A High-Accuracy Rotation Estimation Algorithm Based on 1D Phase-Only Correlation

Team Name - Dream Team

Mentor TA - Prathyakshun

Link to github repository:
https://github.com/niveditarufus/Dip_project-DreamTeam

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Basic Principle of Image Rotation Estimation (2DPOC)

Basic Principle of Image Rotation Estimation 2DPOC

- The problem considered here is to estimate the rotation angle θ between two images that are rotated with respect to each other.
- For estimating the image rotation, we employ the polar mapping of the amplitude spectrum to convert the image rotation into the image translation.

Basic Principle of Image Rotation Estimation

Input : Images f,g

Estimate the 2 D DFT of f,g after applying Hanning window => (F,G)

Estimate Amplitude spectrum and log amplitude spectra.

Estimate Polar mapping F=>F_P , G=> G_P)

Image displacement between F_p and G_P gives our rotation angle Ɵ.

Output : Rotation between f,g

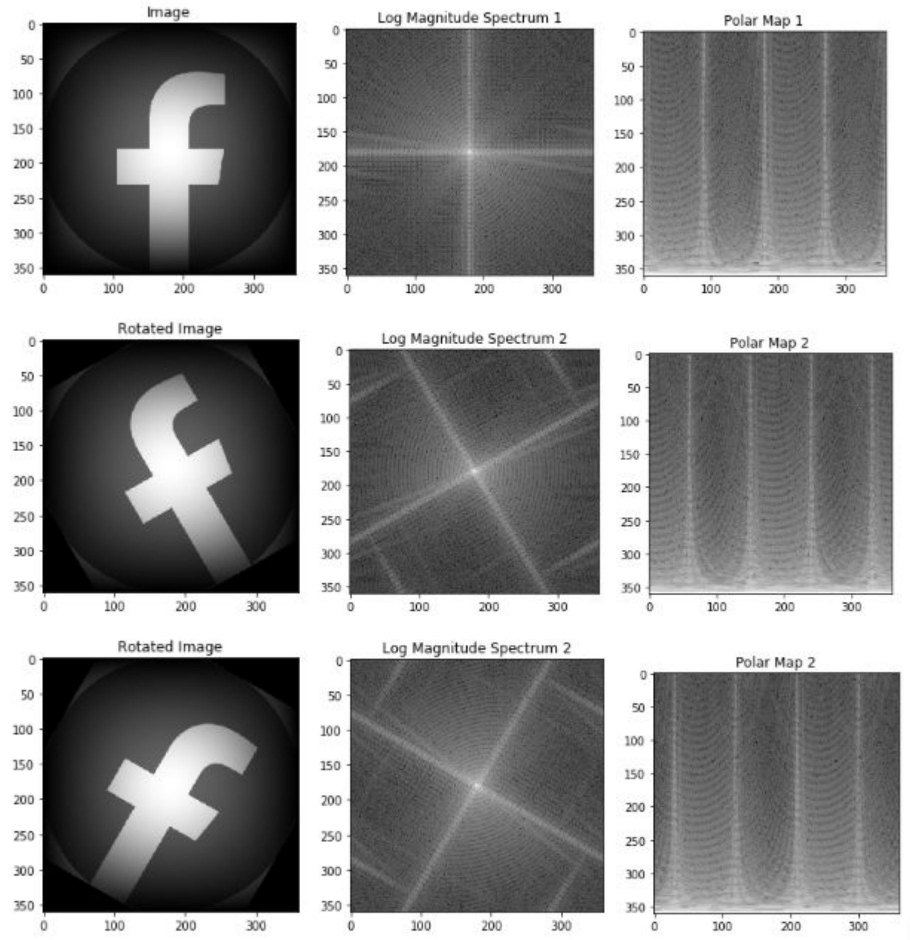


Image
Log Magnitude Spectrum 1
Polar Map 1
Rotated Image
Log Magnitude Spectrum 2
Polar Map 2
Rotated Image
Log Magnitude Spectrum 2
Polar Map 2
0
50
100
150
200
250
300
350

1 D POC

Rotation Estimation Algorithm Using 1D Phase-Only Correlation

The problem of rotation estimation is replaced to 1D displacement estimation between row lines in two polar mappings. The use of 1D POC function makes it possible to reduce the computational cost significantly for estimating the rotation angle. In this section, we first define the 1D POC function and then introduce the details of the proposed rotation estimation algorithm.

