Image Processing (CS313a) – Project

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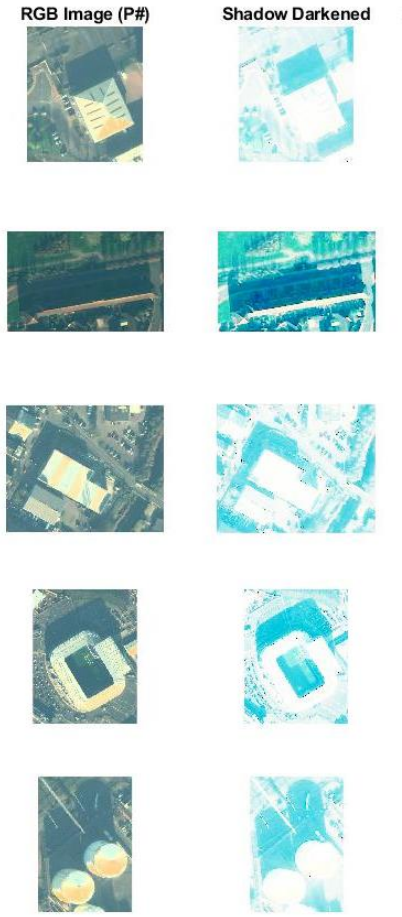
A Shadow-Overlapping Algorithm for Estimating Building Heights From VHR Satellite Images

- **Objective**:

  To identify height of a building from it's shadow on pan-sharpened VHR (Very High Resolution) satellite images.

- **The Procedure are mentioned in the following slides.**

Step 1: Obtain Shadow Image



Initial Image

I_S

Non Linear Mapping Function used:

$$f(x) = \frac{1}{1 + e^{-\alpha\left(1 - x^{\frac{1}{\gamma}} - \beta\right)}}$$

Resultant pixels form image V. NIR channel is taken from tiff file in the dataset.

D = V * NIR ; T = V / NIR

$$I_S = (1 - D)(1 - T)$$

I_S is the shadow darkened image of the original, as shown.

Step 2: Create Initial Shadow Mask

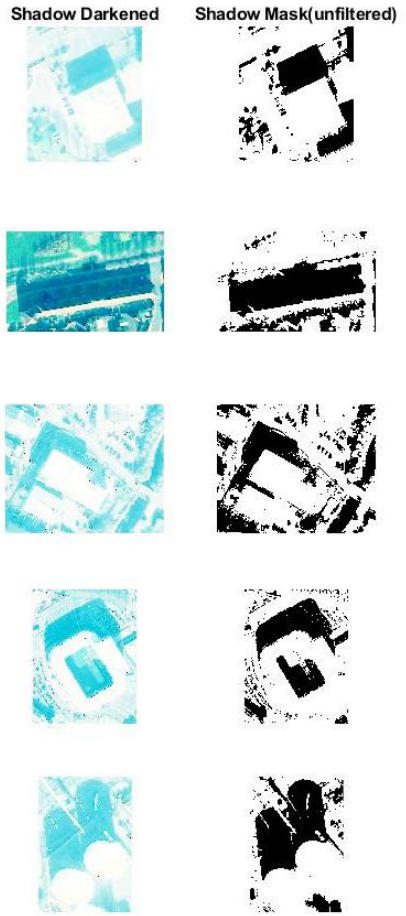
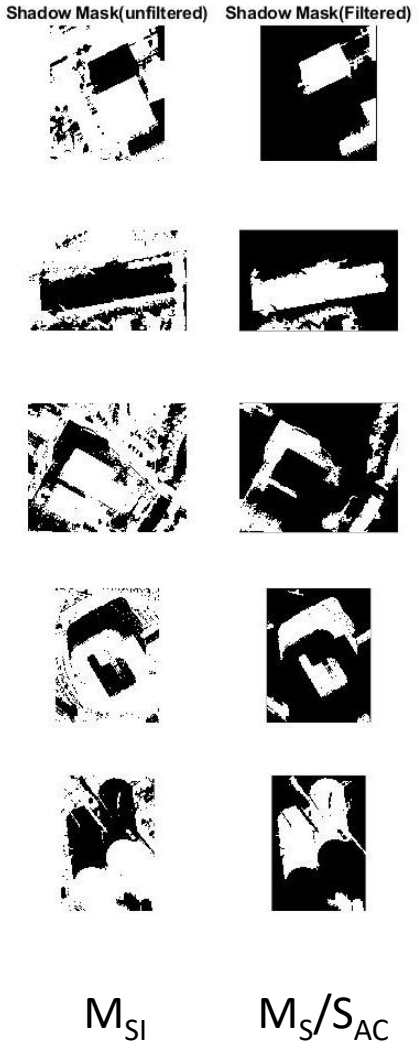


Image Thresholding is applied to I_s and M_{SI} (Initial Shadow Mask) is obtained, which includes all the vegetation's and other irrelavent small object's shadow.

