Department of Electronic & Telecommunication Engineering
University of Moratuwa

# EN3160 - Image Processing and Machine Vision


## Assignment 02
## Fitting and Alignment

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**GitHub Link for Code:** Link to my GitHub repository

# Question 1: Blob Detection

Implemented blob detection using Laplacian of Gaussian (LoG) filters on the sunflower field image. The process involved applying LoG at multiple scales, detecting maxima across the scale-space, and extracting circle parameters.

The largest detected circle parameters:

- **Radius**: 22.6274 pixels
- **Center**: (167, 340)
- **Range of $\sigma$ values**: 0.5 to 64.00

The output image with circles highlighted shown below:

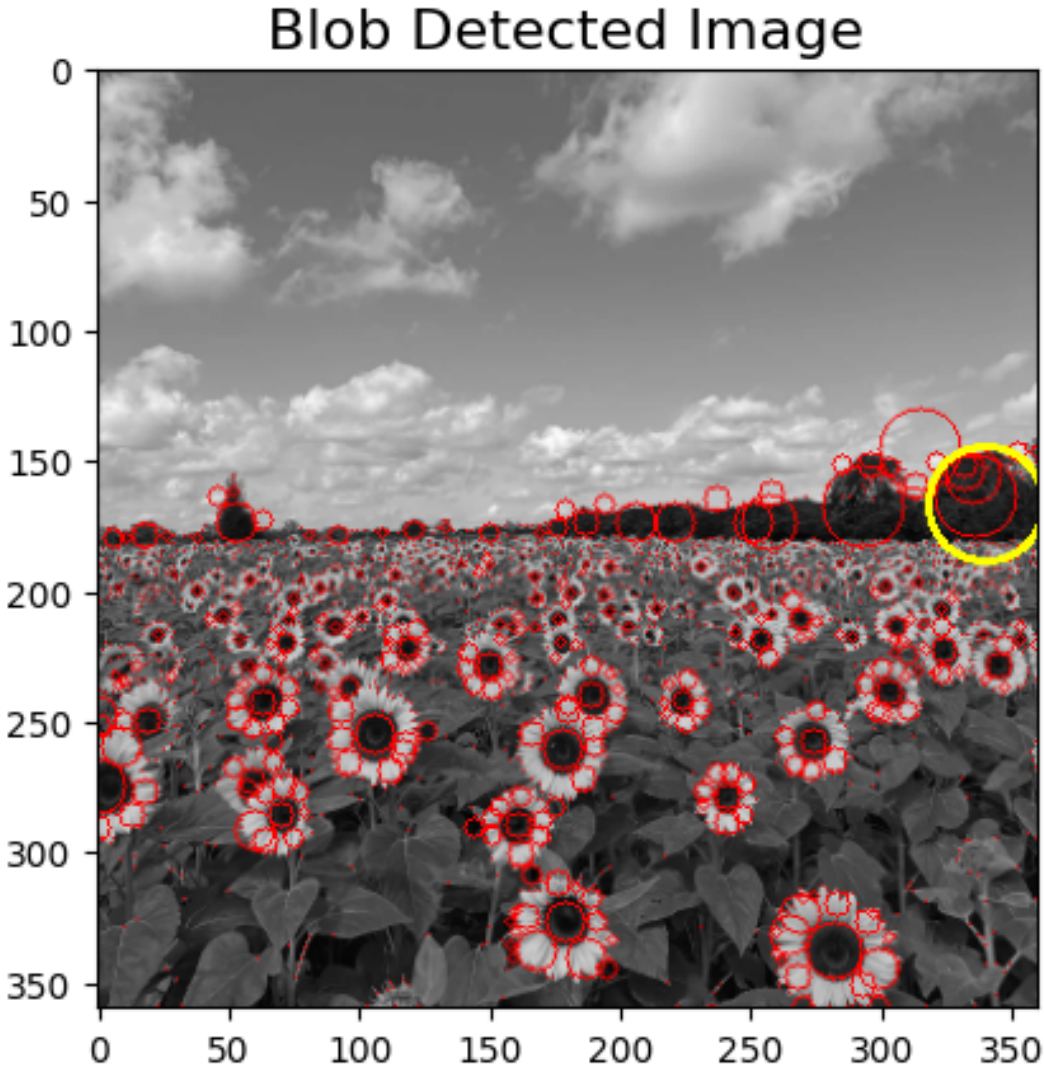


Figure 1: Detected blobs. The largest circle is highlighted in yellow.

