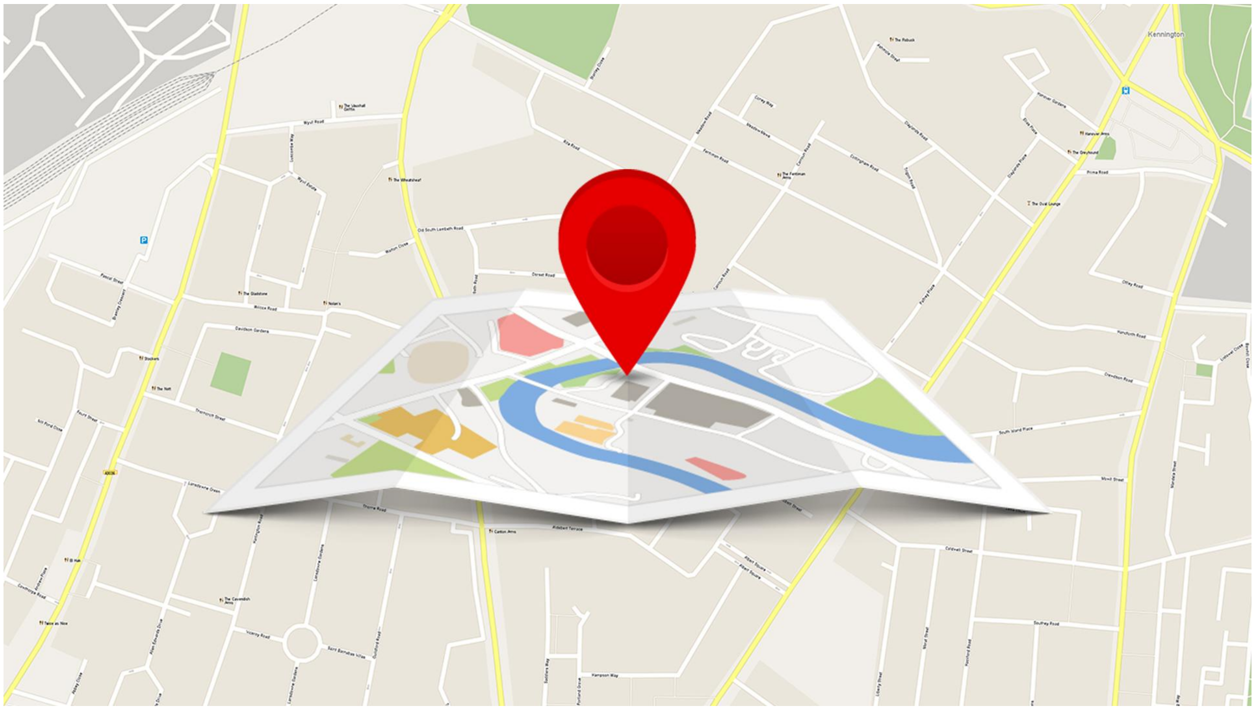


Creating Own Vector Map Using Two Way ANOVA

Under the guidance of

Arindam Banerjee, RKMVERI

Arnab Chakraborty, ISI

Overview

Images appear in two general forms, one is raster, another is vector. Our task is to create a vector map from some screenshots from the google map and creating a global vector map with important landmarks. We plotted the coordinates from the vector maps and matched the points.

Data Collection

Step-1: We have taken 10 screenshots of our University campus as our data. Here we are showing a few sample images.

