Computer Vision Assignment 1

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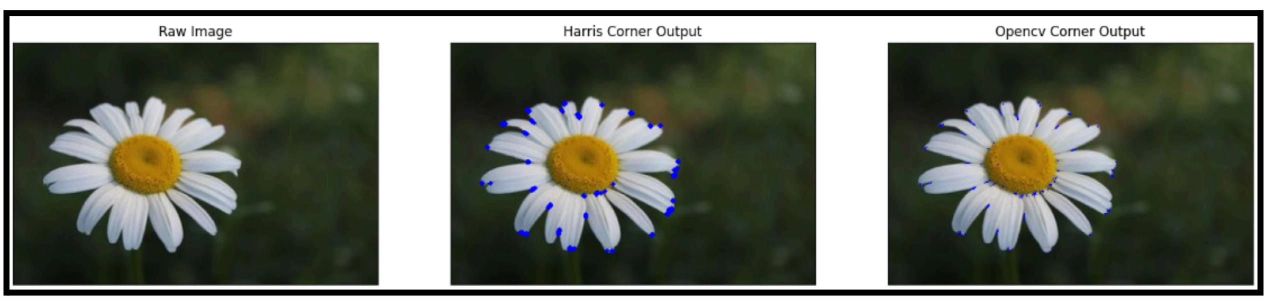
Task 1:- **Harris Corner detection**

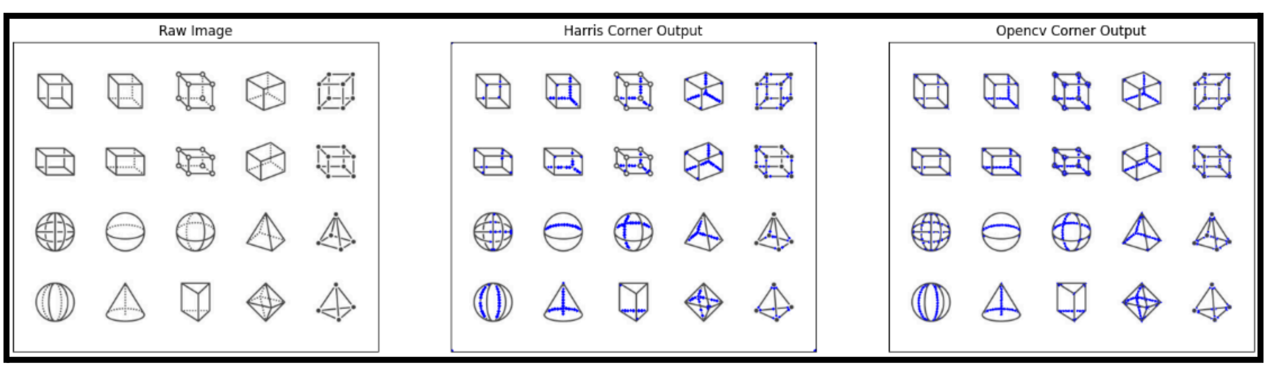
https://www.kaggle.com/code/kushal1506/cv-assign1-q1/notebook

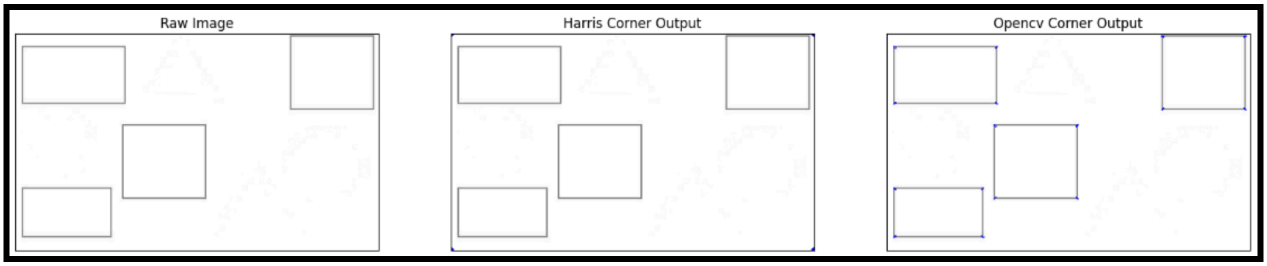
Methodology:

- Image Preparation: Load and convert images to grayscale for uniform processing.
- Sobel Filtering: Apply Sobel filters to compute gradients in horizontal and vertical directions.
- Custom Harris Corner Detection:
    1. Compute gradient products.
    2. Smooth using Gaussian filtering.
    3. Calculate Harris response.
    4. Perform non-maximum suppression.
- Custom Corner Visualization: Overlay detected corners on original images.
- OpenCV Harris Corner Detection: Utilize OpenCV's cornerHarris() function.
- Comparison: Visualize and compare results of custom and OpenCV implementations.