# Question 2: Line and Circle Fitting with RANSAC

### (a) Line Estimation using RANSAC

The RANSAC algorithm was applied to estimate the line from the noisy points. The line is parameterized by $a$, $b$, and $d$, with the constraint that $\|[a, b]^T\| = 1$. The best line was found by minimizing the total error (normal distance) of inliers. The algorithm converged to the following line model after multiple iterations:

$$\text{Best Line Model: } [a, b, d] = [0.674, 0.738, 1.403]$$

The line fitting process selected 41 inliers out of 100 data points. The final error was 9.38.

### (b) Circle Estimation on Remnants using RANSAC

After fitting the line, the remaining points (remnants) were used to fit a circle using RANSAC. The best-fitting circle was obtained by minimizing the radial error. The circle is parameterized by its center $(x_0, y_0)$ and radius $r$. The best circle model given below:

$$\text{Best Circle Model: } (x_0, y_0, r) = (2.183, 3.232, 10.36)$$

This model fit 36 inliers out of 59 remnants with an error of 5.33.

### (c) Visualization

The following image shows the line and circle fitting results. The ground truth line and circle are also shown.

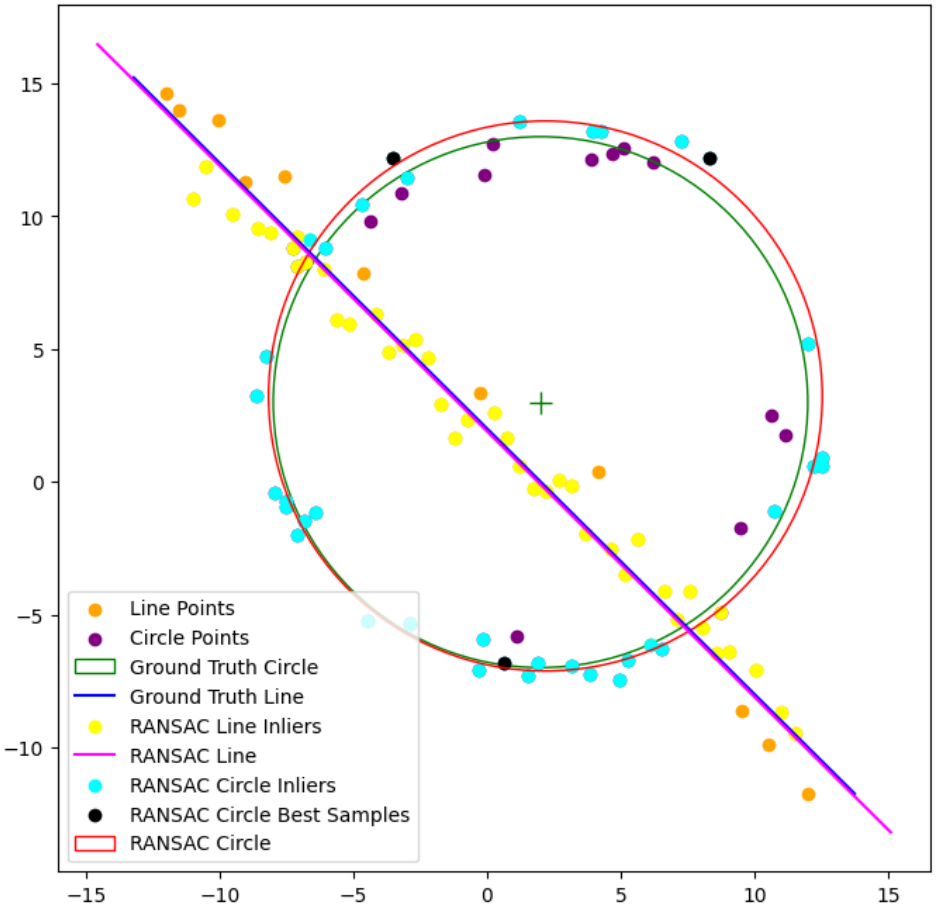


Figure 2: RANSAC fitting: the best-fit line (magenta), the best-fit circle (red), and their inliers.

