Geo Location Detection from object Shadows

Based on paper *"Determining the Geographical Location of Image Scenes Based on Object Shadow Lengths"* by *"Frode Eika Sandnes"*

Introduction:

This report describes the method to get latitude and longitude of the location from images. This method is very convenient and is based on a simple algorithm. It necessitates the use of 3 images with both original object and object shadow. Method is also preferable over other means which include GPS and other expensive equipment. This experiment was conducted during the period close to solstice.

Equipment

This experiment was conducted using very simple equipment cardboard and thin rod. Camera with 2MP resolution was used to conduct an experiment. Images were taken with no arrangements to fix the camera. Setup was done with rod kept vertical on the cardboard and whole setup was kept in the sunlight and images were taken in successive period of time.

Procedure

To perform this experiment, a cardboard was used as a base and ball pen refill was used as a rod with this arrangement set on the cardboard. Refill was used as an object and images were taken from the top view to get good estimate of shadow length. After picture of the shadow is taken, image of the object was taken with the same setting.

Length of the object was calculated manually directly from the image and the shadow image passed to shadow detection algorithm. After the detection of shadow, its length was calculated using another algorithm. Then elevation of the sun at particular time is calculated using trigonometry equation.

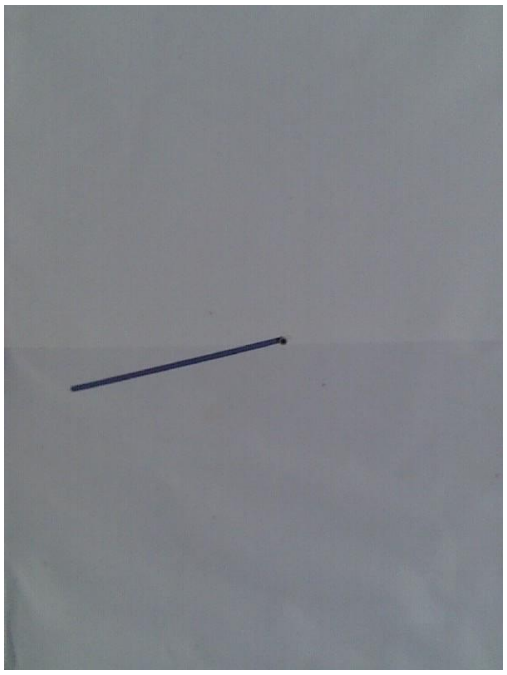
Value of sun's elevation is then passed to the final algorithm which calculates the latitude and longitude of the location at which these input images were taken.

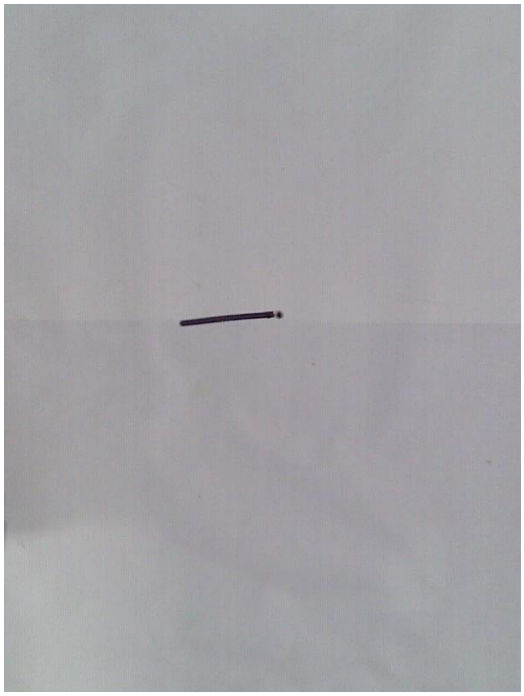
With the same setting, 2 more image are taken. Analysis is done for the latitude and longitude parameters obtained from all three test images and voting is done for each pair of geolocation. Geolocation pair with maximum votes is chosen to be actual value of latitude and longitude.