Results :- Threshold = 0.5 and K-value = 0.035







Observations:-

1. **Accuracy Variation Across Images:** The performance of the custom Harris corner detection algorithm varies significantly across different images. While it may produce accurate results for some images, it may struggle or fail to detect corners accurately in others.
2. **Influence of Threshold and K-value:** The choice of threshold and K-value parameters significantly affects the algorithm's performance. A threshold that works well for one image may not be suitable for another, highlighting the importance of parameter tuning and adaptability.
3. **Impact of Image Complexity:** The algorithm may struggle with images containing intricate structures, occlusions, or variations in lighting and texture. These factors can obscure or distort corner features, making them challenging to detect accurately.
4. **Comparative Performance with OpenCV:** While the custom implementation provides insights into corner detection algorithms' inner workings, the OpenCV built-in function demonstrates more robust and consistent performance across a range of images. OpenCV's implementation likely incorporates optimizations and parameter adjustments tailored for general-purpose corner detection.
5. **Need for Adaptive Thresholding:** The observations emphasize the importance of adaptive thresholding techniques that dynamically adjust threshold values based on image characteristics. Adaptive thresholding can enhance the algorithm's robustness and improve corner detection accuracy across diverse image datasets.

Task 2:- **Stereo 3D reconstruction:**

https://www.kaggle.com/code/kushal1506/cv-assign1-q2/notebook

Methodology:-

- Loading Parameters and Images:
  Load intrinsic parameters and stereo images required for reconstruction.

- Disparity Map Calculation:
  Compute the disparity map using block matching techniques.

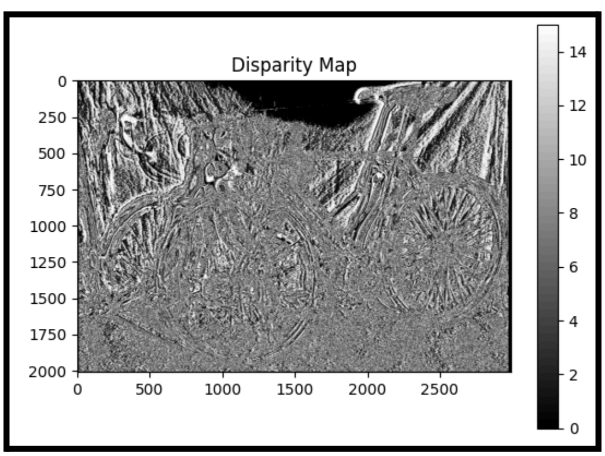
- Depth Map Computation:
  Derive the depth map from the disparity map, baseline, and focal length.

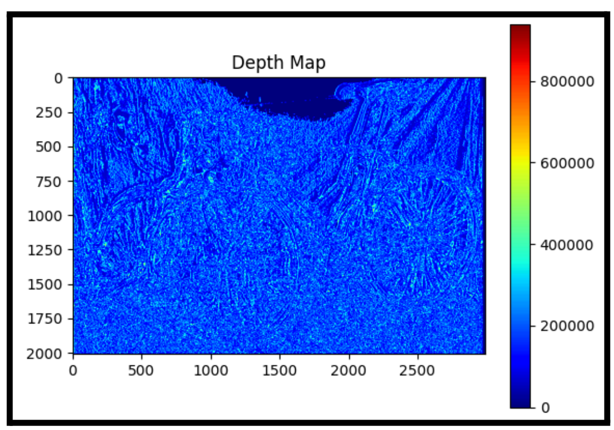
- Stereo Reconstruction:
  Perform stereo reconstruction to generate both disparity and depth maps.