### (d) Fitting the Circle First

If we were to fit the circle before the line, the remaining points would include significant line data, leading to incorrect circle fitting, as the line points would interfere with the circle's radial error minimization.

# Question 3: Homography and Image Superimposition

Followed steps:

1. Loaded the base and overlay images.
2. Selected four points on the base image to define the destination points.
3. Computed the homography matrix using the selected and overlay image points.
4. Warped and superimposed the overlay image onto the base image.

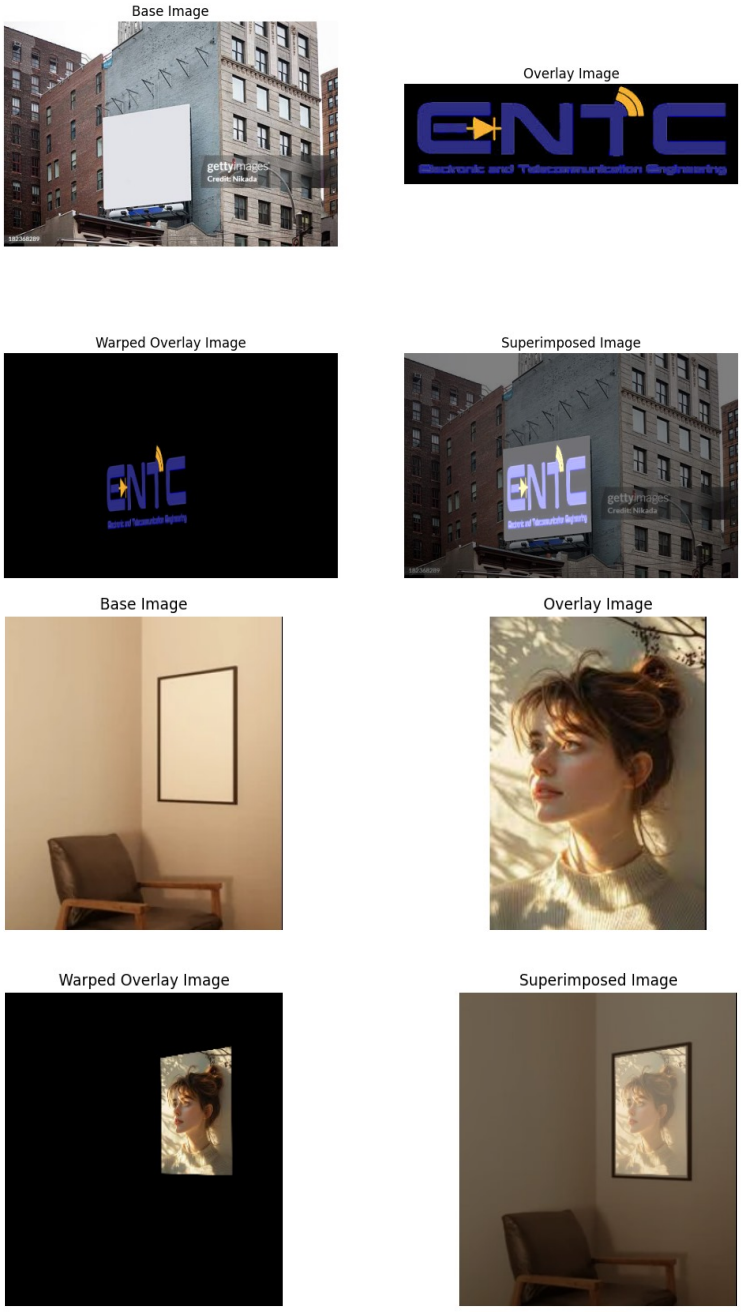


Figure 3: Base Image, Overlay Image, Warped Overlay Image, and Superimposed Image

**Rationale for Image Choice**

- In the first image pair, I simulated an advertisement scenario by overlaying the ENTC department logo onto a billboard in the base image. This demonstrates how companies digitally place advertisements or logos on public surfaces, such as billboards.

