Stitching Images/Videos from two different Camera Sources

A Project Submitted in
Partial Fulfilment of the Requirements
for the Degree of
Bachelor of Technology
in
Computer Science Engineering

As part of the core course
"CSE2707 – Major Project"

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December 2023

CANDIDATE’S DECLARATION

We hereby certify that the work on the project entitled “*Stitching Images/Videos from two different Camera Sources”* in partial fulfilment of requirements for the award of Degree of Bachelor of Technology in School of Engineering and Technology at BML Munjal University is an authentic record of our own work carried out during a period from July 2023 to December 2023 under the supervision of **Dr. Anubhav Agrawal.**

Aditya Rana
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SUPERVISOR’S DECLARATION

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Dr. Anubhav Agrawal
Faculty Supervisor Name

Signature

INDEX

Abstract

This project endeavours to advance the capabilities of Advanced Driver Assistance Systems (ADAS) through the seamless integration of content obtained from two distinct camera sources. The focus lies on employing feature-based image and video stitching techniques to create a comprehensive and panoramic view of the surrounding environment, contributing to enhanced safety and functionality in the realm of ADAS.

The project utilizes the ORB (Oriented FAST and Rotated BRIEF) algorithm for key point detection and description, allowing for efficient feature extraction from frames captured by separate camera sources. The developed system aligns with feature-based image stitching approaches, which offer robustness against scene movement and automatic discovery of overlapping relationships among frames. This methodology not only facilitates the creation of high-resolution panoramic images but extends to video stitching, providing a dynamic and continuous perspective.

The code implementation includes a **Video Stitcher** class, responsible for detecting and matching key points between frames, computing homograph matrices, and seamlessly stitching images and videos. By extending the traditional image stitching paradigm to videos, the project aims to contribute to the convergence of computer vision and ADAS technologies.

The overarching goal is to enhance ADAS features by providing a comprehensive and panoramic view of the vehicle's surroundings, enabling more effective decision-making algorithms. This project not only advances the field of image and video stitching but also explores its practical applications in the context of ADAS, with the potential to significantly improve safety and situational awareness for drivers.

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Chapter 1

INTRODUCTION

In the ever-evolving automotive landscape, Advanced Driver Assistance Systems (ADAS) are pivotal for enhancing vehicle safety and user experience. Multiple sensors and cameras are now ubiquitous in modern vehicles, allowing them to perceive and respond to their dynamic surroundings. However, harmoniously integrating information from diverse camera sources remains a formidable challenge, limiting the full realization of ADAS potential.

This project addresses this challenge by delving into the intricate intersection of feature-based image and video stitching with ADAS. The objective is to forge a comprehensive, panoramic depiction of the vehicle's environment by amalgamating content from two distinct camera sources. This innovative approach transcends traditional image stitching boundaries, extending transformative capabilities into the realm of videos. By seamlessly unifying frames from different cameras, the project aims to create a continuous visual narrative, significantly contributing to the evolution and enhancement of ADAS functionalities.

In essence, the project pioneers bridging the existing gap in assimilating information from diverse camera arrays. As the project extends image stitching techniques to videos, it envisions a paradigm shift in ADAS capabilities, fostering heightened situational awareness and empowering drivers with more informed decision-making tools. The synthesis of dual camera sources aims to provide a panoramic canvas, addressing limitations, minimizing blind spots, and enhancing the driving experience.

Within this context, the project stands at the forefront of innovation, exploring novel ways in which computer vision, image stitching, and ADAS seamlessly converge. This multifaceted approach not only propels the project into uncharted territories of technological integration but also holds the promise of redefining the driver assistance systems landscape, contributing to the continued evolution of automotive safety and intelligence.

Chapter 2

INTRODUCTION TO PROJECT

2.1 OVERVIEW

The primary focus of this endeavour is the development of a robust system capable of stitching images and videos obtained from dual camera sources. The project leverages the ORB algorithm for key point detection and description, a method proven for its efficiency in feature-based approaches. Through the creation of a Video Stitcher class, the code implementation seamlessly blends frames, allowing for a continuous and dynamic perspective.

