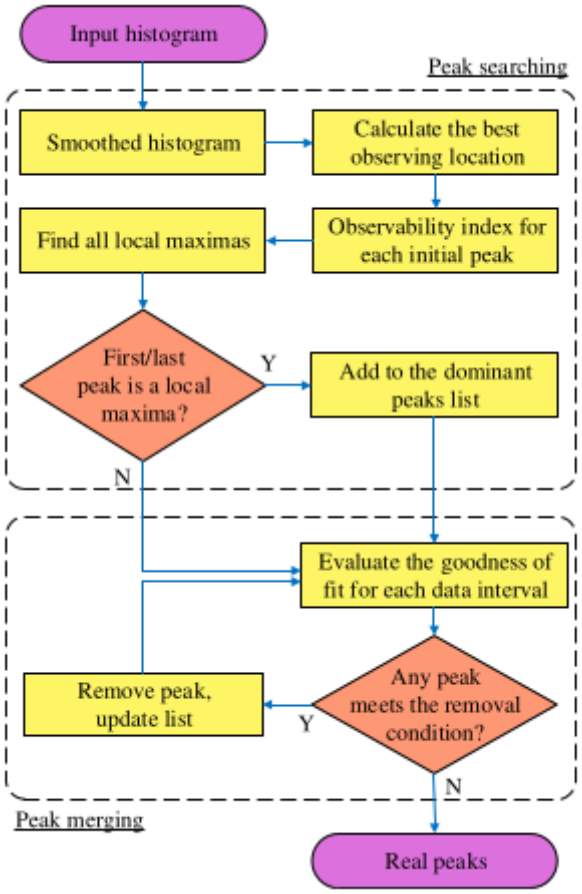
Project Report

Summit Navigator: A Novel Approach for Local Maxima Extraction

Aim

Detect Dominant Peaks using Summit Navigator(SN) and segment the image on that basis.

Flow Diagram



Theory

Preprocessing:

To reduce noise and preserve peaks for detection, a moving average filter with a width of 3 is applied to smooth the input histogram.

Peak detection:

To find the best observing location for initial peaks so that dominant peaks can be extracted based on the search.

Peak merging:

While the peak searching algorithm effectively removes many non-dominant peaks, false peak detections may still occur due to noise at lower frequencies.

Performance Evaluation Measures:

Evaluated by using the F-measure as a compromise between recall and precision. Here

p and r denote the precision and recall measure defined respectively as:

$$F = \frac{2 \times p \times r}{p + r},$$
$$p = \frac{tp}{tp + fp},$$
$$r = \frac{tp}{tp + fn}.$$

Confusion Matrix:

Data class	Classified as *pos*	Classified as *neg*
pos	true positive (*tp*)	false negative (*fn*)
neg	false positive (*fp*)	true negative (*tn*)

Error in paper and our approach

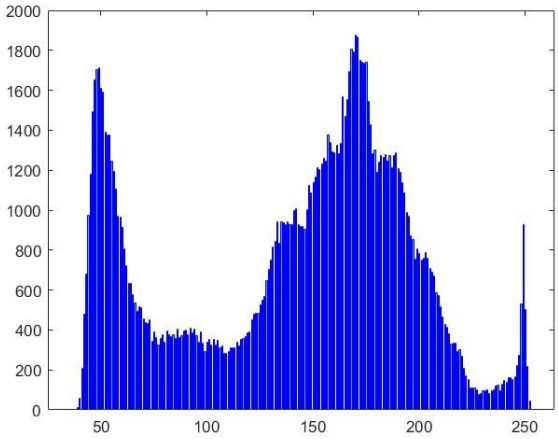
We've identified an error in the research paper. The statement, " R_k^2 is smaller than a pre-defined threshold," is incorrect according to our assessment. Instead of "smaller," it should be corrected to "greater."

Incorrect: "R_k^2 is smaller than a pre-defined threshold"
Correct: "R_k^2 is greater than a pre-defined threshold"

mode. Consequently, a peak at s_k, $k \in \mathbf{v}$, can be determined as false under the following conditions:

- R_k^2 is smaller than a pre-defined threshold, and
- its height, h_{s_k}, is smaller than either the height of the previous peak, $h_{s_{k-1}}$, or the next peak, $h_{s_{k+1}}$.

Upon our observation, we noticed that false peaks yield a considerably higher R_k^2 value compared to the R_k^2 value of genuine peaks. Here's an example for clarification (Human 2):



Detected Peaks after pear searching: 48, 93, 170, 249

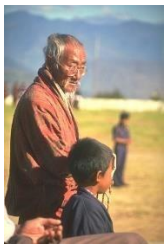
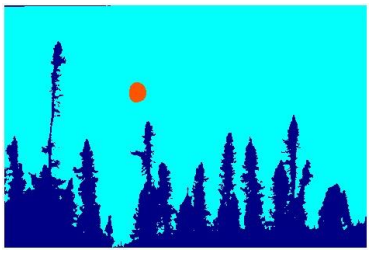
As evident in the histogram, peak 93 lacks dominance.

```
R-square value for 48: 75.6363%
R-square value for 93: 91.5303%
R-square value for 170: 85.0499%
```

Upon evaluating the associated values (as seen above), we notice that the R_k^2 value for peak 93 is higher than that of all other peaks. Therefore, we've concluded that the conditional statement in the research paper is inaccurate.