This gives an Initial Shadow Mask, M_{SI}, of the image, as shown.

Step 3: Filtering M_{si}



Regions whose areas are less than a certain threshold are removed.

Shadow Mask, M_S (or actual shadow, S_{AC}), is obtained, as shown.

Step 4: Segmenting Image to obtain Building Mask

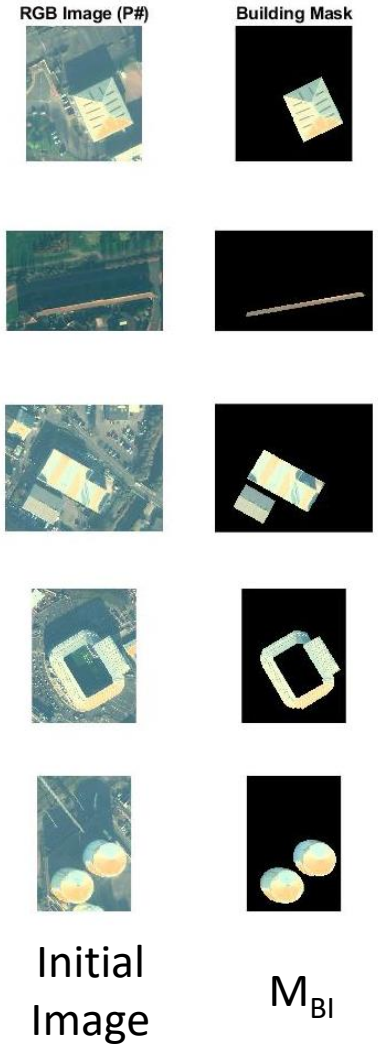
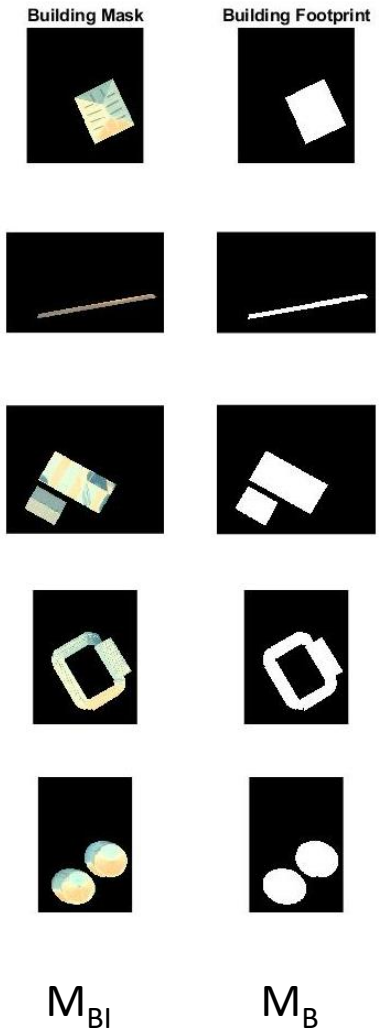


Image segmentation is performed to obtain the building mask.

Foreground is separated and background is removed.

Building Mask, M_{BI}, is obtained, as shown.

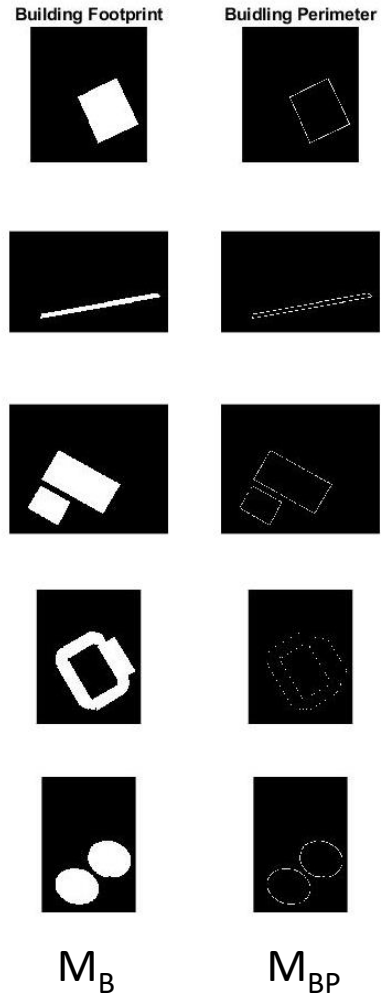
Step 5: Binarize M_{BI}



Building Mask is converted to Black and White image.