The significance of this project lies in its potential to revolutionize the way vehicles perceive their surroundings. By providing an all-encompassing panoramic view, the system contributes to more effective ADAS features, such as lane departure warnings, object detection, and collision avoidance. The integration of dual camera sources ensures a comprehensive understanding of the environment, addressing blind spots and enhancing the overall safety and functionality of ADAS.

As technology continues to shape the automotive industry, the fusion of image and video stitching with ADAS represents a frontier where computer vision meets practical applications. This project seeks to bridge this gap, opening avenues for innovative solutions that can redefine the landscape of driver assistance systems.

2.2 USER REQUIREMENT ANALYSIS

Seamless Integration:

User Need: Users require a system that seamlessly integrates information from diverse camera sources to enhance the overall functionality of ADAS.

System Response: The project addresses this need by focusing on the seamless integration of content from two distinct camera sources.

Video Capabilities:

User Need: Users express a need for extending image stitching techniques to videos for a more dynamic perspective.

System Response: The project innovatively extends traditional image stitching capabilities to videos, providing a continuous visual narrative.

Chapter-3

LITERATURE REVIEW

For merging two images/videos from different camera sources, many articles give methods to extract features from images. The most important, "Joint Video Stitching and Stabilization from Moving Cameras" [1], Image stitching can enlarge the view angle by combining contents from several overlapping images captured by multiple cameras, which is often referred to as panorama [2] or image mosaics [3]. In this work, we extend image stitching to video stitching for videos that are captured simultaneously for the same scene by multiple moving cameras.

The paper [4] proposed a method for stitching two videos capturing through an unstructured camera array. Papers [5] and [6] proposed to stitch videos under static cameras. In general, these hardware-based solutions are expensive and inconvenient.

Feature tracking is usually applied for a single video. Normally, we cannot apply feature tracking between different views due to large view angle diversities (e.g., large scale differences). Feature matching works well under this situation. On the other hand, homograph based RANSAC is often adopted to reject outliers after feature matching. However, a single homograph-RANSAC can only retain matches residing on a single plane.

To solve this problem, [1] propose to integrate the feature tracking with the feature matching, which can produce rich feature correspondences between two videos with multiple planes. Specifically, at frame t−1, plane A is the dominant plane because potentially there are three feature matches in plane A but only two feature matches in plane B. Thus, if we use homograph H(t−1), only matches of plane A can pass homograph -RANSAC. We adopt the bundled-paths approach [7] as the baseline for stabilization. The uniqueness of our approach is that not only intra motions but also inter motions are considered during the optimization. The optimization mainly consists of three components, first a fast and rich feature tracking, a mutually optimal camera path generation and a joint stitching and stabilization.

3.1 COMPARISON

Paper	Highlights	Methodology	Conclusions	Weakness (if any)
Content-Based Image Retrieval using Scale Invariant Feature Transform and moments	This paper proposes a combination of local and global features for CBIR. Local features are extracted through Scale Invariant Feature Transform (SIFT) and global features are extracted through geometric moments.	Moments are statistical measures that describe the shape, distribution, and other properties of an image. They can be used to capture global characteristics, such as intensity distribution and shape, making them useful for image representation.	This paper proposes two new approaches for content-based image retrieval using Scale invariant feature transform method. The main goals of these two approaches are tackling two important drawbacks of SIFT method namely, its memory usage and its matching time, that prevents it to be used as a reliable method for CBIR problem.	CBIR systems must be adaptable to various types of images, including photographs, medical images, art, etc. Ensuring that the system performs well across diverse domains is a persistent challenge.
A Novel Image Retrieval Based on Visual Words Integration of SIFT and SURF	In this it presents a novel visual words integration of Scale Invariant Feature Transform (SIFT) and Speeded-Up Robust Features (SURF). The two local features representations	Image retrieval based on visual words integration of SIFT and SURF. Reduction of the semantic gap between low-level features and high-level image concepts.	The semantic gap between low-level visual features and high-level image concepts is a challenging research problem of CBIR. SIFT and SURF are reported as two robust local features and the integration of visual words of SIFT and	Combining multiple feature extraction methods may result in redundant information and increased