Image-1

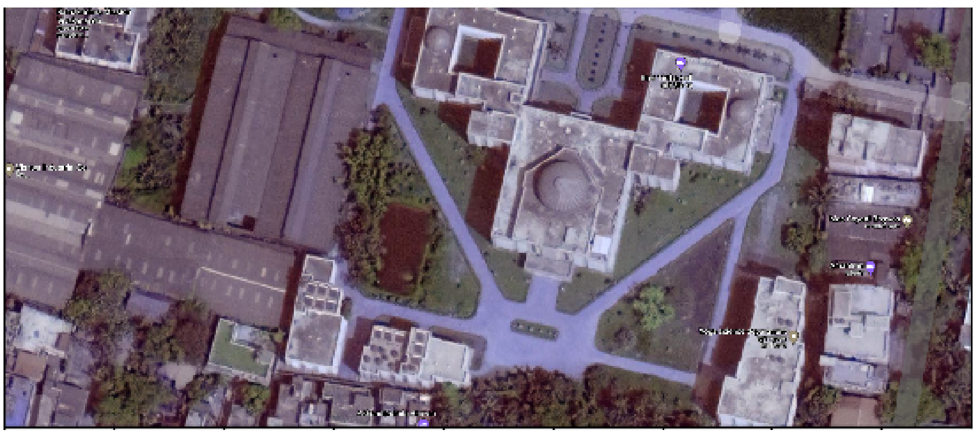


Image-2

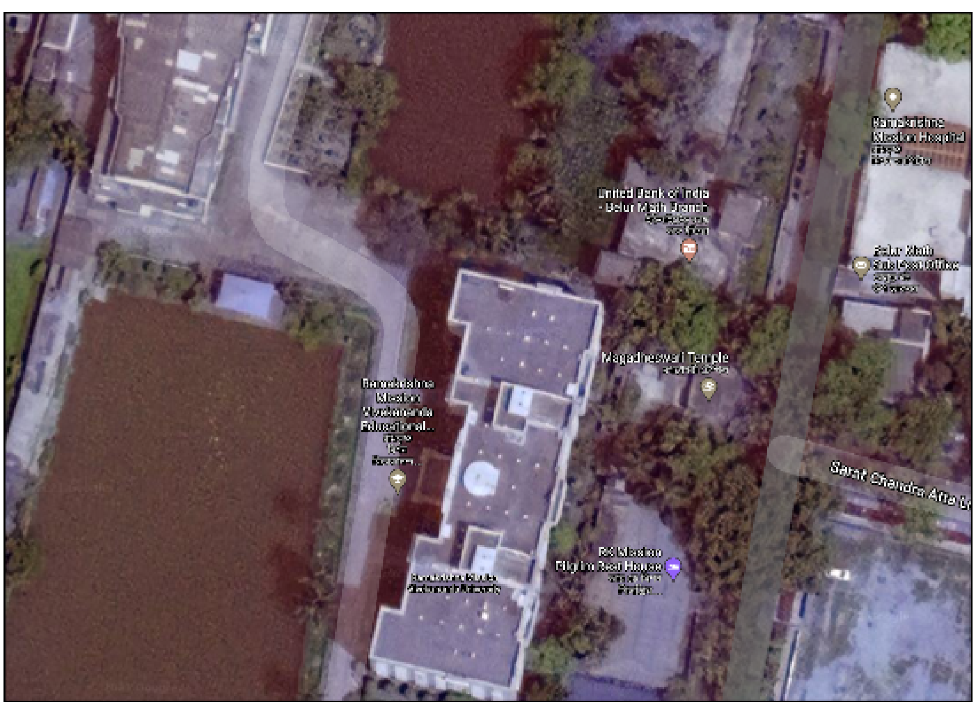


Image-3

Image-4

Step-2: We have taken local coordinates of landmarks from those screenshots.

Image-1

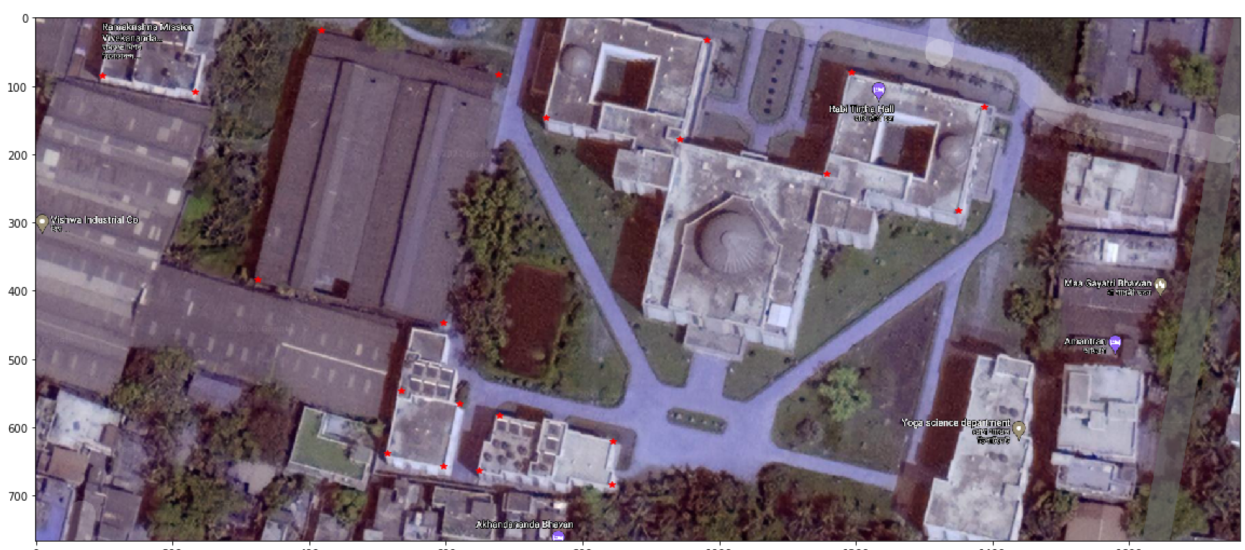


Image-2

Image-3

Image-4

We made a csv file of the manual annotations.

