from each other as operating principles. While the fixed-wing UAV flies through the sky, the rotary-wing UAV can wait stable in the air. Because they have different positive and negative sides, it is not easy to guess which are required for users.

Speeded Up Robust Features (SURF) granted in 2008. SURF algorithm based on Gaussian scale-space analysis of images. SURF detector relies on the determinant of the Hessian Matrix and it utilises integral images to increase feature-detection speed (Bay et al., 2008; Tareen et al., 2018).

Binary Robust Invariant Scalable Keypoints (BRISK) described in 2011. BRISK detects corners the usage of AGAST algorithm and filters them with FAST Corner score to trying to find maxima inside the scale-space pyramid. The BRISK description is based totally on figuring out the feature course of each characteristic for reaching rotation invariance. To provide illumination invariance outcomes of simple brightness tests also are concatenated, and the descriptor is constructed as a binary string. BRISK features are invariant to scale, rotation and constrained affine changes (Leutenegger et al., 2011; Tareen et al., 2018).

The FAST algorithm is a feature detection algorithm suggested by Rosten and Drummond. FAST algorithm is an advancement of the SUSAN corner extraction algorithm. It maintains the SUSAN algorithm to detect the components of several feature points, and the algorithm has the benefits of high-speed detection and excellent efficiency of feature point detection (Rosten and Tom, 2005; Liang et al., 2012; Wu, 2018)

2.1 Features detection and matching of main components

Detection: Defining feature points

Description: Environmental form around each feature point, light ratios (contrast values), angular status, scale, and in-image rotations, etc. it is defined fixedly (ideally). The identifier is recognized by a vector for each feature point.

Matching: Identifiers are compared between images to find similar features. For two images, a pair in one image (Xi, Yi) ↔ (Xi`, Yi`), (Xi, Yi) is a feature in another image, (Xi`, Yi`) is matched if there is a matching feature in both images.

2.2 Points to consider when choosing feature extraction points

The points should have a very well defined position in the image. Despite local distortions in the image, they are fixed as light contract/brightness values, so feature points can be reliably found - with a high probability of repetition.

2.3 The feature identifier

A feature identifier is an algorithm that finds property vectors. Feature identifiers encode different information into a series of numbers and run the information as a kind of numeric “fingerprint" that can be used to differentiate one from another. Ideally, this information should be independent of the image movement. Thus, even if the image is moved in some way, we can find the same feature again. After identifying feature points, an identifier is calculated for each point. Identifiers are divided into two classes:

1. Local Descriptor: An integrated representation of the regional neighborhood relations of a point. This method is very suitable in terms of point matching since a point only deals with the neighborhood and regional relations.
2. Global Descriptor: Global descriptor defines the entire image. It is possible that the change in part of the image will fail, as it will affect the result descriptor, and is usually not very reliable (Zhong, and Yubai, 2019).

2.4 Image matching

Part of several computer visioning applications, such as matching features or image matching in general, image stitching, camera calibration, and object recognition, is the task of detecting that the same object is common to two images. Once the properties and identifiers are specified from two or more images, the next step is to create some preliminary matches between these images (figure 1).

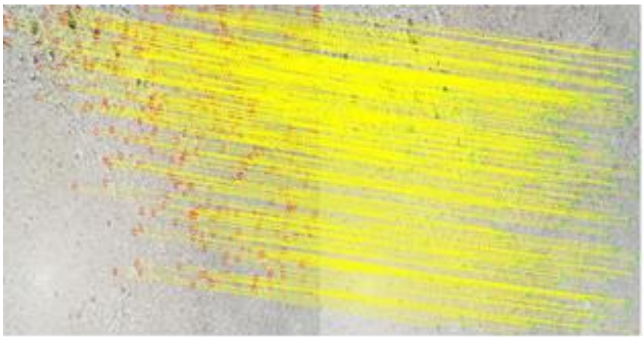


Figure 1. Image matching points

In general, the performance of matching methods based on feature points depends on both the areas of interest of the features and the selection of identifiers of overlapping images. Therefore, detectors and identifiers suitable for the image content should be used in applications. For example, if an image contains bacterial cells, a bubble detector should be used instead of using a corner detector. Feature extraction and matching algorithms processing steps:

- Detect specific key points,
- A region is defined around each key point,
- The defined region is separated and normalized,
- The local identifier is calculated from the normalized region; the defined local identifiers are matched.

