Project Report

Panoramic Photosticher

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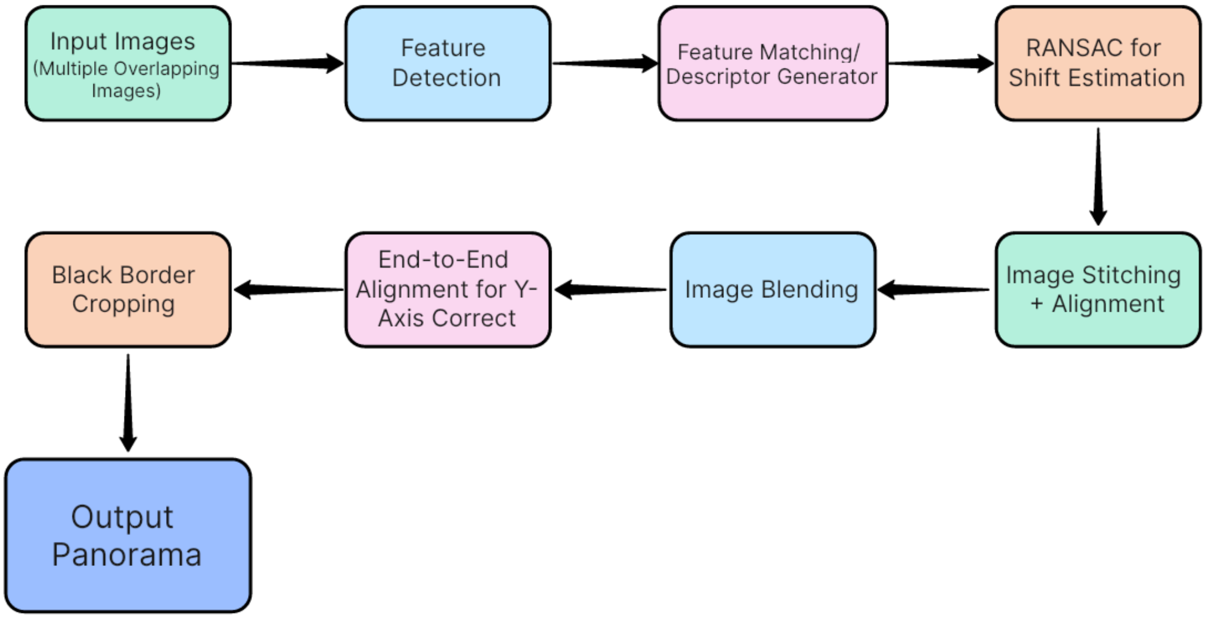
Problem Statement: Advanced Image Stitching for Panoramic Images

1. Introduction:
- Image stitching is a process that involves combining multiple overlapping images to create a single panoramic image. This project focuses on implementing an advanced image stitching system that offers various feature extraction algorithms and blending methods to produce seamless panoramas.
- The main objectives of this project are to explore different feature extraction techniques, implement efficient stitching algorithms, and provide a flexible framework for image stitching.

2. Objectives:

- Explore and compare different feature extraction algorithms for image stitching.
- Implement an efficient stitching process with multiple blending methods to create smooth transitions.
- Provide a flexible and extensible framework for image stitching, allowing customization based on user requirements.

3. Methodology :



1. **Input Image Acquisition**:
    - This phase involves obtaining input images from a specified directory. These images are the raw data that will be used for the image stitching process.
2. **Feature Extraction**:
    - Feature extraction is the process of identifying distinctive points or regions in each input image. In this phase, multiple feature extraction algorithms are applied to the input images. These algorithms include Harris, SIFT, BRISK, ORB, BRIEF, Shi-Tomasi, and FAST.
    - Each feature extraction algorithm operates independently on the input images to detect keypoints and generate feature descriptors.
    - The output of this phase is a set of keypoints and descriptors for each input image, obtained using different feature extraction algorithms.
3. **Stitching Process**:
    - The stitching process involves combining multiple input images to create a panoramic image. This phase consists of several steps:
        - **Feature Matching**: Keypoints and descriptors obtained from the feature extraction phase are used to match corresponding features between adjacent images.
        - **Shift Estimation**: The RANSAC algorithm is applied to estimate the best shift between matched features in adjacent images.

