# Under Vehicle Surveillance System (UVSS): A Complete Pipeline for Undercarriage Imaging and Panoramic Stitching

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Computer Vision Project (4 Credits)

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*Abstract*—**Vehicle security inspection is an essential component of safety at critical checkpoints such as airports, military bases, and government infrastructures. Manual inspection of the vehicle undercarriage using handheld mirrors is slow, error-prone, and inconsistent. This paper presents a complete Under Vehicle Surveillance System (UVSS) pipeline that captures undercarriage images, undistorts them using Scaramuzza's omnidirectional camera model, preprocesses them, and stitches them into a panoramic mosaic using OpenPano. The system forms the basis for future anomaly detection using deep learning. We demonstrate the effectiveness of the approach with both fisheye and planar imaging setups.**

## I. INTRODUCTION

Security agencies require rapid and accurate inspection of the underside of vehicles to detect contraband, explosives, or unauthorized modifications. Traditional mirror-based inspection is inadequate in high-risk environments. Modern automated UVSS systems aim to generate a clear stitched mosaic of the undercarriage for efficient visual or algorithmic inspection.

This project develops a full UVSS pipeline involving image capture, calibration, undistortion, preprocessing, stitching, and preparation for anomaly detection. Both fisheye and planar camera configurations are evaluated.

## II. RELATED WORK

Fisheye calibration and omnidirectional imaging methods are well-studied in computer vision. Scaramuzza's OCamCalib model offers high-accuracy intrinsic estimation for fisheye cameras [2]. Image stitching has been explored widely, and multiband blending with robust feature matching has become standard for panorama generation [3].

## III. SYSTEM OVERVIEW

The proposed pipeline includes:

1) Image acquisition (fisheye and planar)
2) Calibration using OCamCalib
3) Undistortion (C++ implementation)
4) Preprocessing (cropping and histogram equalization)
5) Stitching using OpenPano
6) (Future) Deep-learning-based anomaly detection

## IV. CAMERA CALIBRATION AND UNDISTORTION

We used Scaramuzza's OCamCalib toolbox to calibrate the fisheye camera. Around 30–40 checkerboard images were captured and intrinsic projection polynomials were generated. These calibration parameters were then integrated into C++ using two modules: `omni_cam_model.cpp` and `omni_cam_utilities.cpp`.

The undistortion algorithm computes an inverse projection for each output pixel and samples from the original fisheye frame, producing geometrically accurate images.

## V. PREPROCESSING

To maximize stitching performance:

- Cropping removes irrelevant edges and blank regions.
- Histogram equalization enhances image contrast.

These steps significantly improve feature detection reliability.

## VI. STITCHING PIPELINE

We tested OpenCV's Stitcher, ORB/SIFT-based homography pipelines, and OmniCV-Lib. Finally, we selected Open-Pano, which provides:

- Fast, robust feature extraction
- RANSAC-based homography estimation
- Accurate warping
- Multiband blending for seamless mosaics

## VII. RESULTS

This section shows the complete planar and fisheye imaging pipelines. All images have been equalized in size and framed using a thin black border for consistent IEEE formatting.

### A. Planar Camera Results

### B. Fisheye Camera Results

## VIII. FUTURE WORK

We plan to integrate deep learning for anomaly detection. A convolutional autoencoder will be trained on normal stitched mosaics. Reconstruction error will be used to detect anomalies, and heatmaps will highlight suspicious regions. As shown in Figure 1 and Figure 2, the stitched mosaics are suitable inputs for this task.
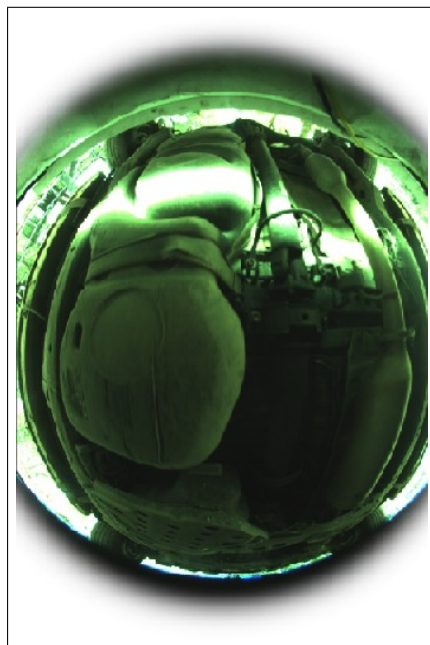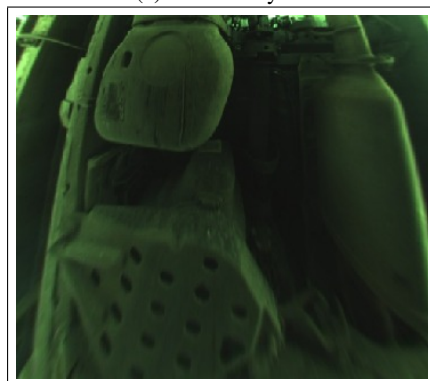
(a) Raw planar



(b) Undistorted & cropped



(c) Stitched planar

Fig. 1: Planar imaging pipeline: raw image, undistortion, and stitched mosaic.



(a) Raw fisheye



(b) Undistorted fisheye



(c) Stitched fisheye

Fig. 2: Fisheye imaging pipeline: raw image, undistortion, and stitched mosaic.

## IX. Conclusion

We developed a complete UVSS imaging pipeline including calibration, undistortion, preprocessing, and stitching. The system performs robustly on both fisheye and planar configurations and forms the foundation for automated anomaly detection.

## Acknowledgements

## References

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