Image Matching Algorithms Report

In today's technology, image matching plays a crucial role in the field of computer vision. Identifying similarities and relationships between two or more images is a critical step for many applications such as object recognition, mapping, augmented reality, and more. In this report, the SIFT and FLANN algorithms are examined in detail, and a performance evaluation of their combinations is presented.

The images used in the evaluations were obtained from the Google Earth application with at least a three-year time difference between acquisition dates and at various spatial resolutions. In the initial implementations, relatively simple matching algorithms were created by integrating SIFT, separately with the Brute Force matcher. In the combined algorithms, Gaussian filtering was applied as a preprocessing step, and the matching process was optimized using RANSAC and FLANN. The results of these approaches were then compared.

Matching Algorithms and Gaussian Filter

Gaussian Filter

In image matching processes, Gaussian filtering is commonly applied to reduce noise in images. This filter smooths image details, allowing feature detection algorithms to operate more efficiently. For example, when algorithms such as AKAZE or ORB are used, the Gaussian filter can reduce the rate of incorrect matches.

The main advantage of the Gaussian filter is that it preserves important information in the image while smoothing only unwanted details. However, excessive blurring may negatively affect the performance of some algorithms. Therefore, the parameters of the Gaussian filter must be carefully selected.

RANSAC Algorithm

RANSAC is a technique used to filter erroneous data that occur during the matching process. For instance, it detects incorrectly matched points between two images and eliminates them. By doing so, RANSAC significantly increases the accuracy of image matching.

Its basic principle is to randomly select a subset of matches, build a model based on this subset, and then evaluate how well the remaining points fit this model. Through this approach, the impact of false matches between images is reduced.

FLANN Algorithm

FLANN (Fast Library for Approximate Nearest Neighbors) is designed to quickly find similar points in large datasets. When searching for nearest matches for a query image within a very large image database, FLANN is frequently preferred due to its efficiency and speed in large-scale datasets.

SIFT Algorithm and Combined SIFT Algorithms (RANSAC and FLANN)

SIFT (Scale-Invariant Feature Transform) is designed to identify distinctive and unique feature points in an image. One of its strongest advantages is its ability to correctly detect features even when the image scale or orientation changes.

Despite its high accuracy, SIFT is generally slow, which can create limitations in real-time applications. For example, when SIFT is used in a surveillance camera system, processing delays may occur.