2.5 UAVs and cameras

UAV with two different characteristics (according to wing types) was investigated in this study. Fixed-wing UAV (Sense Fly Ebee RTK) and rotary-wing UAV (DJI Phantom 4 Pro) are internationally known industrial brands. The cameras fixed on UAVs are also composite RGB cameras provided by the manufacturer (Figure 2). In particular, the feature that distinguishes these UAVs is their movement in the air. Fixed-wing UAV can fly like a plane and penetrate the wind. In this way, its long battery allows it to operate longer. Rotary-wing UAVs have motor and rotor systems that will remain stationary in the air. That causes more energy consumption. However, it is demanded by the users as it can take off / take off vertically and stand in the air.

Sensor	1"
RGB lens	f/2.8 - f/11, 8.8 mm/24 mm
RGB resolution	5,472 x 3,648 px (3:2)
Exposure compensation	±0.7 (3/5 increments)
RGB shutter	1/30 – 1/2000s
ISO range	100-12800
Support RTK/PPK	No

Rotary-winged UAV Camera Specs

Sensor	1"
RGB lens	F/2.8-11, 10.6 mm
RGB resolution	5,472 x 3,648 px (3:2)
Exposure compensation	±2.0 (1/3 increments)
RGB shutter	1/30 – 1/2000s
ISO range	125-6400
Support RTK/PPK	Yes

Fixed-winged UAV Camera Specs

Figure 2. UAVs and camera specs

3. PROCESS OF STUDY

To compare and, if possible, improve the performance of the image matching algorithms, a classification was made based on the slope differences. This classification is based on the selection of images manually. Two types of land structures were identified. The first terrain structure is where the structure of the terrain is considered to be rugged and the slope is observed above 15 ° on average. This land was defined as sloping land. The second type of land is the land structure where the slope does not show very instant changes and the land structure is referred to as flat in the literature and the average slope is below 15 °. This land structure is defined as flat land (Makineci and Karabörk, 2016).

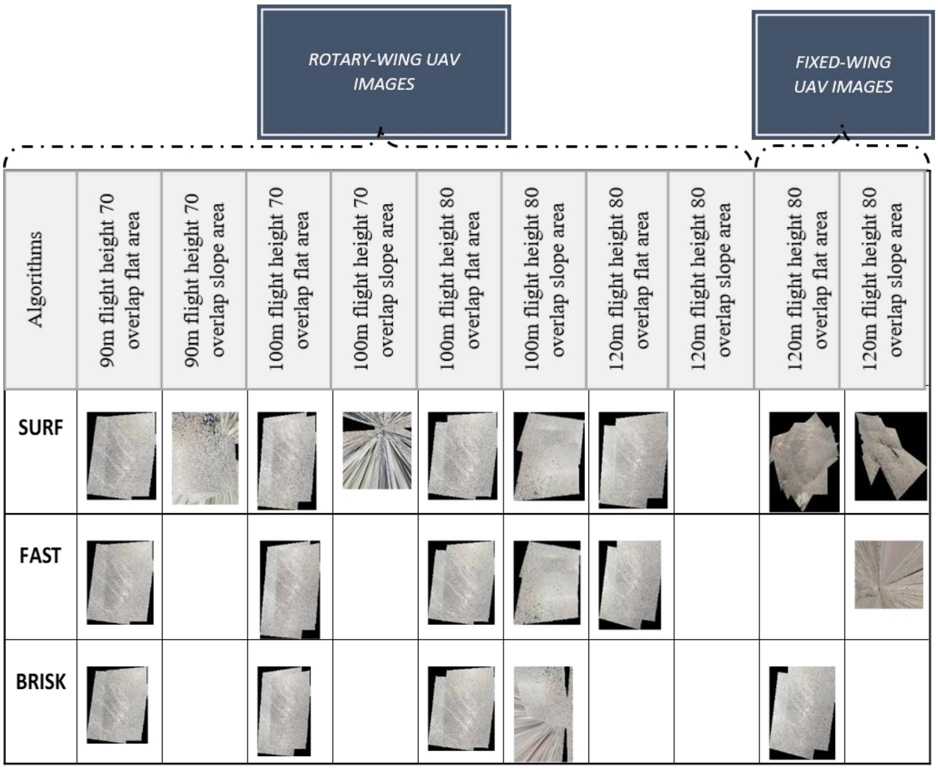
The other compare research of the study is the height and overlay ratio at which the images were taken. Table 1 using all the data in the image matching points were produced and the working principles of the SURF, FAST, BRISK algorithms were investigated. As can be seen from Table 2, which shows the results produced from the images used, different algorithms were able to produce mosaic by showing positive results in different image types. However, results to be classified as positive, negative or results that have been achieved nothing at all (Rublee et al., 2011; Cen et al., 2019; Greengard and Rokhlin, 1986).