1	location	pic	X	Y
2	main gate	p1	240.824	92.5503
3	university gate	p1	1236.97	392.277
4	auditorium NW	p1	968.101	498.063
5	auditorium NE	p1	1142.21	542.14
6	pond1 NW	p1	1276.64	564.179
7	pond1 NE	p1	1439.73	597.237
8	auditorium NW	p2	1012.96	136.317
9	auditorium NE	p2	1181.68	177.357
10	auditorium SW	p2	967.36	437.277
11	auditorium SE	p2	1097.32	466.917
12	pond1 NW	p2	1320.76	202.437
13	pond1 NE	p2	1489.48	232.077
14	pond1 SW	p2	1279.72	407.637
15	pond1 SE	p2	1439.32	450.957
16	medha bhawan NW	p2	1384.6	521.637
17	medha bhawan NE	p2	1539.64	562.677
18	pond2 NW	p2	974.2	542.157
19	pond2 NE	p2	1256.92	605.997
20	playground NW	p2	297.04	456.139
21	playground NE	p2	611.68	561.019
22	premananda NE	p2	228.64	597.499
23	premananda SE	p2	205.84	676.884
24	premananda NW	p3	32.5974	55.5214
25	premananda NE	p3	256.29	105.738
26	premananda SW	p3	14.3368	137.694
27	premananda SE	p3	233.465	183.346
28	playground NE	p3	644.329	69.2169
29	playground SE	p3	555.308	532.581
30	playground SW	p3	206.074	445.843

Methodologies

- Overlapping screenshots of RKMVERI campus and peripherals are taken from google maps satellite at a constant zoom level(in 10m scale).
- Considering the top left corner of each screenshot as origin, coordinates of important and easily recognizable landmarks present on each of the screenshots are taken.
- A .csv file was created consisting of all the landmark names, screenshot number where they were present and their corresponding x coordinates and y coordinates as columns. A total of 143 such landmark points with their coordinates were taken manually.
- To establish connection between two overlapping screenshots, coordinates of a common landmark that is present on both the screenshots are taken into consideration. There can be multiple overlaps and multiple such common landmarks.
- Next aim was to find a global coordinate of these landmarks from these local coordinates.
- For that, the top left corner (local origin) of each image was taken as a parameter (α_i,β_i) for the i^{th} image. Then the global coordinate of a landmark can be given as:

$$(X_j,Y_j) = (\alpha_i,\beta_i) + (x_{ij},y_{ij})$$

  Where (x_{ij},y_{ij}) is the local coordinate of the j^{th} landmark of the i^{th} image and (X_j,Y_j) is the global coordinate of the j^{th} landmark.
- Now for a common landmark between two images with overlapping region, the local coordinate $(x_{ij},y_{ij})$and the local origin (α_i,β_i) will change as it is dependent on the image, but the global coordinate (X_j,Y_j) will remain unchanged as it is only dependent on the location. Global coordinates can be solved from these system of equations.
- But solving these equations can be tricky, as errors in measuring the local coordinates of the landmarks can lead to inconsistency. To tackle that, we take the equations as:

$$x_{ij} = \alpha_i - X_j + \varepsilon_{ij}$$

  where ε_{ij} is the random error occurred due to manual measurement of the coordinates.