Test Dataset

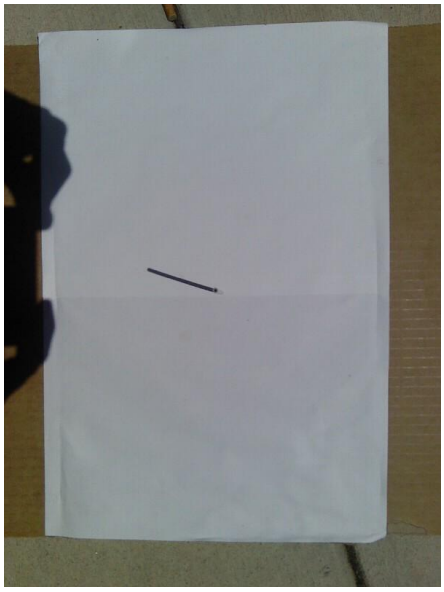
This experiment required very large set of images. Some images had bad resolution or taken with tilted camera angle which would have given good results. Test images contained over 140 images. And were taken at particular interval of day. Following images represent some of the images from test dataset. It was also required to filter some of the images to ensure accuracy of final result.

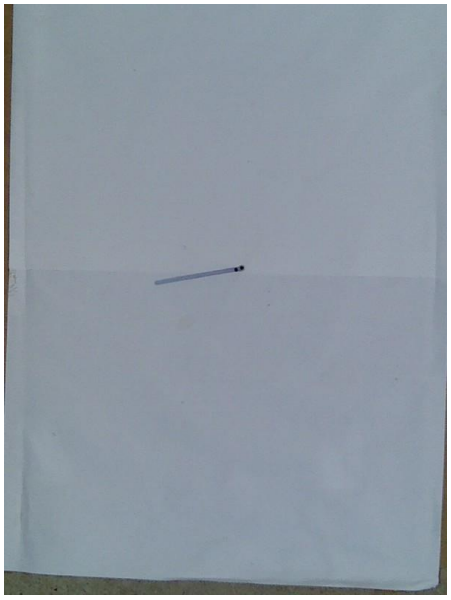
Good Images



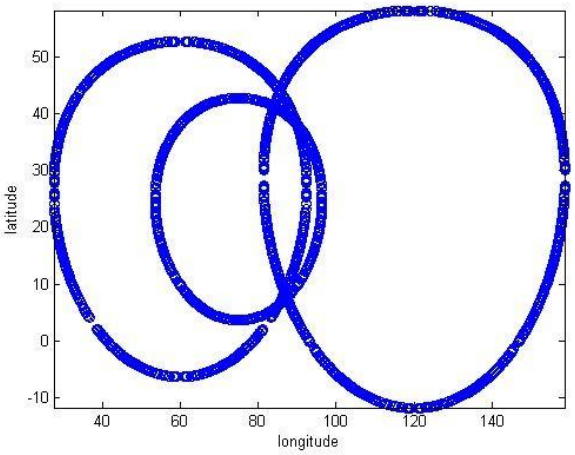


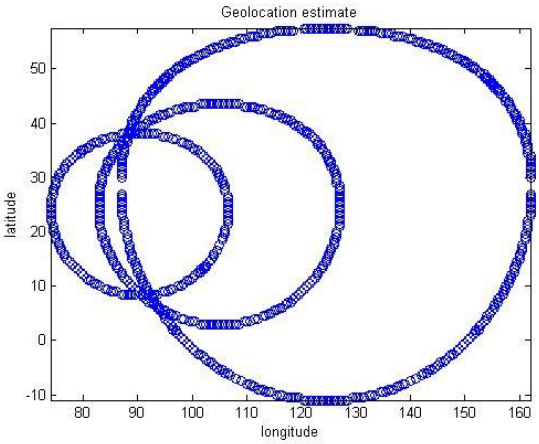
Bad Images

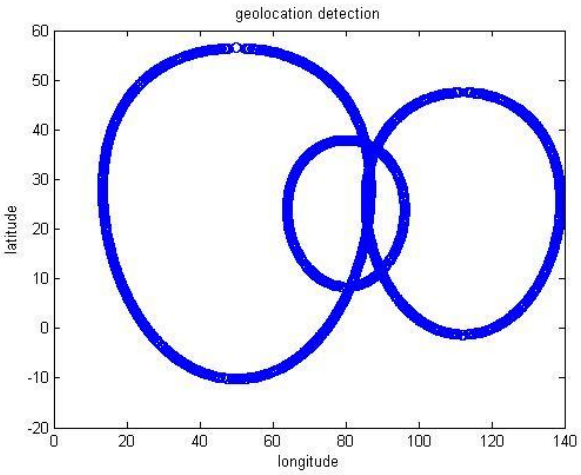


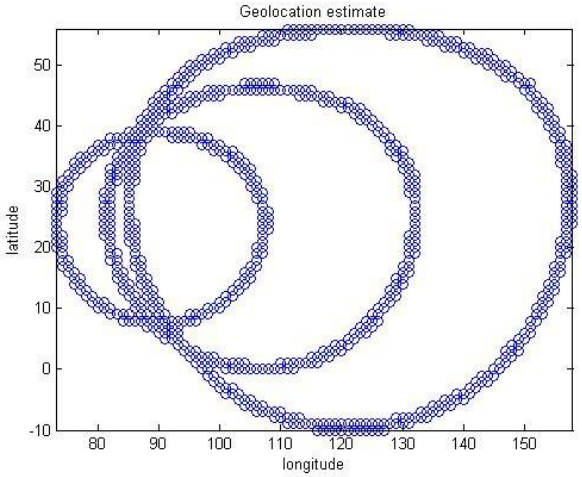


Plots of Geo Location pair (Extracted from set of 3 images)









Results

A. Following table shows cumulative result of the experiment.

	Mean Difference	Max Difference
Latitude	3.83	9.35
Longitude	1.43	5.88

From the result it is evident that this method gives the latitude and longitude of the place with fairly good accuracy. Maximum difference between actual and theoretical latitude and longitude was found to be 9.35 and 5.88 respectively.
Also mean difference between actual and theoretical value for latitude and longitude was 3.83 and 1.43 which is very close to actual value.

B. Following table shows the detailed result of above experiment

Observation No.	**Date**	**Time - Image 1**	**Time - Image 2**	**Time - Image 3**	**Latitude**	**Actual Latitude**	**Longitude (24 Hour Clock)**	**Longitude (12 Hour Clock)**	**Actual Longitude**	**Step**	**Threshold**
1	*26-Jun-12*	*13.12*	*14.01*	*14.29*	*40*	*39.2499*	*86*	*-86*	*-86.52*	*1*	*0.02*
2	*19-Jun-12*	*13*	*16*	*12*	*42.8*	*39.2499*	*92.4*	*-92.4*	*-86.52*	*0.1*	*0.02*
3	*26-Jun-12*	*14.01*	*15.12*	*16.08*	*46*	*39.2499*	*86*	*-86*	*-86.52*	*1*	*0.5*