Also, in addition, GSD is 2.5 cm/px in fixed wing UAV and 2.2 cm/px in rotary wing UAV for 120 m height. Likewise, for a height of 100 m, the GSD is 2.1 cm/px in fixed wing UAV and 1.85 cm/px in rotary wing UAV.

Table 1. Classification of images used in research

	Fixed-winged UAV Images	**Rotary-winged UAV Images**
1.Comparision	120m flight height 80 overlap flat area	120m flight height 80 overlap flat area
2.Comparision	120m flight height 80 overlap slope area	120m flight height 80 overlap slope area
	Rotary-winged UAV Images	**Rotary-winged UAV Images**
3.Comparision	100m flight height 80 overlap flat area	120m flight height 80 overlap flat area
4.Comparision	100m flight height 80 overlap slope area	120m flight height 80 overlap slope area
	Rotary-winged UAV Images	**Rotary-winged UAV Images**
5.Comparision	100m flight height 80 overlap flat area	100m flight height 70 overlap flat area
6.Comparision	100m flight height 80 overlap slope area	100m flight height 70 overlap slope area
	Rotary-winged UAV Images	**Rotary-winged UAV Images**
7.Comparision	90m flight height 70 overlap flat area	100m flight height 70 overlap flat area
8.Comparision	90m flight height 70 overlap slope area	100m flight height 70 overlap slope area

Table 2. Mosaic results produced by algorithms according to classes



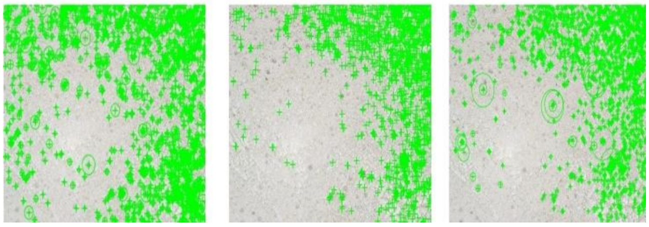


Figure 3. Feature point selection of algorithms

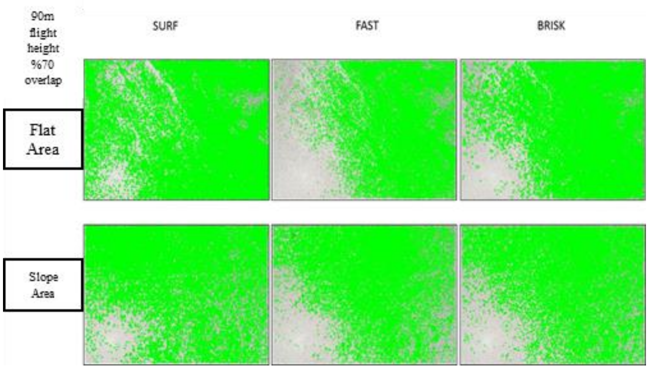


Figure 4. Feature point selection of algorithms

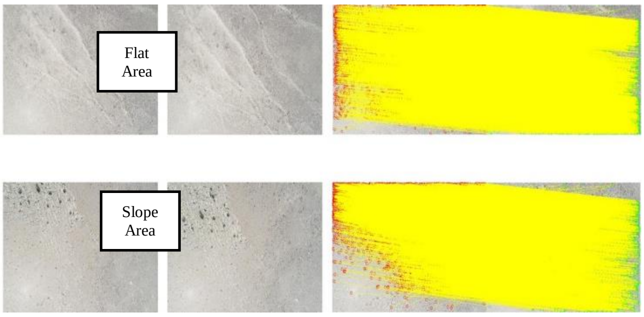


Figure 5. Mosaic extraction from images by matching SURF algorithm feature points

Figure 6. Mosaic extraction from images by matching FAST algorithm feature points

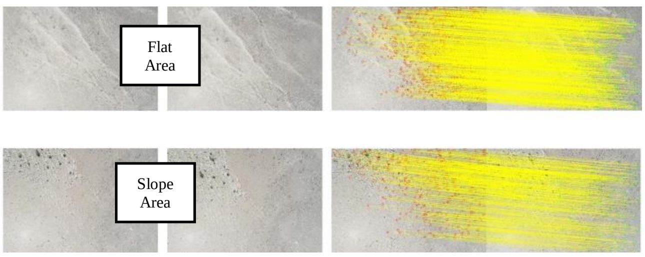


Figure 7. Mosaic extraction from images by matching BRISK algorithm feature points

Figure 3 and Figure 4 show the selection of feature points, Figure 5, Figure 6 and Figure 7 show the mapping of feature points.