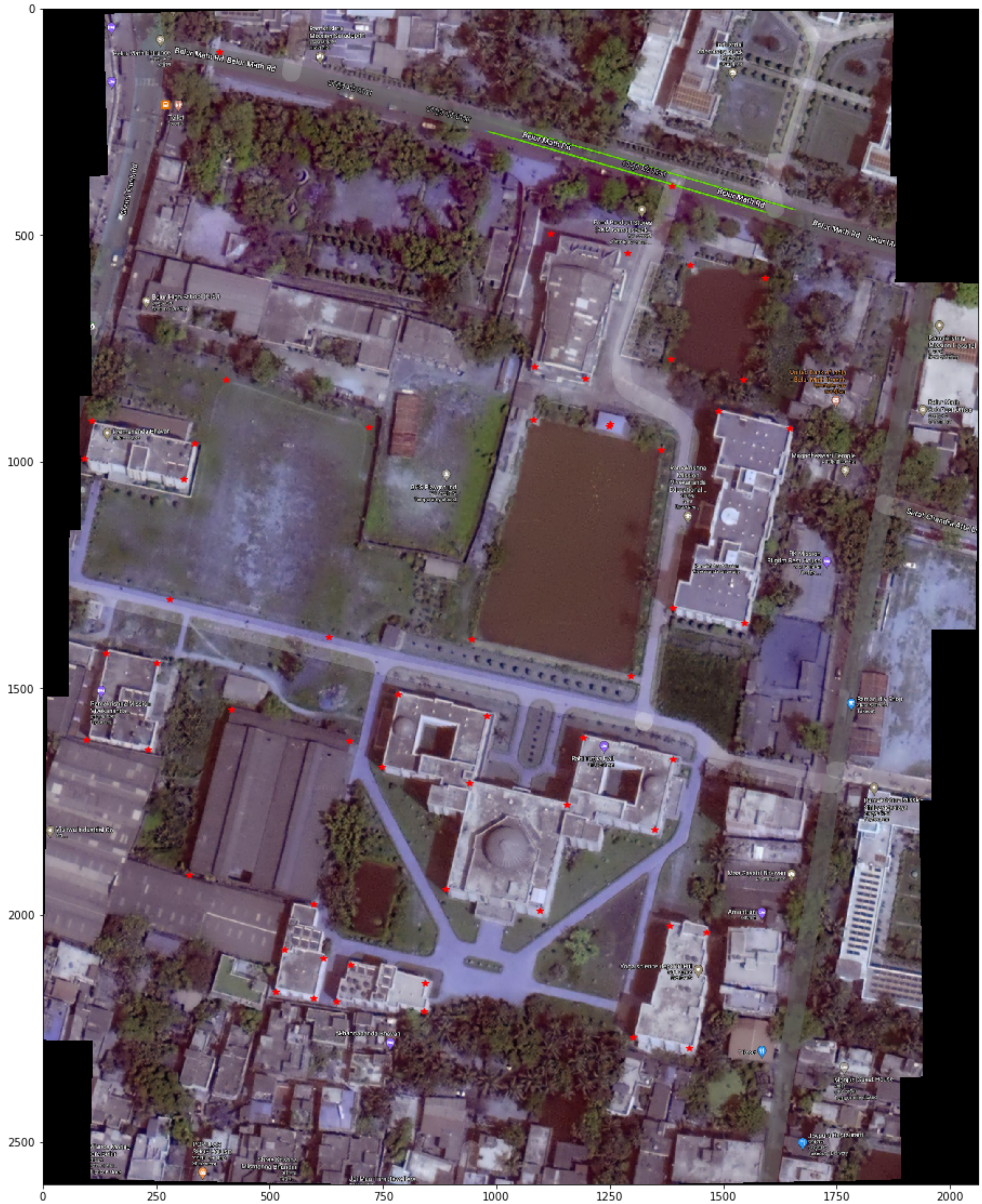
- Such linear equations with a random error can be solved using ANOVA (2 way) model, more generally known as linear model where $\left|A\vec{x} - \vec{b}\right|$ is minimized with respect to x, where $A\vec{x} \approx \vec{b}$ is a linear equation with random error.

- So, here the error is $x_{ij} - (\alpha_i - X_j)$, so we try to minimize $\sum_{i,j}(x_{ij} - (\alpha_i - X_j))^2$. This way the linear model solves the system of equations with random error and gives the global coordinates.

Output

We have stitched the screenshots to form a single image of our University campus.

We computed the global coordinates to build our own vector map and marked the points on the stitched raster map of the University campus as shown below.


0
500
1000
1500
2000
2500
0
250
500
750
1000
1250
1500
1750
2000
Belur Math Rd

Possible Improvements

We can make further extensions on our work. Two of them are proposed below.

- Doing the same job on rotated screenshots or from scanned images(which will be rotated eventually). In that case we will consider the angle of rotation also in our model.
- Also taking screenshots at different zoom levels will be another extension of our work. This part is a little bit different though. Let's discuss in detail. We can take another categorical variable named zoom level. On the basis of the new set up we build the model:

  $m_i * x_{ij} = \alpha_i - X_j + \varepsilon_{ij}$, m_i is for zoom level

  Now we can write : $x_{ij} = \alpha_i/m_i - X_j/m_i + \varepsilon_{ij}$

  Or, $x_{ij} = d_i - X_j/m_i + \varepsilon_{ij}$

  Here we have the variables : x_{ij}, d_i, X_j , m_i . Clearly our model is not linear here. But it the one of the simplest form of non linearity. Here we can use Iteratedly Reweighted Least Square method to minimize the error and to fit the model.

Discussion

Finally we have our own map now using a linear model. We can use the same trick in various fields where our variables have several categories. We can simply build our ANOVA model and fit a linear model with "lm" function in R and then just taking the coefficients from the fitted model will do our job. Let's see a few case studies where we can use similar technique.

Case-I:

Prediction of the admission status of students on the basis of their GRE score level(categorized), CGPA in previous university.

Our linear model will be: adm = gre + gpa + error

Case-II:

Prediction of success of the students in our class with respect to the study hours levels and different IQ levels.

Our linear model will be: score = hours + IQ