Results

Berkley Data set

	Nature 1	Human 2	Human 1
Original Image			
Image Thresholded using SN			
R_k^2	86	86	80

Scores of images obtained using the Summit Navigator algorithm

Image Name	F	p	r
Nature 1(238011.jpg)	0.9971	0.9994	0.9948
Human 2(246016.jpg)	0.9972	0.9998	0.9946
Human1(23025.jpg)	0.8192	0.8535	0.7875

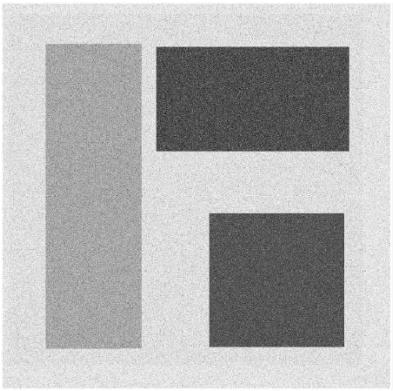
Synthetic Data

R_k^2 is set 20%

Peak Locations after SN algorithm 28, 77, 151, 255

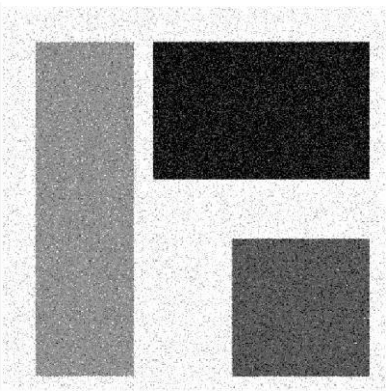
Algorithm Name	F	p	r
SN(Summit Navigator)	0.8094	0.8054	0.8135

Input Image

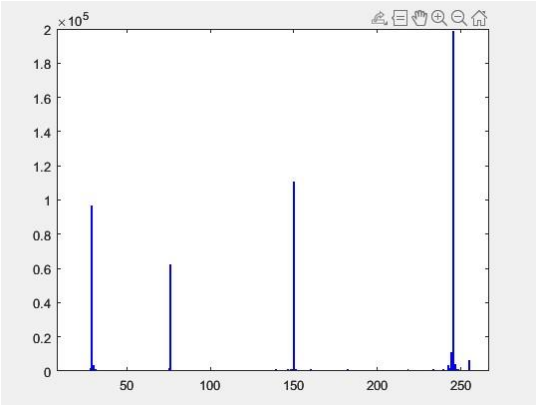


Ground Truth

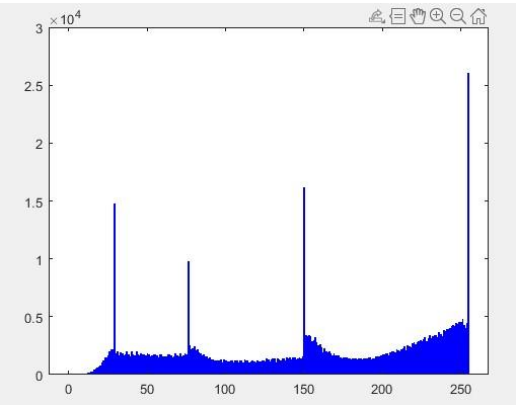
Thresholded Image



Original Image Histogram



Noised Image Histogram



Probable Reason for the difference in F measure value obtained by us vs Research Paper

There are multiple locations at which minimum(used to threshold image) occurs authors might be taking a different one and we are taking location in the middle say minimum occurs at [L1, L2, L3] authors might be taking L1 or L3 we are taking L2.

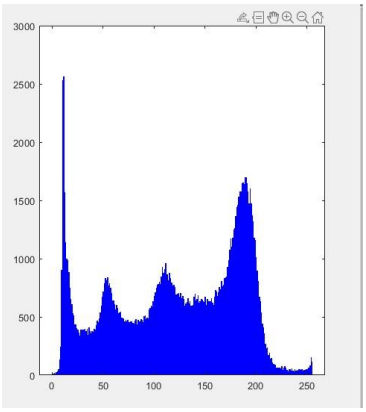
Further extension for achieving better results

For Human 1 addition to the reason mentioned above Peak Merging algorithm needs to be modified as well to obtain better results.

Problem with the current implementation

```
Pair 4: 190 228
R-square value: 87.2165%
Pair 5: 228 255
R-square value: 26.4808%
Final vk values after peak merging:
    11    53   110   190   228   255
```

Current results consider 228 to be a true peak while it is not as evident as evident from the following histogram for the image



This is happening because 228 and 255 are on two different modes and the current algorithm considers a peak to be true if the current peak and the peak next to it are on two different modes.

Let v_k be the peaks from the peaks searching algorithm.

To make the algorithm better we propose the following addition – Check if v_k, and v_{k+1} peaks are on the same modes, if they are then remove the peak that is lower in height, earlier in the implementation we removed the peak only if v_k is lower in height. Keep the peaks if two peaks are on different modes.

To check if they are in the same mode we can use the method as described in the paper. R_k^2 is high for peaks on the same mode and low for peaks on different modes.

Inputs Table for main.m file

Image Name	R_k square value	Ground truth threshold
Nature 1(238011.jpg)	86	[54,180]
Human 2(246016.jpg)	86	[109, 228]
Human1(23025.jpg)	80	[27, 83, 158, 231]

Group Member Contribution

Harsh Gupta - 12140750

PeakSearching.m – Implementation of Peak Searching algorithm
Fmeasure.m, Thresholding.m, main.m, ThresholdingSyn.m, mainSyntheticData.m
Project Report

Dhruv Gupta – 12140580

PeakMerging.m – Implementation of Peak Merging Algorithm
Rmeasure.m, Demonstration Video, Readme
Project Report

Rounak R. Kamble - 12141410

Histogram.m, InitialPeaks.m – Implementation of Pre-Processing part.

Reference

T. H. Dinh, M. D. Phung, and Q. P. Ha, "Summit Navigator: A Novel Approach for Local Maxima Extraction," in IEEE Transactions on Image Processing, vol. 29, pp. 551-564, 2020, doi: 10.1109/TIP.2019.2932501.