Figure 1: Satellite image of the universtiy area from 2024

Figure 2: Satellite image of the universtiy area from 2020

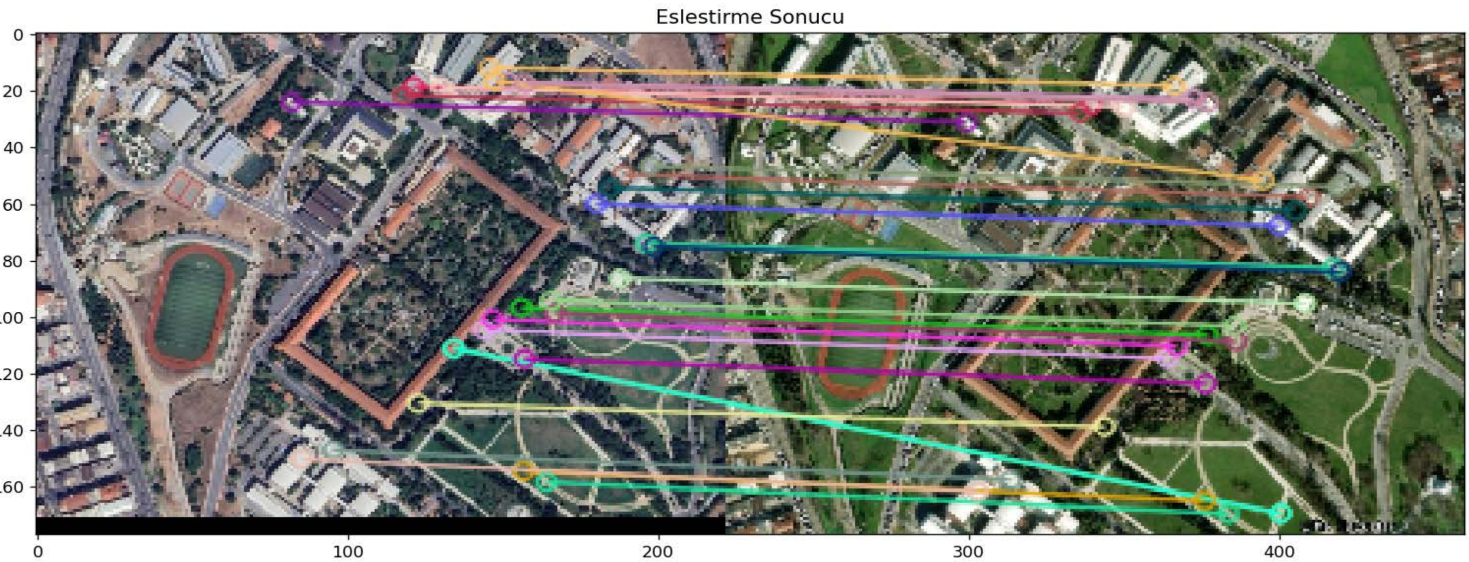

Figure 3: Results obtained from SIFT and Brute Force matching of school satellite images from 2020 and 2024.

SIFT + Brute Force

The provided SIFT and Brute Force code did not perform well on two low-resolution satellite images. As shown in Figure 3, the low resolution of the images resulted in a large number of incorrect matches. Since the Brute Force method attempts to match all keypoints between both images, incorrect matches are also included, leading to erroneous results.

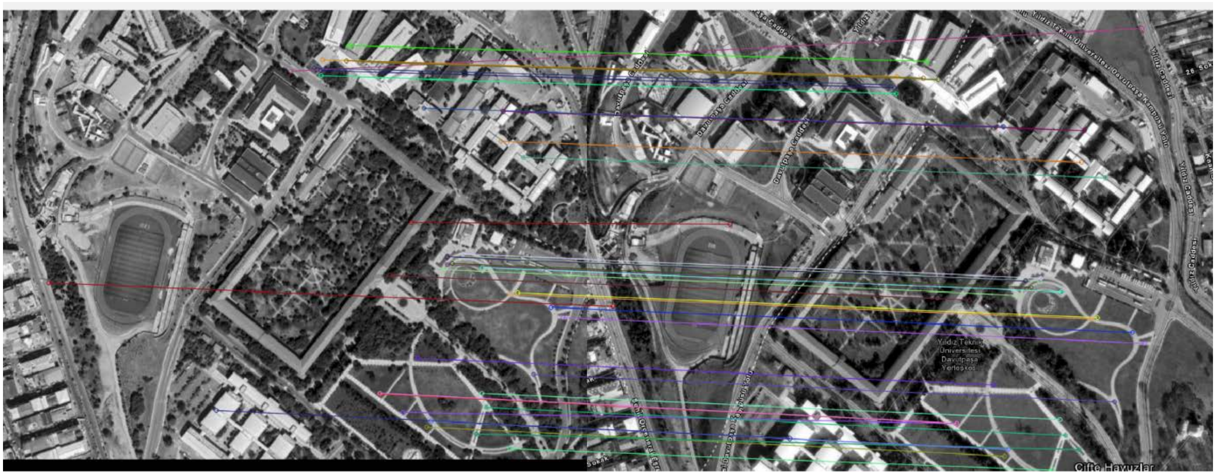

Figure 4: Results obtained from SIFT and FLANN matching of school satellite images from 2020 and 2024.

SIFT + FLANN

The matching process shown in Figure 4 was performed using the SIFT algorithm. In the first stage, both images were converted to grayscale to improve matching accuracy. Subsequently, a Gaussian Blur filter was applied to both images to reduce noise. This preprocessing step slightly improved the effective image quality and increased the accuracy of the matching process.

Next, keypoints and their corresponding descriptors were extracted from both images using the SIFT algorithm. While keypoints represent important features in the image, descriptors provide numerical representations of these features.

Unlike the previous brute-force approach, matching was performed using the FLANN algorithm. FLANN is optimized to find nearest neighbors between keypoints more efficiently, resulting in faster and more reliable matches. The FLANN-based matcher compares the descriptors from both images and identifies the best matches.

To further improve match quality, a filtering process was applied to the matching results. The distance of each match was calculated, and matches with smaller distances were selected. This filtering helps assess the reliability of each match. Additionally, the best 40 matches were sorted and visualized.

