MP6 Report

In this project the objective is to implement the Hough Transform to detect straight lines in input images. Our focus was to understand how quantization of the Hough parameter space (theta and rho resolutions) affects the detection quality, accuracy, and visualization of lines.

- Edge detection was performed using the Canny algorithm.
- The Hough accumulator was computer with configurable theta_res and rho_res.
- Peak detection selected the top N intersections based on voting strength.
- Lines were drawn back on the original image using these detected peaks.

Three configurations were tested:

1. **Fine Quantization** (theta_res = 1, rho_res =1)
   - Produces accurate and dense line detection across all images.
   - The accumulator captured subtle differences in angle and distance, making line almost precise. Different thresholds effected the detection to be precise.
   - Accumulator heatmaps showed well-defined peaks.
2. **Medium Quantization** (theta_res = 2, rho_res = 2)
   - Lines were not precise and more dispersed.
   - Many important lines were missed due to reduced angular and spatial resolution.
   - Peaks were broader and less defined, leading to very low confidence detections.
3. **Coarse Quantization** (theta_res = 5, rho_res = 5)
   - No useful lines were detected.
   - The large bin sizes in the accumulator resulted in diluted votes, and significant peaks disappeared.
   - Even with an increased number of peaks and a lower threshold the method failed to find any meaningful lines, especially in images with fine edge structure.

Key Insights

- The resolution of theta and rho is critical: lower values improve accuracy at the cost of computation.
- Choosing an appropriate number of peaks is essential. Setting num_peaks prevented noise from dominating results.
- Too coarse quantization leads to underfitting in the Hough space, failing to capture lines.

Conclusion

The Hought Transform is highly sensitive to quantization resolution. Fine quantization at (1,1) consistently produced the best results in our experiments. Coarse quantization sacrificed too much accuracy, leading to missing or inaccurate line. This highlighted the balance between computational efficiency and detection accuracy in practical computer vision systems on images.