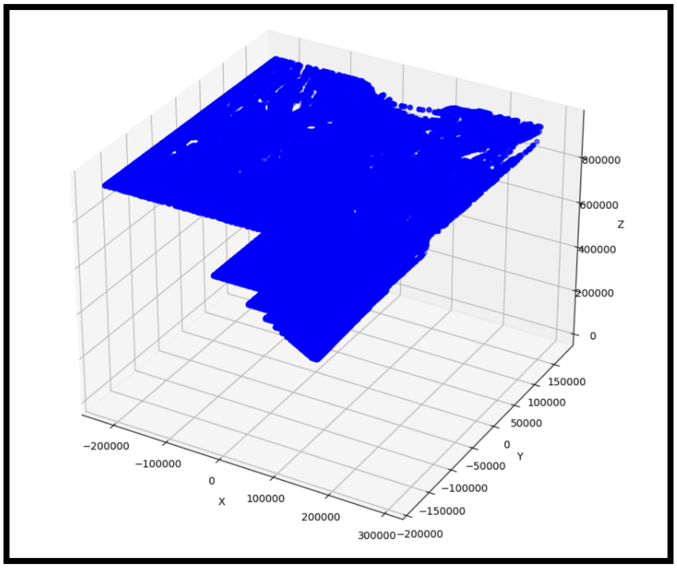
- Visualization:
  Visualize the disparity and depth maps to understand the geometric information in the images.

- 3D Point Cloud Generation and Visualization:
  Convert the disparity map into a 3D point cloud using camera parameters.
  Plot the 3D point cloud for a comprehensive representation of the reconstructed scene.

Results:-







3D point cloud representation

Observations:-

1. **Disparity Map Quality:** The disparity map appears to be of good quality, as the image is clear and distinct. This indicates that the algorithm used for computing the disparity map effectively captured the disparities between corresponding points in the stereo images.
2. **Depth Map Quality**: Similarly, the depth map also seems to be of good quality, with the image being clearly visible. This suggests that the depth estimation process, which utilizes the disparity map along with camera parameters, effectively calculated the depths of different points in the scene.
3. **Poor 3D Reconstruction**: Despite the apparent clarity of the disparity and depth maps, the 3D reconstruction appears to be unsatisfactory. Only a plane is visible in the 3D representation, which indicates that the reconstructed scene lacks depth and detail.

   Possible Issues:
   - Disparity Consistency: The disparities between corresponding points may not be consistent throughout the scene, leading to inaccuracies in the 3D reconstruction.
   - Baseline Effect: The baseline distance between the stereo cameras might not be sufficient to capture significant depth variations in the scene, resulting in a flattened 3D reconstruction.

Task 3:- **Epipolar lines**

https://www.kaggle.com/code/kushal1506/cv-assign-q3/notebook

Methodology:

- Image Loading: Load images from the provided directory.
- Epipolar Line Computation:Compute epipolar lines using the given fundamental matrix for each image.
- Corresponding Points Determination:Find points lying on the epipolar lines within image boundaries.
- Visualization:Plot epipolar lines and corresponding points on both images for analysis.

Results:-

```
Image Shape (1226, 370)

Epipolar line 1 [-2.00187697e-03  2.45203515e-04  9.85412202e-01]

Epipolar line 2 [ 0.00143141 -0.00433173  0.99113045]

points on epipolar line 1 [(492, -1), (496, 30), (500, 63), (504, 95), (508, 128), (512, 161), (516, 193), (520, 226), (524, 25
9), (528, 291), (532, 324)]

points on epipolar line 2 [(0, 228), (42, 242), (84, 256), (126, 270), (168, 284), (210, 298), (252, 312), (294, 325), (336, 33
9), (378, 353), (420, 367)]

points on epipolar line 1 which lie on image [(496, 30), (500, 63), (504, 95), (508, 128), (512, 161), (516, 193), (520, 226), (5
24, 259), (528, 291), (532, 324)]

points on epipolar line 2 which lie on image [(0, 228), (42, 242), (84, 256), (126, 270), (168, 284), (210, 298), (252, 312), (29
4, 325), (336, 339), (378, 353), (420, 367)]
```

Observations :-

1. Geometric Relationship between Epipolar Lines:
    - The epipolar line in the first image corresponds to a specific epipolar line in the second image, and vice versa.
    - Specifically, the epipolar line in the first image, which lies approximately in the middle, corresponds to the epipolar line at the leftmost bottom of the second image, and vice versa.
    - This correspondence follows the fundamental geometric relationship between corresponding points and epipolar lines in stereo images.

2. Consistency of Corresponding Points:
    - Points uniformly spaced along the epipolar lines in one image have corresponding points along the corresponding epipolar lines in the other image.
    - This consistency confirms the accuracy of the epipolar lines and the validity of the fundamental matrix used for computing them.

*There are some points which lie outside the image , those points are ignored.