- In the second image pair, I inserted a picture of a girl into a picture frame on a wall, illustrating how personal photos are seamlessly integrated into indoor environments for decorative purposes.

# Question 4: Image Stitching with Homography

### (a) SIFT Feature Matching

SIFT features were detected and matched between `img1.ppm` and `img5.ppm` using a brute-force matcher (BFMatcher). The 50 best matches were visualized, showing clear correspondences between the two images.

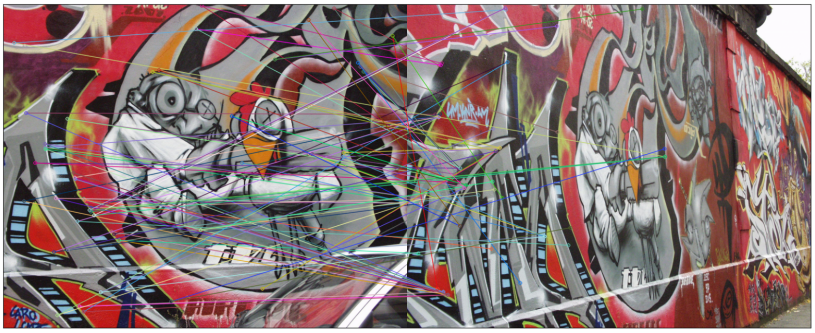

Figure 4: Top 50 SIFT matches between `img1.ppm` and `img5.ppm`.

### (b) Homography Estimation using RANSAC

A homography matrix was computed using RANSAC by selecting random correspondences and minimizing the reprojection error. The estimated homography matrix was:

$$H_{\text{RANSAC}} = \begin{bmatrix} 1.411 & -1.478 & 406.45 \\ 0.941 & -1.000 & 283.68 \\ 0.003 & -0.004 & 1.000 \end{bmatrix}$$

The number of inliers was 191, and the computed homography matrix was compared to the one provided in the dataset.

### (c) Image Stitching

The homography matrix was applied to warp `img1.ppm` onto `img5.ppm`. The perspective-transformed image was blended with `img5.ppm` to create the final stitched image.

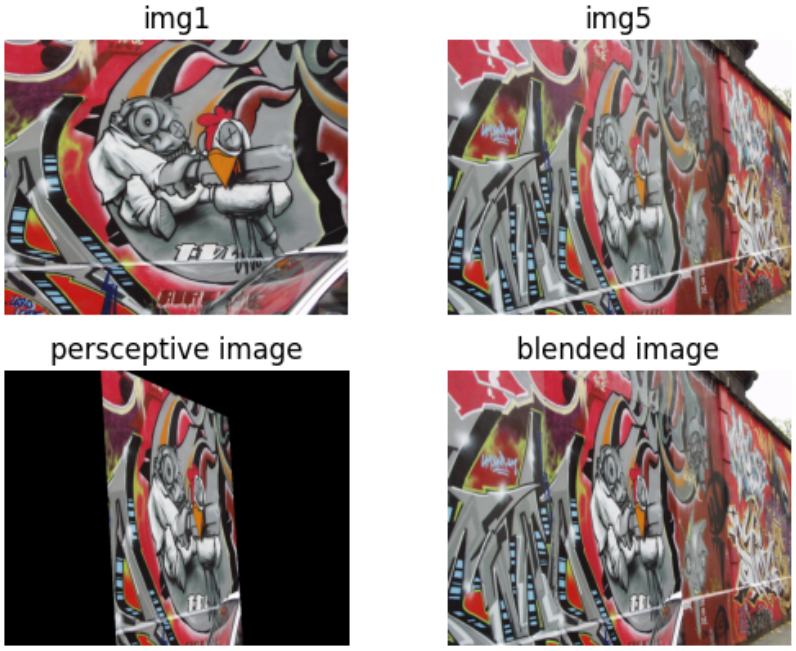


Figure 5: Result of stitching `img1.ppm` onto `img5.ppm`.