4	*21-Jun-12*	*10.28*	*15.21*	*16*	*48.6*	*39.2499*	*86.7*	*-86.7*	*-86.52*	*0.3*	*0.03*
5	*20-Jun-12*	*15*	*16.3*	*14.02*	*38*	*39.2499*	*87*	*-87*	*-86.52*	*0.5*	*0.2*
6	*30-Jun-12*	*11.34*	*13.34*	*15.48*	*37.9*	*39.2499*	*85.5*	*-85.5*	*-86.52*	*0.1*	*0.03*

C. Mathematical Analysis of result set

	Mean Difference	Max Difference	Population Standard Deviation	Population Standard Variance
Latitude	3.83	9.35	3.19	10.22
Longitude	1.43	5.88	2	4

(More detailed and arranged result set can be found in Excel sheet attached on the project page)

Improvements

This experiment was conducted in constrained environment. It contained cardboard with white background and black colored rod. However in real world it is not always possible to have the same setting. It will require that geolocation should be evaluated from any images with both object and shadow clearly visible.

Also the current experimentation requires calculating the object length manually which is time consuming task. We can incorporate a line detection or more sophisticated object recognition algorithm to detect and calculate the object length directly.

Conclusion

From the above experiment it was found that calculated values of latitude and longitude are pretty close to actual values. One of the major criteria to determine the accuracy of results is the accuracy in calculating elevation of the sun from object and shadow length. Images with high blur or angular tilt do not give accurate calculation of sun elevation and it hampers the final geo location parameters.

References:

Determining the Geographical Location of Image Scenes based on Object Shadow Lengths,
By Frode Eika Sandnes

I am also thankful to Prof. Frode Eika Sandnes and Prof. David Crandall for their valuable inputs towards success of this project.