Indoor Navigation System Based on Image Matching Algorithm
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Abstract. Many indoor navigation systems aimed at high accuracy have been presented. In this paper we put forward a system based on improved ORB algorithm, which can be used in smart phones with low computation and high accuracy. We process an improved image matching algorithm based on ORB. We jointly use other image matching algorithms as well ORB. These changes makes ORB more suitable for Android system and made ORB algorithm more efficient. In order to validate and demonstrate the performance of the system, we carry out the related experiments. The performance of our method can be seen in the experiments.

Introduction
In recent years, LBS become more and more important in our daily life. The need of indoor navigation is increasing fast, for instance, in the restaurant.

The processing effect of image matching is directly affected by the quality of feature points and the extraction speed of feature points. Lowe is a scale invariant feature algorithm, and the SIFT algorithm has a far-reaching influence in the field of feature point matching algorithm. The algorithm in the past decade has been widely used in object recognition, matching the image features, making the maps visual etc, however it brings real-time system a huge computation burden, which led to the deepening of the SIFT algorithm low-cost alternative research, SURF algorithm was born. The scale space decomposition in the sift algorithm is replaced by the box-type filter and integral image in SURF algorithm, making it a shorter time when doing the same work. However, these two algorithms still cannot meet the requirement of modern application for higher real-time performance. Rublee et al.[4] proposed ORB in ICCV2011. It has a better adaptation in real-time conditions, and the noise have a less influence in it. When these three algorithm working in the same stage, they have a common process.
The purpose of this study is to use the improved ORB algorithm to match the feature points with images in database to identify the indoor location in the Android mobile environment. ORB algorithm consists of 2 parts, feature point extraction with FAST algorithm and the feature points description based on BRIEF algorithm. Feature extraction is developed by the Features from Accelerated Segment Test. The feature point description is improved by the feature description algorithm of the Binary Robust Independent Elementary Features. O-Fast, after using FAST to extract feature points, defines an orientation of the feature point to achieve the rotation invariance of the feature point. O-Fast uses the moment method to determine the direction of the FAST feature point. That is to calculate the characteristic points with r as the center of mass within the radius, and the feature point coordinates to the center of mass to form a vector as the direction of the feature point. In the following parts, the moment definition is stated:

\[
M_{00} = \sum_{x=-R}^{R} \sum_{y=-R}^{R} I(X,Y)
\]

\[
M_{10} = \sum_{x=-R}^{R} \sum_{y=-R}^{R} I_X(X,Y)
\]

\[
M_{01} = \sum_{x=-R}^{R} \sum_{y=-R}^{R} I_Y(X,Y)
\]

\[
Q_x = \frac{M_{01}}{M_{00}} \quad Q_Y = \frac{M_{10}}{M_{00}}
\]

In brief algorithm, select n to the pixel point PI, qi (I = 1, 2... n). Then compare the grayscale value of each point pair. If I(PI) > I(qi), then I generate 1 in the binary string, otherwise 0. All point pairs are compared, and a binary string with length n is generated. General n is 128, 256, or 512 (OPENCV defaults to 256). In addition, in order to increase the noise resistance of the feature descriptor, the algorithm needs to process the image first. In the ORB algorithm, we optimize the functions, and other operations are used to make the Gaussian function smoother, making it more anti-noise. The characteristic points calculated by using o-Fast algorithm include the orientation Angle of feature points. Suppose the original BRIEF algorithm selects n pairs of points in the neighborhood of the feature point S*S (general S take 31).

\[
D = \begin{bmatrix} x_1, x_2 \ldots, x_{2n} \\ y_1, y_2 \ldots, y_{2n} \end{bmatrix}
\]

A binary string descriptor is formed at the new point set location. It is important to note that the o-Fast algorithm is used to extract feature points on different scales. When using BRIEF character
description, therefore, to transform the image to the image of the scale of the corresponding, and then in
the dimension of feature points in the image take S*S neighborhood, and then the option to rotate, get the binary string descriptor.
This benefits from using the FAST detection feature point, which is as FAST as its name. In addition, a BRIEF algorithm is used to calculate the description. The representation of the two-step string that is unique to the description not only saves the storage space, but also greatly reduces the matching time.

For example, the description of A and B is as follows.

A: 10101011
B: 10101010

Set a threshold, such as 80%. When the similarity of the description of A and B is greater than 90%, we judge that A and B are the same feature points, that is, these two points can find each other and match successfully. It is easy to calculate the similarity of A and B by making A and B different or operating. And the different or operation can be done by hardware, with high efficiency, speed up the match.