        - **Image Alignment**: The images are aligned based on the estimated shifts to correct any misalignments and create a seamless panorama.
        - **Blending**: Two blending methods, alpha blending and feather blending, are applied to blend the aligned images together. Alpha blending uses a weighted combination of pixel intensities, while feather blending creates smooth transitions between images by blending their edges.
    - The output of this phase is a stitched panoramic image created by combining and blending the aligned input images.
4. **End-to-End Alignment**:
    - This phase involves additional alignment to correct any remaining y-axis shift errors in the stitched image.
    - The end-to-end alignment mechanism adjusts the position of the stitched image to ensure a consistent panorama without noticeable shifts or distortions.
5. **Black Border Cropping**:
    - After alignment, a cropping function is applied to remove any black borders or unwanted regions from the stitched image.
    - This ensures that the final panoramic image is clean, visually appealing, and free from unnecessary artifacts.
6. **Performance Evaluation**:
    - Performance metrics such as the average number of matched features and total computation time are calculated for each feature extraction algorithm.
    - Bar plots are generated to visualize and compare the performance of different feature extraction algorithms.
    - Users can use these metrics to evaluate the efficiency and effectiveness of each algorithm and choose the best approach based on their requirements.

4. Key Features:

Feature Extraction:

Harris Corner Detection: Harris corner detection is a widely used method for feature extraction, especially in scenarios where corners play a crucial role in image matching. It detects corners based on variations in intensity in different directions, making it robust to noise and illumination changes.

Alpha Blend Result:

Feather Blend Result:

SIFT (Scale-Invariant Feature Transform): SIFT is a feature detection algorithm that identifies key points in an image, invariant to scale, rotation, and illumination changes. It computes descriptors for these key points, allowing for robust matching between images.

Alpha Blend Result:

Feather Blend Result:

BRISK (Binary Robust Invariant Scalable Keypoints): BRISK is a feature detection and description algorithm that offers a balance between speed and robustness. It uses a binary descriptor, making it efficient for real-time applications while maintaining high matching accuracy.

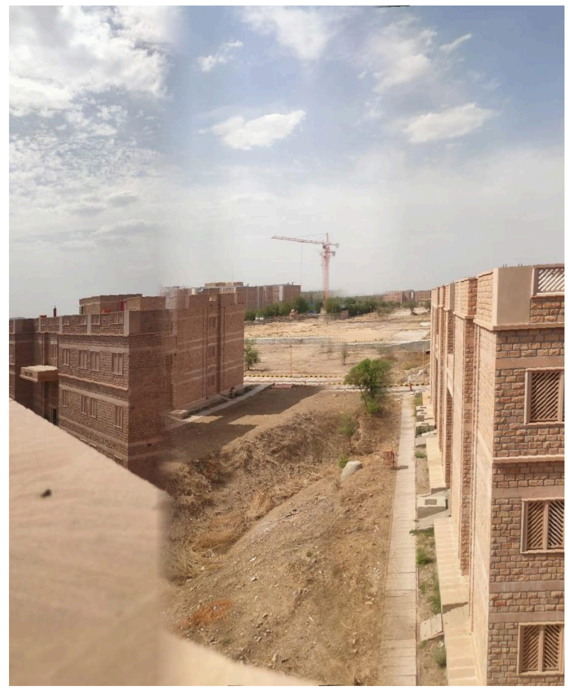
Alpha Blend Result:

Feather Blend Result:

ORB (Oriented FAST and Rotated BRIEF): ORB combines the speed of FAST (Features from Accelerated Segment Test) and the robustness of BRIEF (Binary Robust Independent Elementary Features) to create a fast and efficient feature extraction algorithm. It is particularly suitable for real-time applications.

Alpha Blend Result:

Feather Blend Result:



BRIEF (Binary Robust Independent Elementary Features): BRIEF is a fast feature extraction algorithm that generates binary descriptors for key points in an image. It focuses on speed and efficiency, making it suitable for applications where real-time performance is critical.