Rotation Estimation Algorithm Using 1D Phase-Only Correlation

Input : 1D signals f,g

Estimate the DFT of 1D signals
f=>F , g=>G

Estimate its Cross-phase spectrum
R(k)

$$R(k) = \frac{F(k)\overline{G(k)}}{\left|F(k)\overline{G(k)}\right|} \simeq e^{j\frac{2\pi}{N}k\delta}$$

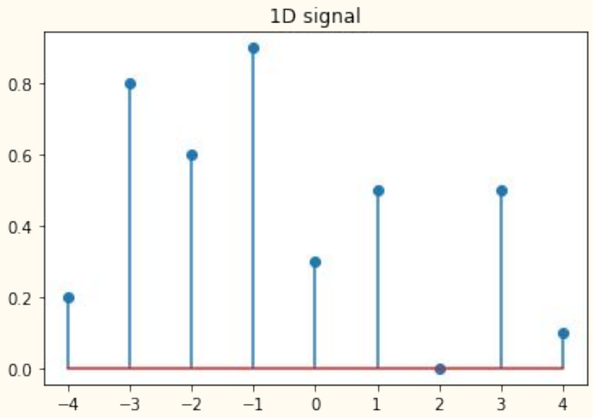
Estimate the Inverse Discrete
Fourier Transform of R(k) => r(k)

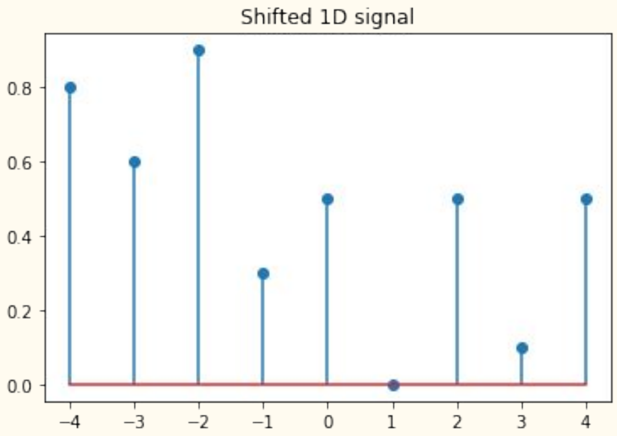
$$r(n) = \frac{1}{N}\sum_{k=-M}^{M} R(k)W_N^{-kn}$$

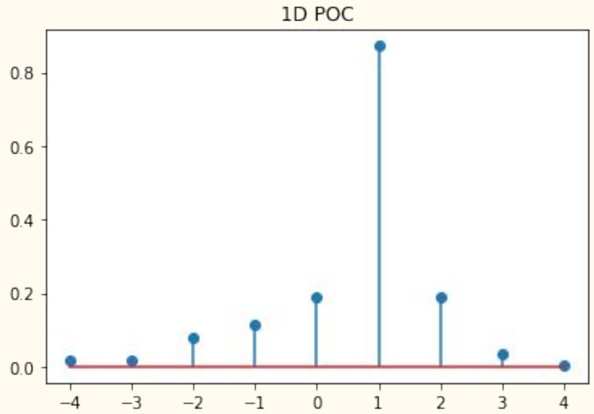
The peak position δ of the function corresponds to the displacement between the two signals

Output : Rotation between f,g

Result of 1D POC







High-Accuracy Image Rotation Estimation Algorithm

Effective line extraction

Input : Image f

Rotate the original image by a degree f', (Θ = 40 degree , assumed)

Estimate the polar mappings of Amplitude spectra $F_p(l_1,l_2)$, $F_p'(l_1,l_2)$

Extract row wise signals u_{l1} and u_{l2}' in l_2 direction and obtain displacement & 1D phase correlation peak (δ_{l1} ,α_{l1})