	are selected for image retrieval because SIFT is more robust to the change in scale and rotation, while SURF is robust to changes in illumination.		SURF adds the robustness of both features to image retrieval.	dimensionality.
Joint Video Stitching and Stabilization from Moving Cameras	In this paper they extend image stitching to video stitching for videos that are captured for the same scene simultaneously by multiple moving cameras.	Directly applying image stitching methods for shaking videos often suffers from strong spatial and temporal artifacts. To solve this problem, they propose a unified framework in which video stitching and stabilization are performed jointly.	The joint video stabilization and stitching is formulated into a constrained optimization problem, in which inter motions enforce the spatial alignment and intra motions maintain the temporal smoothness	Managing parallax effects due to different viewpoints and depth variations in the scene is a challenge.
Creating Full View Panoramic Image Mosaics and Environment Maps	This paper presents a novel approach to creating full view panoramic mosaics from image sequences. Unlike current panoramic stitching methods, which usually require pure horizontal camera panning, our system does not require any controlled motions or constraints on	High Dynamic Range (HDR) imaging is often employed in panoramic imaging, and these papers discuss techniques for capturing and rendering HDR content. As technology advances, there is a growing interest in real-time and mobile panoramic imaging.	Researchers have made significant strides in developing techniques for capturing, stitching, and rendering panoramic images, with applications ranging from virtual tours to immersive environments.	Handling occlusions and parallax effects remains a substantial challenge, especially in dynamic scenes where objects move or obstruct the view.

	how the images are taken.			

3.2 OBJECTIVES

In the context of Advanced Driver Assistance Systems (ADAS), image and video stitching from two different sources serve several crucial objectives to enhance the capabilities of the system. ADAS technologies aim to improve vehicle safety, increase situational awareness, and provide assistance to drivers.

1. 360-Degree Surround View:

- **Objective:** Stitch images from multiple cameras around the vehicle to provide a complete 360-degree surround view.
- **Application:** Assist drivers in parking, maneuvering, and navigating tight spaces by eliminating blind spots.

2. Enhanced Object Detection and Tracking:

- **Objective:** Stitch images or video frames from different sensors to improve the accuracy of object detection and tracking algorithms.
- **Application:** Enhance the reliability of collision warning systems and adaptive cruise control by providing a more comprehensive view of the surroundings.

3. Improved Lane-Keeping Assistance:

- **Objective:** Combine images from multiple cameras to create a seamless and detailed view of the road, improving the accuracy of lane-keeping assistance systems.
- **Application:** Assist drivers in staying within their lanes and provide warnings if they unintentionally drift.

4.Create Panoramic Views:

- **Objective:** Combine images or video frames from different sources to create a panoramic or wide-angle view.
- **Application:** Virtual tourism, architectural photography, surveillance, and immersive experiences.

5. Enhance Field of View:

- **Objective:** Expand the field of view beyond the limitations of a single camera or sensor.

- **Application:** Security and surveillance, robotics, and monitoring large areas.

6. Improved Low-Light Visibility:

- **Objective:** Stitch images from sensors with different light sensitivity to improve visibility in low-light conditions.
- **Application:** Enhance performance in nighttime driving and adverse weather conditions.

Chapter 4

METHODOLOGY:

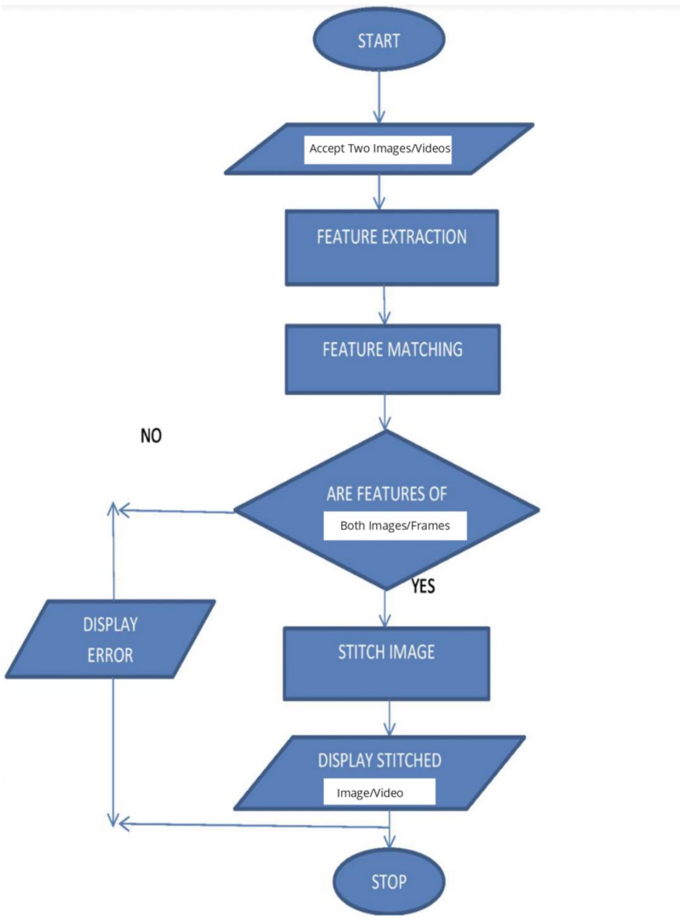

Image or video stitching involves combining multiple images or video frames from different sources to create a panoramic or seamless view. The process typically consists of several steps, and the methodology can vary based on whether you are working with images or video.

Pre-Processing Phase:

1. Image Calibration:

- **Objective:** Ensure that images/videos from different sources are calibrated to correct for distortions and variations in camera parameters.
- **Steps:**
  - Perform camera calibration using known calibration patterns.

- Correct lens distortion and other intrinsic camera parameters.

2. Color Correction:

- **Objective:** Harmonize colour and brightness levels across images to create a visually consistent output.
- **Steps:**
  - Apply colour correction techniques to balance colour tones.
  - Adjust brightness and contrast to create uniform appearance.

3. Exposure Normalization:

- **Objective:** Normalize exposure levels across images to avoid visible seams in the stitched output.
- **Steps:**
  - Apply exposure correction to balance the brightness levels.
  - Address issues related to overexposed or underexposed regions.

4.**Camera Overlap:**

- **Assumption:** There is sufficient overlap between images or video frames.
- **Rationale:** Overlapping regions are necessary for feature matching and establishing correspondences between images.