Alpha Blend Result:

Feather Blend Result:

Shi-Tomasi Corner Detection: Shi-Tomasi corner detection is an improvement over the Harris corner detection algorithm, providing more accurate results by considering the minimum eigenvalue of the covariance matrix. It is widely used in feature extraction tasks due to its reliability and robustness.

Alpha Blend Result:

Feather Blend Result:

FAST (Features from Accelerated Segment Test): FAST is a popular corner detection algorithm known for its speed and efficiency. It identifies corners by comparing pixel intensities around a circular region, making it suitable for real-time applications where computational resources are limited.

Alpha Blend Result:

Feather Blend Result:

Image Stitching

Alpha Blending:

- Alpha blending is a technique used to seamlessly merge images by assigning transparency levels to pixels based on their overlap.
- It creates smooth transitions between images, resulting in a natural-looking panorama.

Feather Blending:

- Feather blending is another blending method that creates smooth transitions between images by gradually blending pixel intensities along the boundary.
- It results in a softer, more diffused transition compared to alpha blending.

End-to-End Alignment:

- End-to-end alignment is a crucial step in the stitching process that corrects y-axis shift errors to create a more consistent panorama.
- It ensures that images are properly aligned, reducing distortions and improving overall image quality.

Black Border Cropping:

- Black border cropping is a post-processing step that removes any unwanted black borders from the stitched image, ensuring a clean and visually appealing final result.

Performance Metrics:

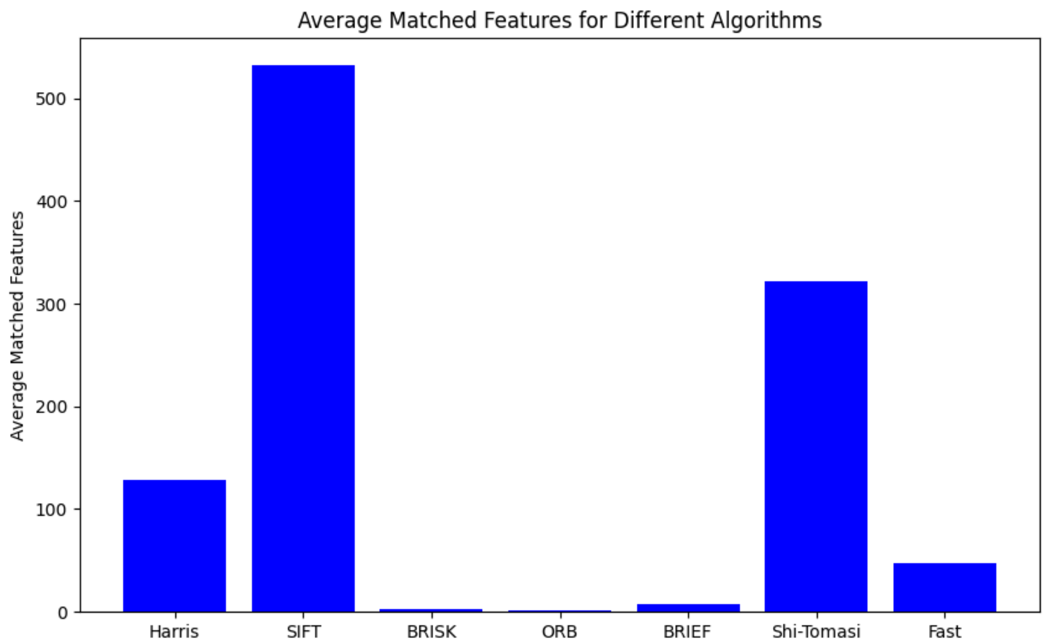
- The project provides metrics such as the average number of matched features and total computation time for each feature extraction algorithm.
- These metrics allow users to evaluate the efficiency and effectiveness of different approaches and make informed decisions about algorithm selection.