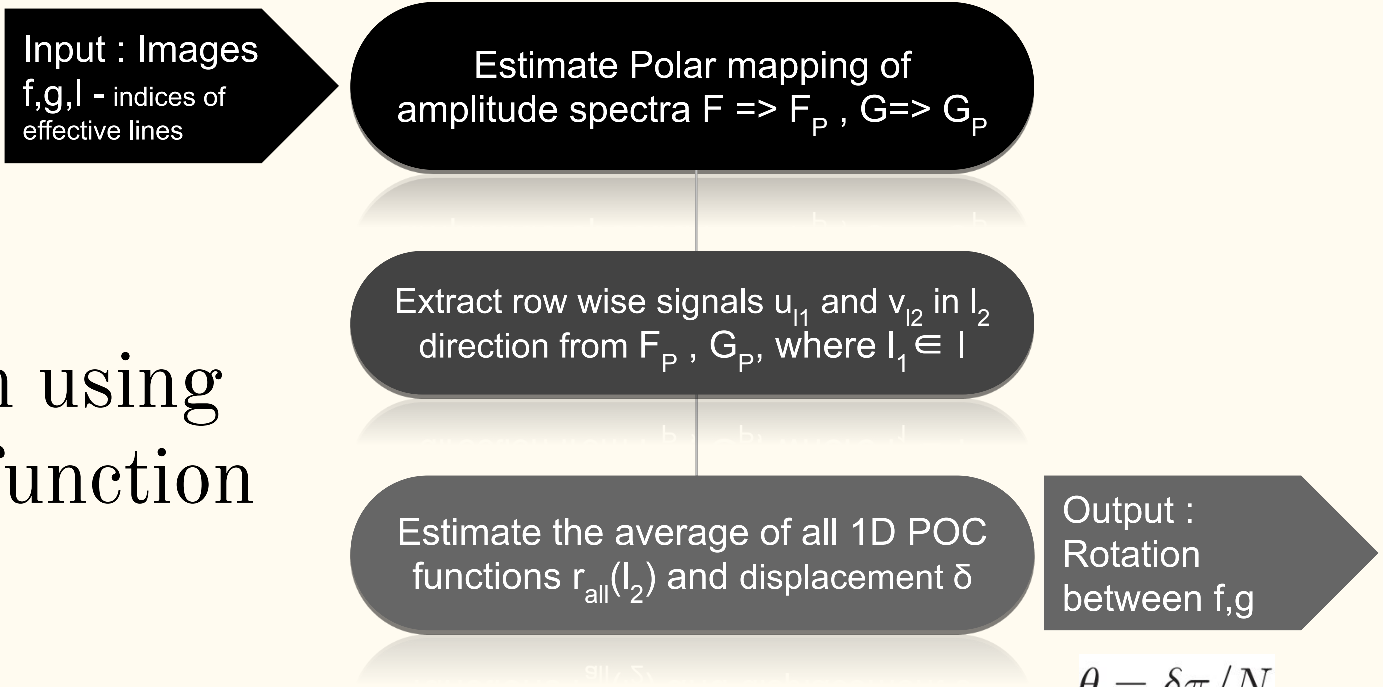
Consider only the lines which give an error below a certain threshold, to get the effective lines.

$$\boldsymbol{l} = \{l_1 : \ |\delta_{l_1} - N\Theta/\pi| < \delta_{th}, -M \le l_1 \le M\}$$

Update the indices l by extracting upper half of the correlation peak value α_i .

Output : Indices of effective lines

Rotation estimation using 1D POC function



$$\theta = \delta\pi/N$$

Function Fitting

Function Fitting

- Function fitting is done for high-accuracy estimation of peak location. This leads us to have sub-pixel accuracy.
- The fitting function used in the paper is given by the following equation where α and δ are the fitting parameters

$$R(k) = \frac{F(k)\overline{G(k)}}{\left|F(k)\overline{G(k)}\right|} \simeq e^{j\frac{2\pi}{N}k\delta},$$

$$r(n) = \frac{1}{N}\sum_{k=-M}^{M} R(k)W_N^{-kn}$$

$$\simeq \frac{\alpha}{N}\frac{\sin\{\pi(n+\delta)\}}{\sin\{\frac{\pi}{N}(n+\delta)\}},$$