Resulting image is the Building Mask, M_B, as shown.

Step 6: Obtain Perimeter of Building, M_{BP}



Following operations are performed:

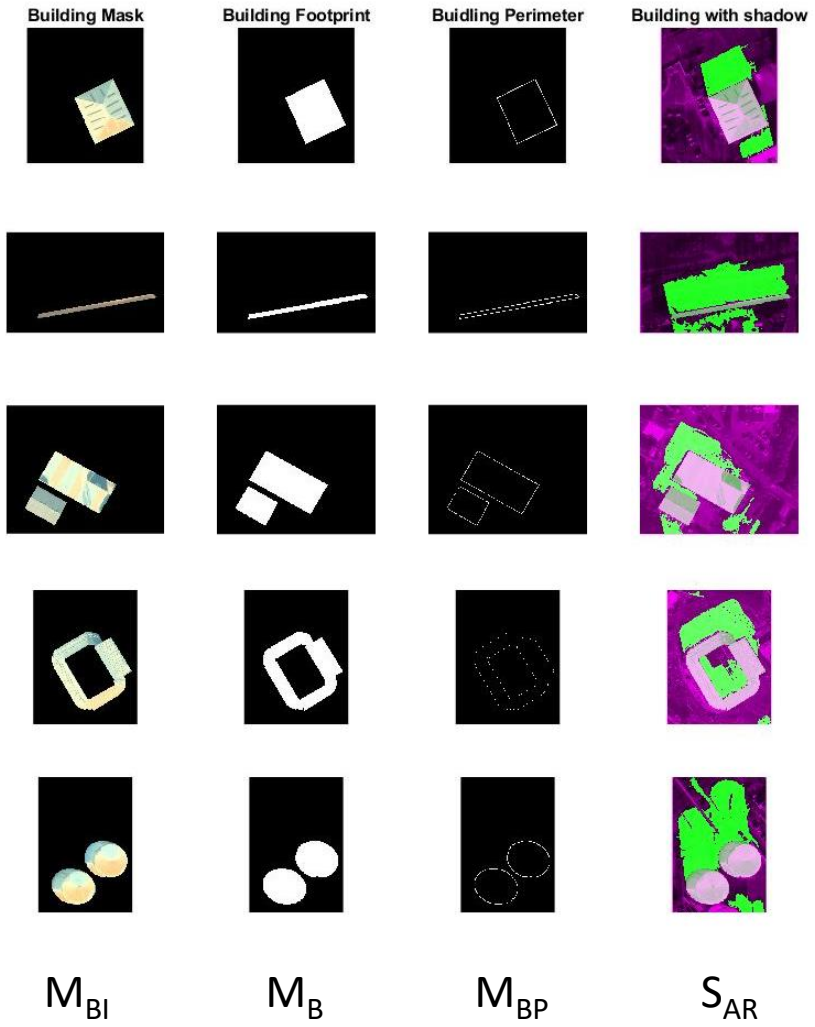
$$M_{BC} = 1 - M_B; \qquad M_{BA} = M_{BC} \oplus O;$$

O is a 3×3 matrix of 1.

M_{BP} is obtained from intersection of M_{BA} with M_{BP}.

The resultant is the Building Perimeter, M_{BP}, as shown.

Step 7: Create Artificial Shadows of Buildings



Artificial Shadows, S_{AR}, of buildings are generated using a linear structuring element made by:

$$\lambda = Az - \pi/2$$

$$L = \frac{H_T^{max}}{\tan\phi \; R_{img}}$$

where, A_Z is the Azimuth angle = 173.2° (in metadata),

ϕ is the Solar Elevation = 16.3° (in metadata),

R_{img} is resolution of the image,

and, H_T^{max} is the maximum height threshold.

Using neighborhood from the structuring element above, S_{AR} is obtained, as shown.