Since the mosaic produced using these images did not present positive results, new flights were organised. These new flights were carried out on land more useful for the algorithms to create the mosaic. The result products of this alternative operation are shown in figure 8.

Alternative images were used to produce mosaics from SURF, FAST and BRISK algorithms because the images taken in the field studies did not actually give the expected performance. The flight height of the first project was 30 m (GSD = 0.82 cm / pixel) and the flight height of the second project was 60 m (GSD = 1.64 cm / pixel). 10 images from both projects were combined in all algorithms. The results of these images produced from mosaics are shown in Table 3. Also, Figure 8 shows the mosaics of alternative operations.

The most critical result expected in this study was to determine how the popular FAST, SURF and BRISK algorithms produced in a mosaic from UAV images. For this reason, it was first attempted to produce mosaic using the images (from different heights) acquired with two different types of UAV (Table 2). But in some, the mosaic was never produced. Some of the mosaics were produced for a very long time or were produced inaccurately. Several different searches were made to fix faults. Finally, to a cause of inaccuracy, it was understood that the texture of the land was very similar. For this understanding, new images with different characteristics of the texture were acquired with the rotary-wing UAV. So, it has been tried to determine how much they perform only in producing mosaic. As seen in Figure 7, the mosaics produced are represented as mosaic produced from A 30 m flight altitude images and B 60 m is presented as mosaic produced from flight height images. As and Bs show the mosaics produced from SURF algorithm. The mosaics produced from the Af and Bf FAST algorithm also show the mosaics produced from the Ab and Bb BRISK algorithm.

Table 3. Algorithms and results

Algorithm: SURF	**Mosaic Production Time**	**Mosaic Description**
30 m flight height %80 Overlap	76,5 min	As
60 m flight height %80 Overlap	238 min	Bs
Algorithm: BRISK	**Mosaic Production Time**	**Mosaic Description**
30 m flight height %80 Overlap	11 min	Ab
60 m flight height %80 Overlap	95 min	Bb
Algorithm: FAST	**Mosaic Production Time**	**Mosaic Description**
30 m flight height %80 Overlap	1839 min	Af
60 m flight height %80 Overlap	3350 min	Bf

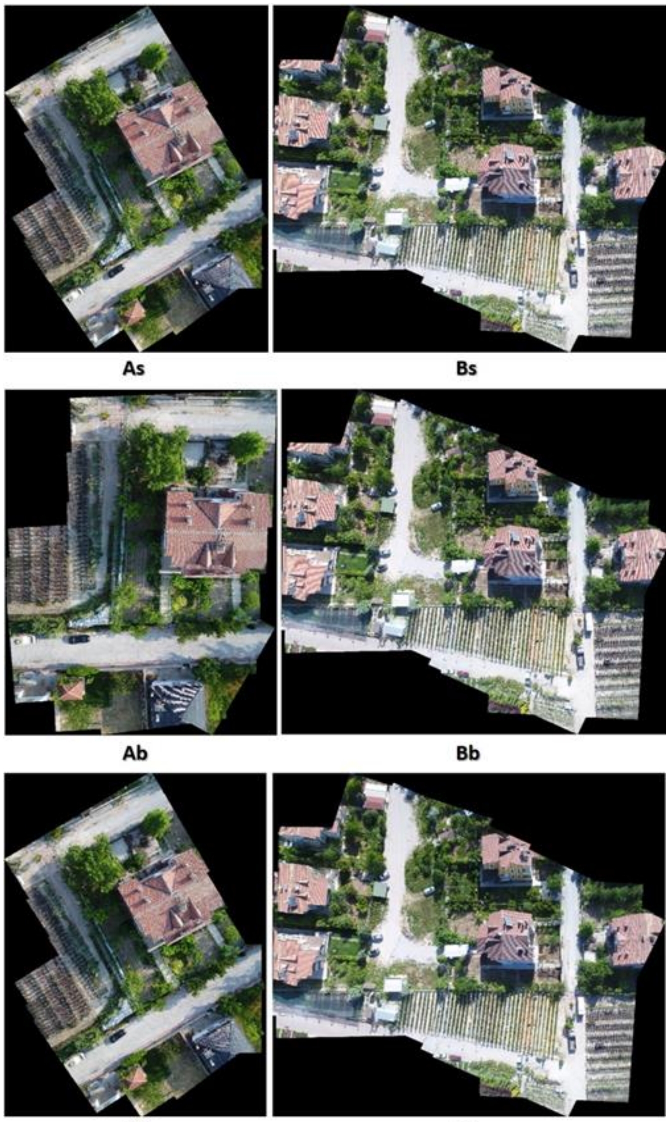


Figure 8. Mosaics of SURF, FAST and BRISK algorithms

4. CONCLUSION

In this study, two different types of UAV were used. The production time and production accuracy of the mosaics produced with varying structures of the slope were investigated. It was considered that the results from SURF, FAST and BRISK algorithms are not adequate. An alternative application was made to compare performances and mosaics were produced from UAV images. The created mosaics were as seen in figure 8. The effort to provide these mosaics was as in table 3.