Experiments and Discussions

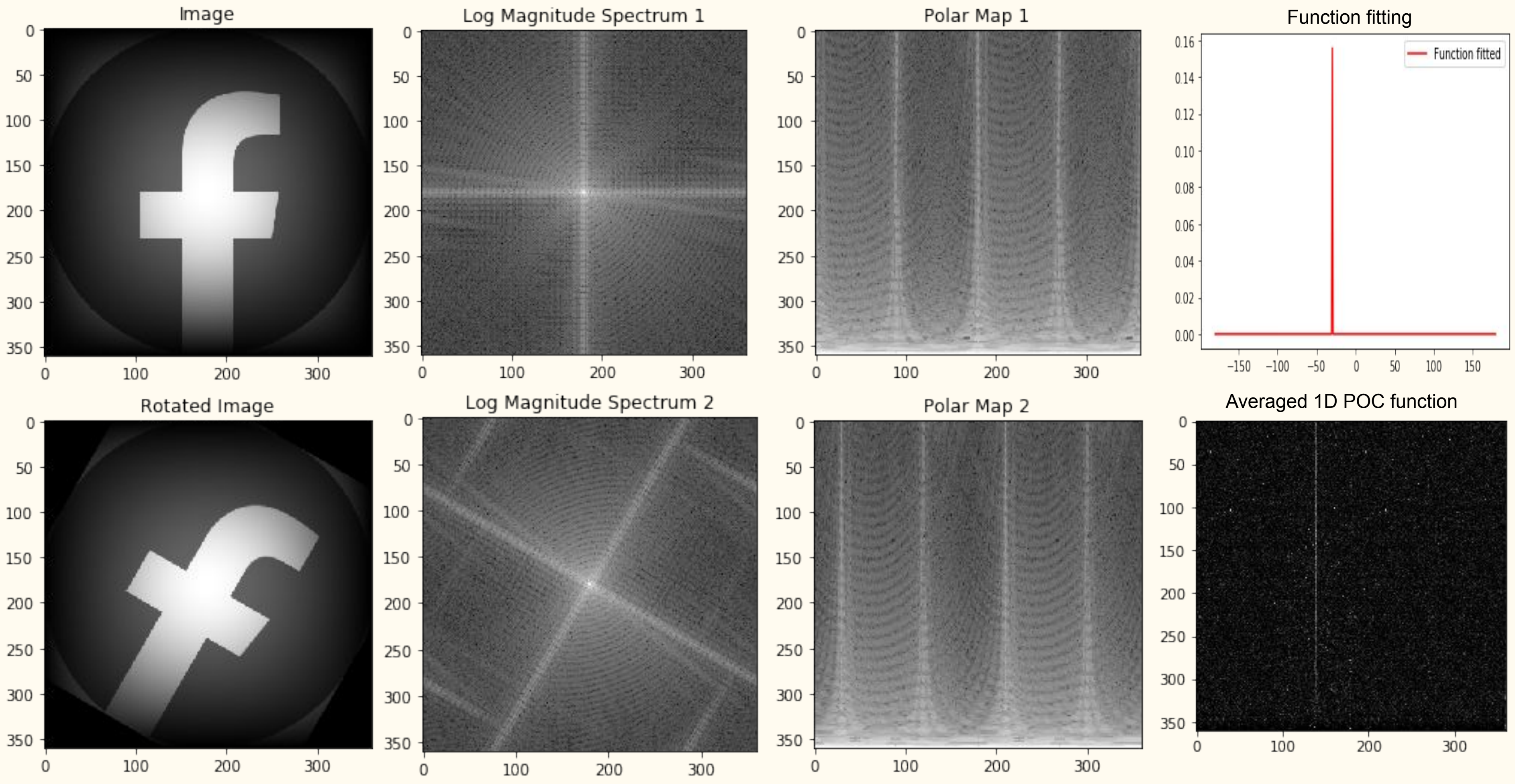


Image
Log Magnitude Spectrum 1
Polar Map 1
Function fitting
Function fitted
Rotated Image
Log Magnitude Spectrum 2
Polar Map 2
Averaged 1D POC function