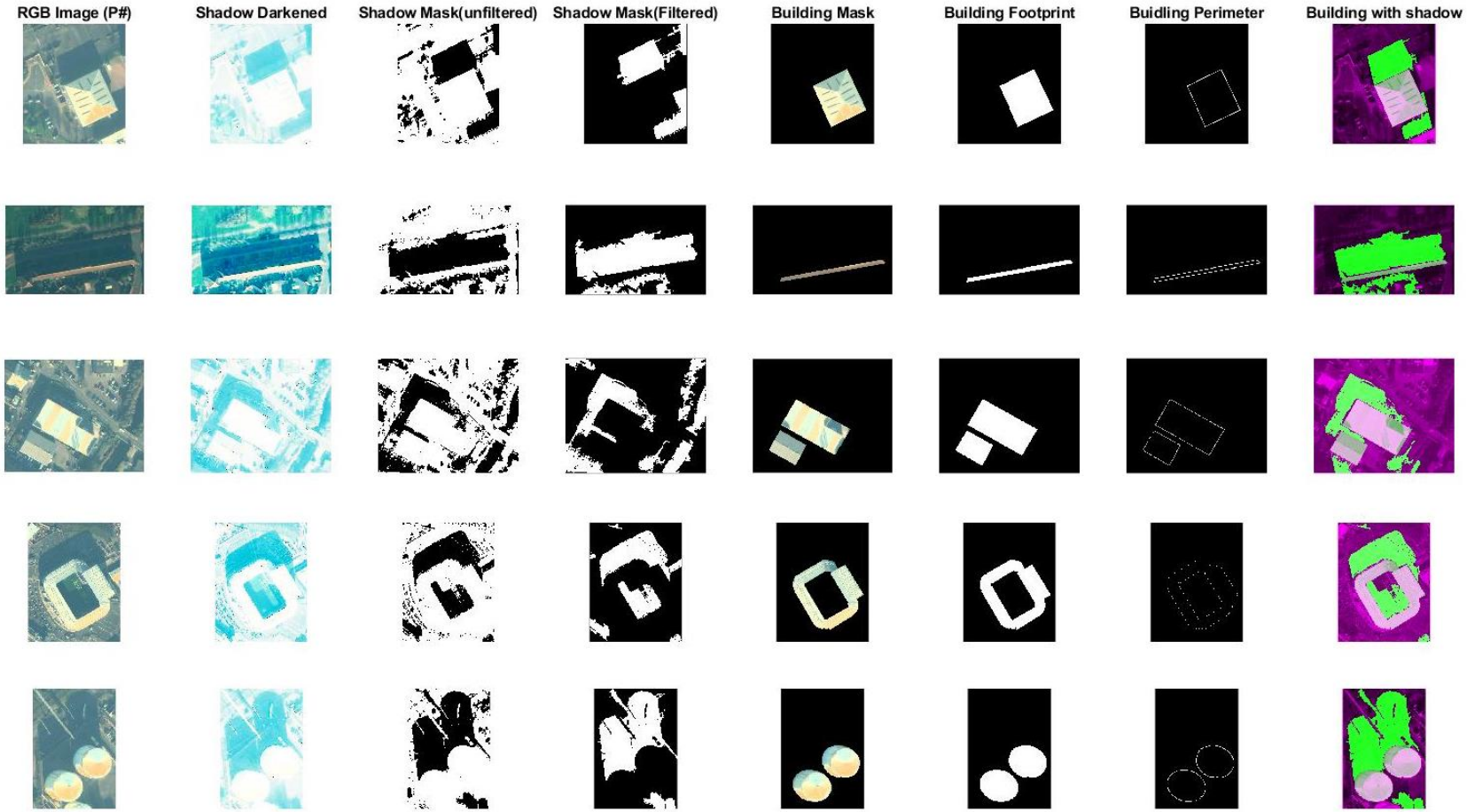
Step 8: Calculate Height Using Jaccard Index

Jaccard index between actual shadow, S_M, and generated artificial shadow, S_{AR}, is calculated for various heights (H_t^{min} to H_t^{max}).

This is done till an optimal Jaccard Index is found, and is used to calculate the optimal height.

$$JI = |S_{Ac} \cap S_{Ar}| / |S_{Ac} \cup S_{Ar}|$$

The Complete Process



Results

The Jaccardian Index finds similarities between the Artificial Shadows and the Actual Shadow, and the height which gives the most similarity gives the optimal height of the building.

Thank You