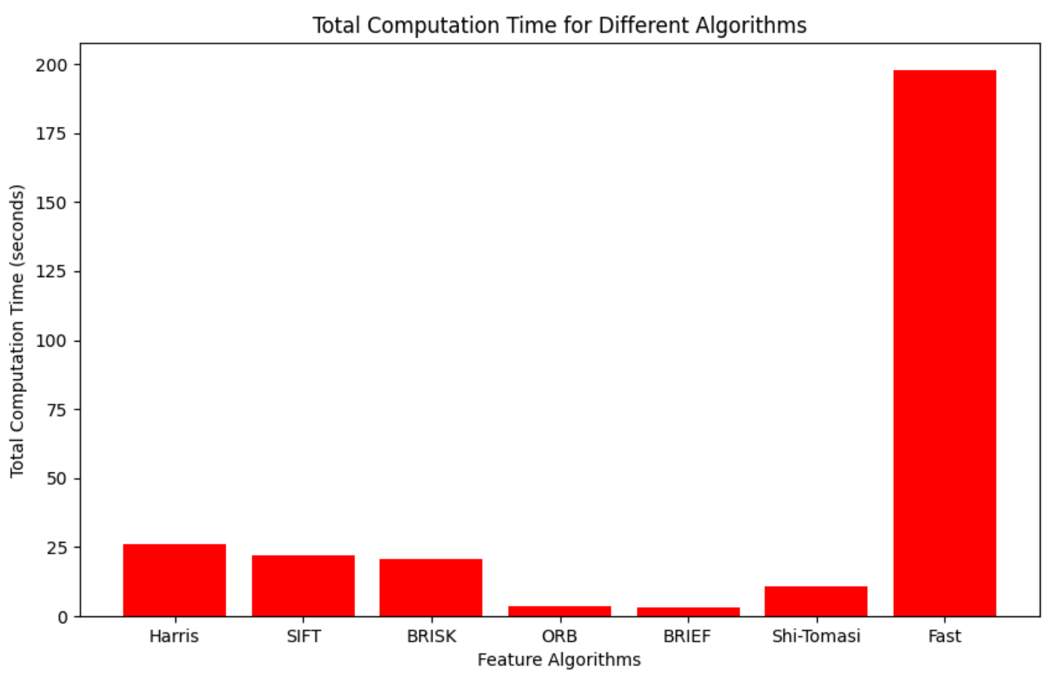
Visualization:

- The project includes bar plots to visually compare the performance of different feature extraction algorithms.
- These visualizations provide insights into the relative strengths and weaknesses of each algorithm, helping users make informed decisions during the image stitching process.