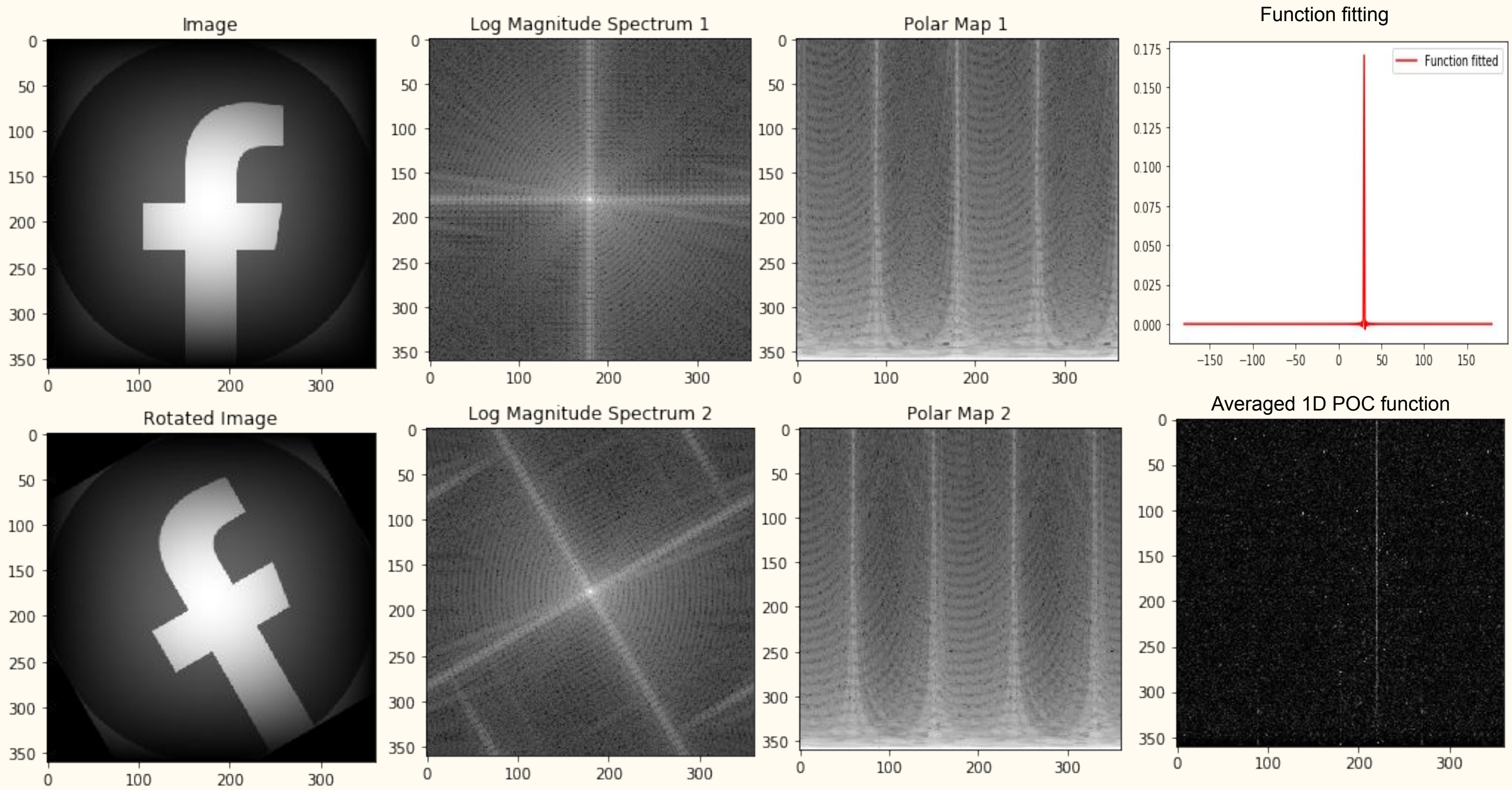


Image
Log Magnitude Spectrum 1
Polar Map 1
Function fitting
Function fitted
Rotated Image
Log Magnitude Spectrum 2
Polar Map 2
Averaged 1D POC function

Computational cost comapision between 1D POC and 2D POC

	Polar mapping generation	Displacement Estimation	Total
2D-POC	2N	4N	6N
1D-POC	2N	N/2 + 1	2.5N +1

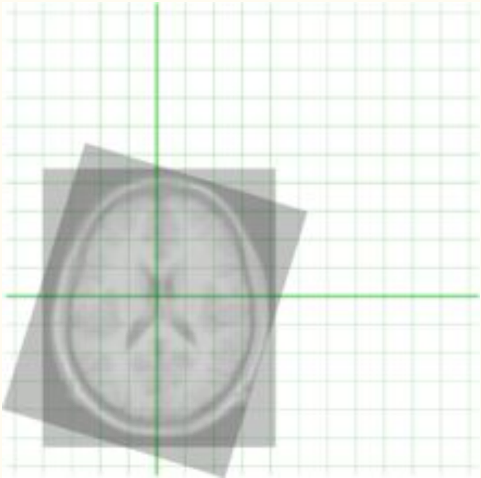
Applications

Image sensing

Image/video processing

Computer vision

Industrial vision



Future Scope

The adaptive line search algorithm can be replaced by a Neural Network.

THANK YOU

Division of Work -

Sravya - Code and report for 1D phase correlation and function fitting.

Nivedita - Code and report for 2D phase correlation and effective line search.

Note : All parts were discussed before coding it individually

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