This paper aims to introduce an efficient and high-quality image matching system based on feature extraction approach. Figure 3 shows the very important step when we match images using ORB. Although ORB algorithm has an outstanding advantage in feature points detection, it still perform weakly in real-time situations. After the change of parameters of ORB, the efficiency of ORB algorithm has been improved. The optimum threshold value of the improved ORB algorithm in Android environment made the algorithm more suitable with the indoor positioning application running in smart phones.

![Figure 3. Image matching process of the ORB algorithm.](image)

We devided the paper into 5 parts. An overview of some related work of image matching based on ORBalgorithim has been mentioned in section 2. Section 3 contains the discussion of some common features matching techniques. The improvement of ORB algorithm has been introduced in section 3. The experiments' results can be found in Section 4. the conclusions contained in Section 5.

Related Work
The methods to decrease the costs and improve the efficiency of image matching have been studied by many researchers. For instance, [1] Yu-Doo Kim (2014) finds the algorithm performs well in some specific threshold. [2] Chinmoy Biswas proposed a method (2015) combinedSURF, SIFT. This code is not very much invariant to illumination according to the different experiments done by author. [3]Bind et al. put forward a robust algorithm which can be used in 3-D condition with stiching method. [4] Skoczylas (2014) put forward a joint method using SURF and SIFT. But it constraints that people can only use some specific kind of system. The computation of this method is not high, so that it can be used in smart phone. It can find the key points efficient. [5]. With the increase of
matching method, the points are increasing also. Adel et al. [6] made a comparison among SURF, SIFT, ORB to evaluate their ability. With the knowledge of the result, ORB is the fast one and SIFT is the robust one.

Features Detection and Description

The features of images can be extracted and then match with other images in image matching systems that are based on the feature approach, by correspondence similarity. 3 main steps consist the stage: detection, description, and matching. ORB and BRIEF are binary descriptors. Some of the famous detectors and descriptors are studied in following subsections of this article.

Feature points extraction is a significant stage during images matching. Many factors such as lighting conditions changes, angular deviation and the influence caused by obstructions can bring errors during the matching process. We must improve the ORB algorithm to match the images more accurate. We are going to discuss the traditional ORB algorithm in this part.

This paper shows an indoor navigation system based on the improvement ORB algorithm. There are following steps in our algorithm:

1. Find the features from the overlapping images input.
2. Match the features with each other.
3. Filter the features with improved ORB algorithm.
4. Use image blending method to improve the accuracy.

![Figure 4. The block diagram of the image matching system.](image)

Experimental Result

This system was simulated in an Android-based tablet PC. In order to test it in a real-time condition, we used the library of OpenCV.

![Figure 5. Simulation environment.](image)
Table 1. Image Matching Time Corresponding to Number of Blob.

| Blob | Image Matching Times [ms] |
|------|---------------------------|
| 1    | 1, 96, 89, 84, 77, 98, 68, 100 |
| 2    | 90, 98, 87, 99, 90, 96, 69, 95 |
| 3    | 78, 99, 88, 90, 93, 94, 95, 92 |
| 4    | 87, 98, 90, 76, 45, 77, 78, 102 |
| 5    | 90, 89, 89, 91, 93, 94, 95, 98 |
| 8    | 93, 95, 98, 92, 99, 99, 99, 100 |
| 100  | 95, 98, 97, 98, 96, 94, 95, 97 |
| 150  | 98, 94, 97, 98, 98, 99, 83, 123 |

Table 1 shows the performance with adjusting number of blob

Table 2. Image matching time corresponding to threshold value.

| Threshold | Image Matching Times [ms] |
|-----------|---------------------------|
| 1         | 1, 99, 98, 97, 95, 88, 90, 99, 123 |
| 2         | 90, 9790, 99, 80, 89, 95 |
| 3         | 88, 9999, 96, 93, 94, 9399 |
| 4         | 86, 98, 80, 7965, 87, 88, 107 |
| 5         | 97, 87, 86, 97, 99, 99, 97, 98 |
| 8         | 96, 95, 98, 98, 98, 9697, 145 |
| 100       | 99, 98, 87, 98, 96, 94, 99114 |
| 150       | 93, 94, 80, 93, 94, 99, 86, 152 |

We do the experiment in the Building of Computer Science in Jilin University, the result shows that our improved indoor navigation system can maintain high efficiency as well as low computation. We degress the impact of rotation influence when using the system.

**Conclusion**

The improved ORB algorithm used in the fusion navigation system solved the problem, which influence the accuracy when people is turning. Our further study is continue, the algorithm is going to be more efficient.

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