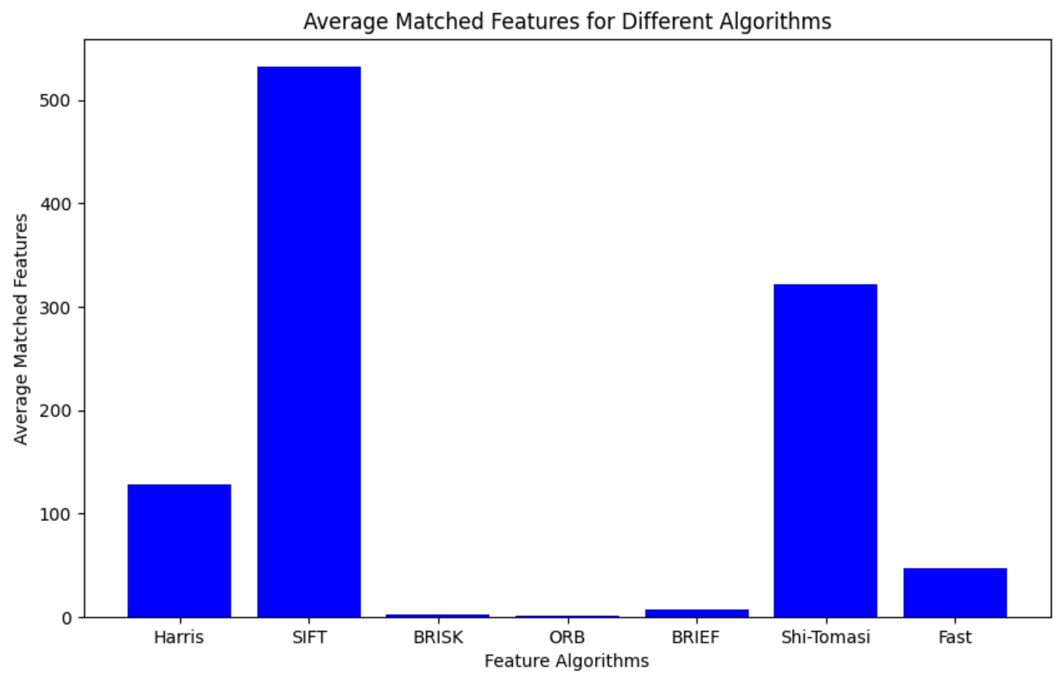
5. Observations

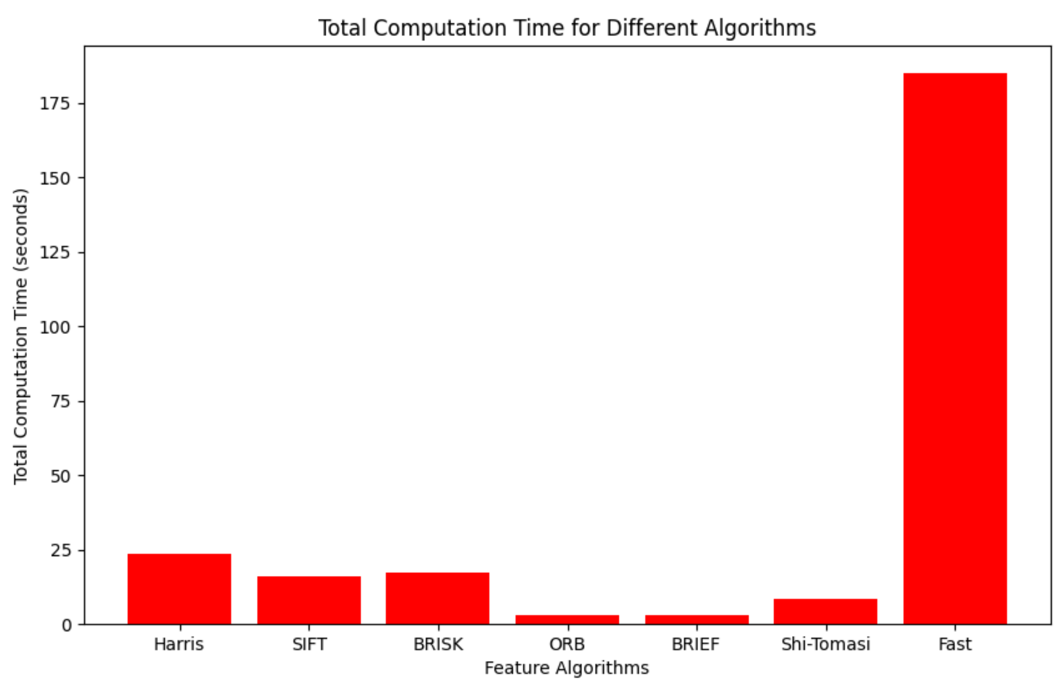
- Graphs have been plotted for the time taken and average number of matchings generated by each of the algorithms and it is as shown below:
- For alpha feather blending:





- For alpha blending





- Computation time is very high in case of FAST feature matching algorithm whereas its number of features matched is less compared to other time consuming algorithms like Harris and SIFT.
- SIFT and Harris proved to be extracting maximum features and match points.
- Along with this the results from default alpha blend and alpha feather blend are also compared and it seemed to have distinctive differences between them.
- Alpha feather blend showed more realistic blurring than the alpha blend which can be seen in the results shown earlier.

6. Conclusion

- After comparing the average number of matching points and the time taken to compute them, it is observed that the SIFT and Harris performed better than other algorithms.
- However if we do not put the time constraint then the results of the FAST algorithm are also good in terms of feature matching and stitching.
- Results from alpha blend and alpha feather blend also give distinctive differences in the realistic view of the final stitched images.

7. References

- *https://github.com/Jie-Geng/360-panorama-python*
- *https://snawarhussain.com/blog/computer%20vision/python/tutorial/image-stitching/*
- *https://github.com/OpenStitching/stitching*
- *https://youtube.com/watch?v=uMABRY8QPe0*
- *https://pyimagesearch.com/2018/12/17/image-stitching-with-opencv-and-python/*