As a general function of the software that detects feature factors, they are attempting to identify distinct places that can be matched over the image. Since there are no factors inside the terrain that can produce lots of detail, the algorithms try and map the locations which can be very similar to each other as feature factors. Therefore, there was a problem in mosaic production. Mosaics produced due to mismatches and very long strategies were now not found to be satisfactory. The operating ideas of an automated software program that provide models from UAV are based on similar algorithms. However, the aforementioned software has developed different operating policies to increase accuracy by reducing the processing time. Since UAVs acquire the pixels coordinately, the images are fascinated with their approximate region known. Also, the parameters of skewness and curvature are recognized by the software close to their real position. Besides, seeing that this software is produced on a photogrammetric basis, it can expect the maximum wide variety of images that can be matched. In mild of this information, feature points of images are extracted quicker and more accurately.

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REFERENCES

Aslan, M. F., Durdu, A., & Sabanci, K. (2019). Fusion of CT and MR Liver Images by SURF-Based Registration. *International Journal of Intelligent Systems and Applications in Engineering*, 7(4), 216-221.

Bay, H., Ess, A., Tuytelaars, T., & Van Gool, L. (2008). Speeded-up robust features (SURF). *Computer vision and image understanding*, 110(3), 346-359.

Cen, C., Li, R., & Xu, X. (2019, June). Fast robust matching algorithm based on BRISK and GMS. In *Journal of Physics: Conference Series* (Vol. 1237, No. 2, p. 022070). IOP Publishing.

Durdu, A., & Korkmaz, M. (2019). Autonomously simultaneous localization and mapping based on line tracking in a factory-like environment. *Advances in Electrical and Electronic Engineering*, 17(1), 45-53.

Greengard, L., & Rokhlin, V. (1986). A fast algorithm for particle simulations (No. YALEU/DCS/RR-459). *YALE UNIV NEW HAVEN CT DEPT OF COMPUTER SCIENCE*..

Juan, L., & Oubong, G. (2010, July). SURF applied in panorama image stitching. In *2010 2nd international conference on image processing theory, tools and applications* (pp. 495-499). IEEE.

Leutenegger, S., Chli, M., & Siegwart, R. Y. (2011, November). BRISK: Binary robust invariant scalable keypoints. *In 2011 International conference on computer vision* (pp. 2548-2555). Ieee.

Liang, Y. J., Li, Q., Chen, D. P., & Yan, X. J. (2012). Fast and Robust LOG-FAST Corner Algorithm. *Computer Science*, 39(6), 251-254.

Makineci, H. B. (2016). İnsansız Hava Araçları Lidar Etkileşimi. *Geomatik*, 1(1), 19-23.

Makineci, H. B., & Karabörk, H. (2016). Evaluation digital elevation model generated by synthetic aperture radar data. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *1*.

Tareen, S. A. K., & Saleem, Z. (2018, March). A comparative analysis of sift, surf, kaze, akaze, orb, and brisk. In *2018 International conference on computing, mathematics and engineering technologies (iCoMET)* (pp. 1-10). IEEE.

Rublee, E., Rabaud, V., Konolige, K., & Bradski, G. (2011, November). ORB: An efficient alternative to SIFT or SURF. In *2011 International conference on computer vision* (pp. 2564-2571). Ieee.

Rosten, E., & Drummond, T. (2005, October). Fusing points and lines for high performance tracking. In *Tenth IEEE International Conference on Computer Vision (ICCV'05) Volume 1* (Vol. 2, pp. 1508-1515). Ieee.

Wu, M. (2018). Research on optimization of image fast feature point matching algorithm. *EURASIP Journal on Image and Video Processing*, *2018*(1), 106.

Zhong, B., & Li, Y. (2019, July). Image Feature Point Matching Based on Improved SIFT Algorithm. In *2019 IEEE 4th International Conference on Image, Vision and Computing (ICIVC)* (pp. 489-493). IEEE.