# Estimation of urbanization of an area using Image Segmentation Technique

## Introduction

Urbanisation means an increase in the proportion of people living in urban areas compared to rural areas. An urban area is a built-up area such as a town or city. A rural area is an area of countryside. It refers to the population shift from rural to urban areas, "the gradual increase in the proportion of people living in urban areas", and the ways in which each society adapts to the change. It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas.

Previous literature measures the extent of urban areas using household-survey-based socio-economic data, night-time lights, and mobile-phone records which requires some professional expertise for estimation. Almost whole earth is covered by satellite images freely available. Our purpose is to develop the application to estimate the urban area with an algorithm used for the automatic classification of satellite images. In our project we will classify Built Up(BU) and Non Built-Up Area(NBU), and use some techniques for vegetation extraction and building detection, which will result in the urbanization of an area.

The analysis of satellite image has great impact on several areas of life such as urban planning, nature monitoring, agriculture, change detection, military application.

## Objectives

- Classification of Built-Up and Non Built-Up areas based on area population.
- Extraction of building from high resolution satellite image using Hough Transformation.
- Graphical representation of Urbanization of an area.

# Material and methodology

Following techniques are used –

- **For classification of BU and NBU areas based on population:**

  Dataset of population is available at Worldpop and we will map this population data to our image using Google Earth Engine (GEE) API and decide a parameter to find Built-up and Non Built-up areas.

- **Extraction of building from high resolution satellite image using Hough Transformation**

  **Hough transform**

  In automated analysis of digital images, a subproblem often arises of detecting simple shapes, such as straight lines, circles or ellipses. In many cases an edge detector can be used as a pre-processing stage to obtain image points or image pixels that are on the desired curve in the image space. Due to imperfections in either the image data or the edge detector, however, there may be missing points or pixels on the desired curves as well as spatial deviations between the ideal line/circle/ellipse and the noisy edge points as they are obtained from the edge detector. For these reasons, it is often non-trivial to group the extracted edge features to an appropriate set of lines, circles or ellipses. The purpose of the Hough transform is to address this problem by making it possible to perform groupings of edge points into object candidates by performing an explicit voting procedure over a set of parameterized image object.

  The Hough transformation is a feature extraction technique used in image analysis, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform.

  **Delineating the Rectangular Buildings**

  To delineate the boundaries of the rectangular buildings, the edges were detected using the Canny Edge Detection algorithm. Then, the detected edges were vectorized using the Hough transform. In Hough transform, a point ($x$, $y$) and all the lines that pass from it are considered. Infinitely many lines pass through ($x^i$, $y^i$), all of which satisfy the slope-intercept equation:

$$Y^i = ax^i + b \qquad \text{...(Eq. 1)}$$

Where, $a$ is the slope of the line and $b$ is the $y$ intercept. For all lines that pass through a point ($xi$, $yi$), there is a unique value of $b$ for $a$:

$$b = -x^i a + y^i \qquad \text{...(Eq. 2)}$$

The difficulty in slope-intercept approach is that the slope of the line moves towards to infinity when the line is about vertical and the slope is 0 when the line is horizontal. To handle this problem, in the Hough transform normal representation of a line
can be used

$$r = x \cos\theta + y \sin\theta \qquad \text{...(Eq. 3)}$$

where, $r$ represents the length and $\theta$ is an angle from the origin of a normal to the line.
The computational attractiveness of the Hough transform arises from sub-dividing the $r\theta$ parameter space into so-called accumulator. The transform is implemented by quantizing the Hough parameter space into accumulator cells. In the beginning, the accumulator cells are set to zero. As the algorithm runs, each ($x^i$, $y^i$) is transformed into a discretized ($r$, $\theta$) curve and the accumulator cells that lie along this curve are incremented. Resulting peaks in the accumulator array represent strong evidence that a corresponding straight line exists in the image.

## Delineating the Circular Buildings

The original Hough transform was designed to detect lines and curves . However, it can be extended to detect analytic shapes. The aim of Circular Hough transform is to extract circular objects from digital images. It is similar to the Hough transform for lines, but uses the parametric form for a circle. Each edge point ($x$, $y$) generates a circle in a 3D parameter space with radius $r$ and the circle can be expressed with equation 4.

$$(x - a)^2 + (y - b)^2 = r^2 \qquad \text{...(Eq. 4)}$$

The parametric representation of the circle is given in equations 5 and 6.

$$x = a + r\cos(\theta) \qquad \text{...(Eq. 5)}$$
$$y = b + r\sin(\theta) \qquad \text{...(Eq. 6)}$$

To find the circles using Circular Hough transform, for each edge point, a circle is drawn in the parameter space with the desired radius. The accumulator array is incremented for the coordinates that belong to the perimeter of the drawn circle. This process is performed for all edges. At the end of this process the highest numbers in the accumulator space corresponds to the centres of the circles in the image space.

- **K-Nearest Neighbor Clustering**

The goal of this clustering method is to simply separate the data based on the assumed similarities between various classes. Thus, the classes can be differentiated from one another by searching for similarities between the data provided.

A distance is assigned between all points in a dataset. Distance is defined as the Euclidean distance between two points or:

$$\mathbf{d} = \sqrt{\sum_{i=0}^{i=n} (x_i - y_i)^2}$$

From these distances, a distance matrix is constructed between all possible pairings of points (x, y).Each data point within the data set has a class label in the set, C={c1,...,cn}.

The data points', k-closest neighbors (k being the number of neighbors) are then found by analysing the distance matrix. The k-closest data points are then analysed to determine which class label is the most common among the set. The most common class label is then assigned to the data point being analysed.

In the case where two or more class labels occur an equal number of times for a specific data point within the dataset, the KNN test is run on K-1 (one less neighbor) of the data point in question. This is a recursive process. If there is again a tie between classes, KNN is run on K-2. This continues in the instance of a tie until K=1. When K=1 there is only one class represented in the outcome and thus there can be no tie.

# Expected Outcomes

We are expecting the following outcomes:

- Classification of BU and NBU areas.
- Estimation of Urbanization
- Visualization of development of an area graphically.

# References


- Digitalglobe : http://www.digitalglobe.com/
- Geoeye : http://www.geoeye.com/
- BigPixel : http://www.bigpixel.ucsd.edu/
- Worldpop : http://www.worldpop.org.uk/
- International Journal of Computer Applications Volume 145 – No.3, July 2016


# Team

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Extraction of Building using Hough Transformation:

- Delineating the Rectangular Buildings
- Delineating the Circular Buildings

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Classification of Built-Up and Non Built-Up area:

- Google Earth Engine (GEE) cloud-computational services for planetary-scale analysis.
- Design an algorithm for Supervised Image Classification

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Image Enhancement Technique:

- Implementation of Internal Gray Variance Technique
- K-Nearest Neighbour point Clustering

Common Activities -

Documentation and comparison of different techniques and visual the results graphically.