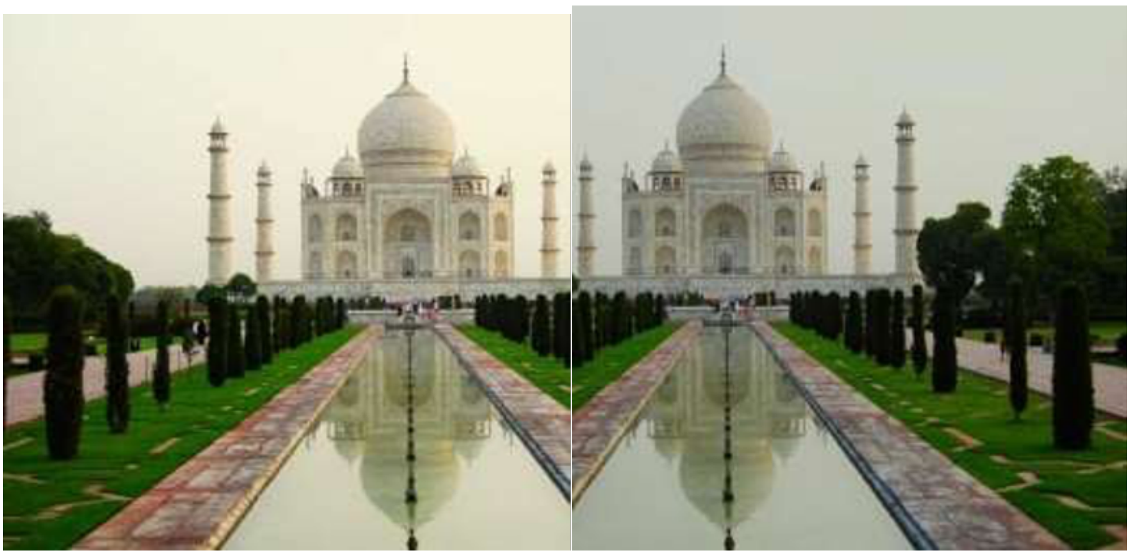

Fig 1.1,1.2 Two Images with matched keypoints

Fig 1.3 Stitched Image

Image Stitching

- **Image Capture:**
  - Capture a set of images with some overlap between consecutive images. Ensure that the images have common features.
- **Feature Detection:**
  - Use a feature detection algorithm (e.g., SIFT, ORB, AKAZE) to identify key points and descriptors in each image. These points are used to find corresponding features in different images.
- **Feature Matching:**
  - Match the features between pairs of images. Establish correspondences between key points in adjacent images.
- **Homograph Estimation:**
  - Use the matched feature points to estimate the homograph matrix, which represents the transformation between two images. This transformation helps align the images correctly.
- **Image Warping:**
  - Apply the homograph transformation to warp the images so that they align properly. This step ensures that the matched features in different images are in the same coordinate space.
- **Blending:**

- Blend the warped images together to create a seamless panorama. Common blending techniques include feathering, alpha blending, or multi-band blending.
- **Optional post-processing:**
  - Apply any necessary post-processing to enhance the stitched image quality, such as colour correction or vignette correction.

Video Stitching:

- **Video Capture:**
  - Capture video frames from multiple cameras or sources. Ensure that there is some overlap between consecutive frames.
- **Frame-by-Frame Image Stitching:**
  - Apply the image stitching methodology described above to each pair of consecutive frames. This involves feature detection, matching, homograph estimation, warping, and blending.
- **Temporal Alignment:**
  - Ensure that the stitched frames are temporally aligned. This may involve adjusting the timing of frames to create a smooth transition between consecutive frames.
- **Blending Across Frames:**
  - Extend the blending process across multiple frames to ensure a smooth and continuous transition between different parts of the video.
- **Optional post-processing:**
  - Apply any necessary post-processing techniques to enhance the overall video quality.

Tools and Libraries:

- **OpenCV:**
  - The OpenCV library in Python provides functions for feature detection, image warping, and blending. It is widely used for both image and video stitching.

- **Scikit-Image:**
    - Scikit-Image is a collection of algorithms for image processing. It provides functions for image alignment and other related tasks.

RESULTS

The implemented code successfully stitches frames from two video sources, providing a continuous, panoramic view. The system dynamically adjusts to the input frames, ensuring proper alignment and smooth transitions between consecutive frames.

Key point correspondences are accurately identified and matched across different frames, as shown by the lines connecting the key points in the output image. This is crucial for creating a seamless panorama.

The output image displays a wide-angle or panoramic representation of the scene captured in the individual images, providing drivers with a more complete picture of their surroundings and potentially enhancing situational awareness and improving safety.

The stitched output of two different videos smoothly blends the overlapping regions of adjacent frames, ensuring that there are no noticeable seams or artifacts in the final video. This demonstrates the system's ability to seamlessly integrate information from multiple sources, creating a single, coherent panorama.

The successful implementation of this code offers promising potential for ADAS applications. By providing drivers with an expanded view of their surroundings, the system can potentially contribute to improved situational awareness, enhanced decision-making, and ultimately, safer driving experiences.