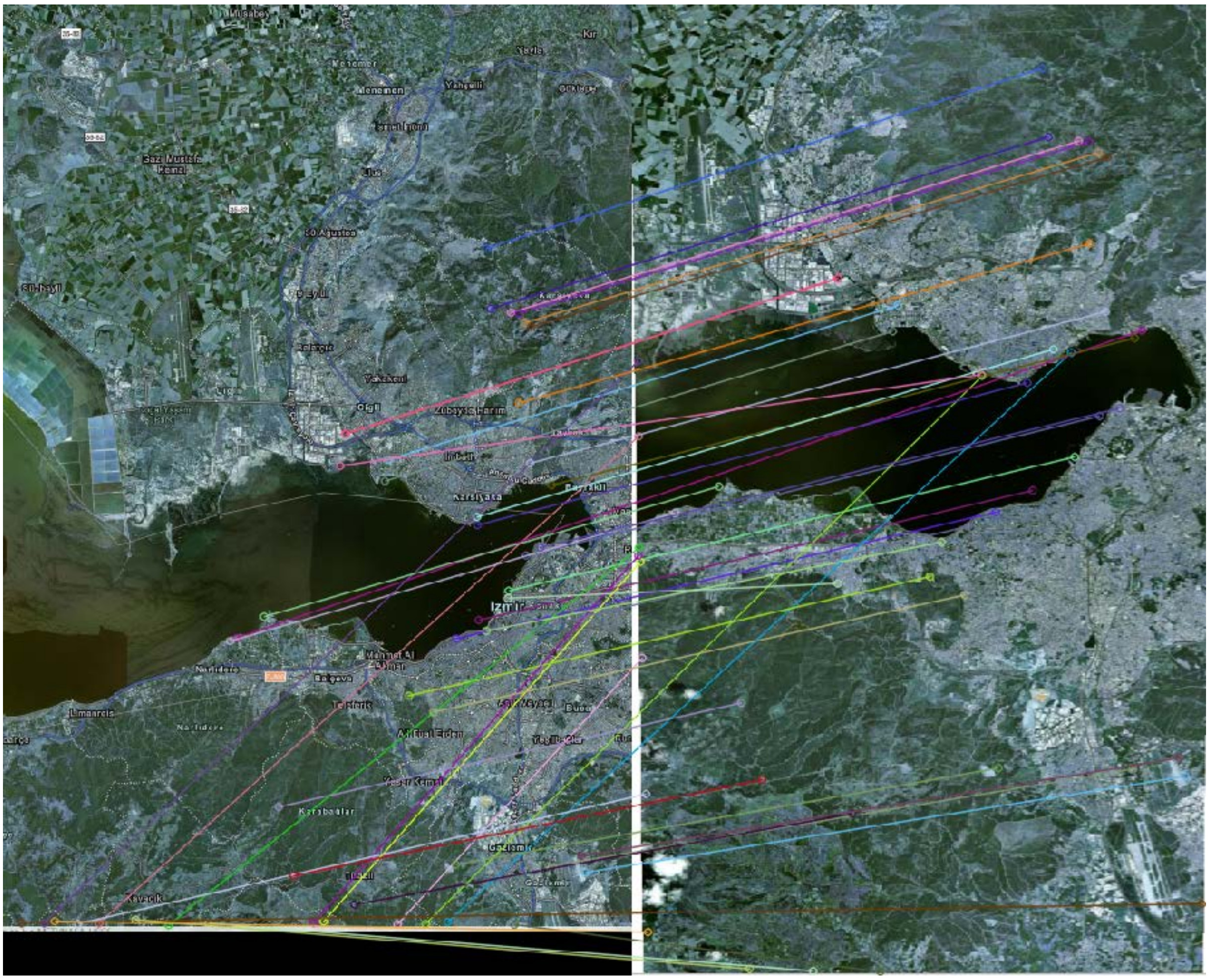

Figure 5: Results obtained from SIFT and FLANN matching on satellite images from 2020 and 2024.

Although the SIFT and FLANN combination performed well on school satellite images, it produced a significant number of errors when applied to the satellite image shown in Figure 5. Incorrect matches occurred particularly along edges and boundaries. While SIFT attempts to detect prominent keypoints, it struggled to accurately match edges and boundaries in this case.