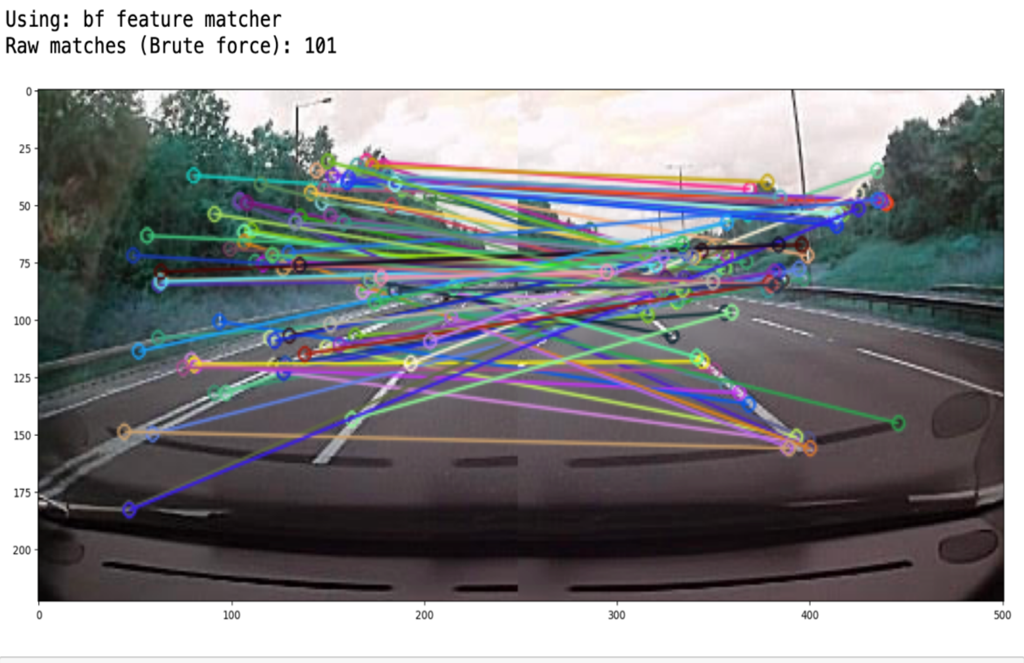

Fig 1.4 output image showing the correspondences between key points in two input images. The lines connecting the key points highlight the established matches.

Fig 1.5 and 1.6 The output image shows a wide-angle or panoramic representation of the scene captured in the individual images

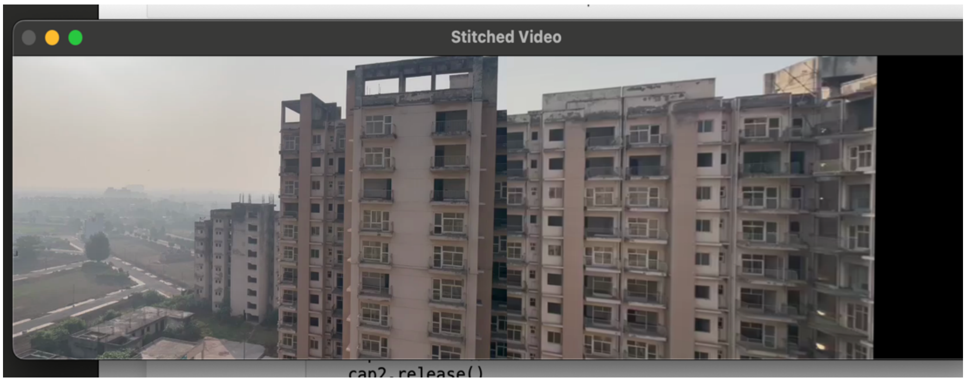

Fig 1.7 Stitched output of two different videos. Output has is blend of the overlapping regions of adjacent frames, ensuring that there are no noticeable seams or artifacts in the final video.

Chapter 7

7.1 CONCLUSION:

Video stitching serves as a technology designed to overcome the limitations of the field of view in images and videos by combining multiple overlapping frames or images. This process entails aligning and blending the images to produce a continuous and seamless final output. In the realm of video production post-production, video stitching plays a vital role by seamlessly blending images and sounds to craft a final product that is both cohesive and emotionally resonant.

However, it's crucial to acknowledge that video stitching is an intricate technology requiring careful consideration of various factors. Factors such as moving objects or abrupt camera movements can introduce challenges like jitter, shakiness, ghosting, and blurring, thereby complicating the stitching process. To address this, the use of specialized software and hardware becomes essential to ensure a smooth and seamless stitching process.

In summary, video stitching stands as a pivotal technology for producing high-quality videos with an expanded field of view. Despite its complexity, thoughtful consideration of various factors, coupled with the right tools and techniques, enables the creation of final products that are not only seamless but also emotionally captivating for audiences.

7.2 Future Scope

The future of image stitching from dual cameras holds immense potential in VR, AR, surveillance, and sports broadcasting. Advancements in technology offer opportunities to refine the process, using advanced algorithms and AI for precise and rapid stitching.

With the rising demand for realistic 360-degree views, future developments may leverage AI to enhance precision and speed. In surveillance, evolving stitching techniques could enable more sophisticated monitoring, integrating machine learning and computer vision for real-time insights. In sports broadcasting, advanced stitching may deliver more captivating views, allowing for immersive perspectives and real-time replays.

The ongoing evolution of technology promises significant advancements, shaping immersive experiences across VR, AR, surveillance, and sports broadcasting.

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