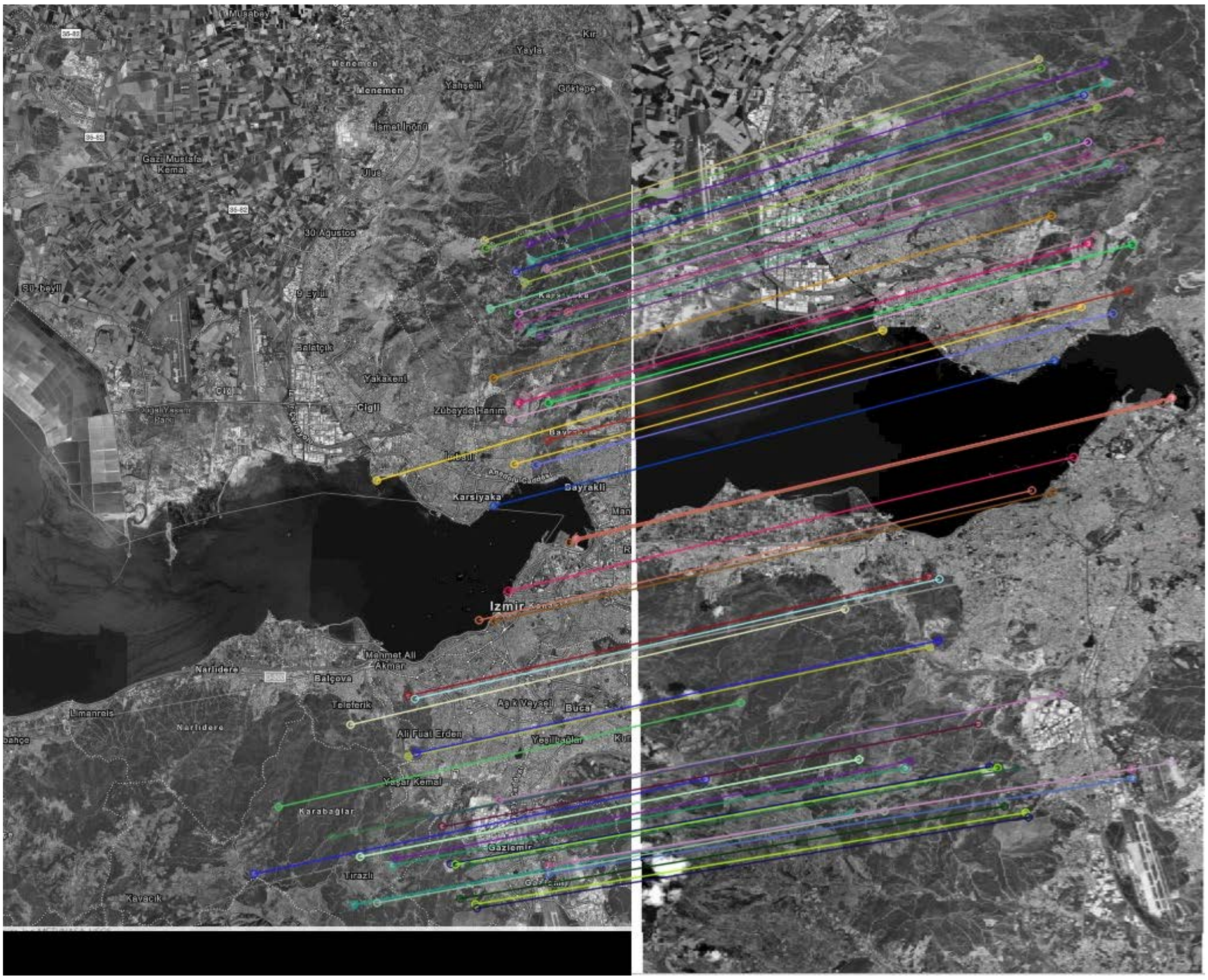

Figure 6: Results obtained from SIFT + FLANN + RANSAC matching of satellite images from 2020 and 2024.

SIFT + FLANN + RANSAC

After applying SIFT and FLANN-based matching, several incorrect matches were identified in Figure 5. To reduce these errors and improve matching accuracy, the RANSAC algorithm was applied, as shown in Figure 6.

RANSAC excludes non-linear and noisy correspondences, enabling the estimation of a more reliable geometric model. As a result, matching accuracy was significantly improved.