Using shadow on the ground cast to orient high resolution satellite image

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ABSTRACT
Some planimetric features' shadows on high resolution satellite image, of which angles' dispersion show average 34.87(s4.869) and 35.02(s 4.040) degree. Shadow lengths, of which show good angles are up to 15m. So pole's or planimetric feature's length needs 32 to 12m, of which shadow using to orient images.

INTRODUCTION

Usually, map's image data is made from aerial photograph. Now, one can get map's image data from high resolution satellite image, whose resolution about 1m. Satellite image's advantage is able to get image so many times than aerial photograph [1]. However one can't operate satellites like plane, one can't get some area's image data set from one satellite origin [2]. And then one need to use some satellites images for make a map. Satellite image has the same problem whose orientation needs many labor and time. And there are many type satellite images and those automatic orientation methods aren't established like aerial photograph.

Therefore algorithm and method are need which can orient some satellite images by less metadata and automatically.

On high resolution satellite image, one can get the shadow's edge on the ground. Shadow's Azimuth (direction) changes 1degree/4 minutes and angle is fixed by the place's Long/Lat and the time [3] [4].

In this research, by using IKONOS image, calculated shadow's angle and GPS continuous observation station (It is 5m height and 0.6m thick stainless steel pillar) and other object measured data, report possibility of orientation, object and shadow's condition.

EXPERIMENTAL

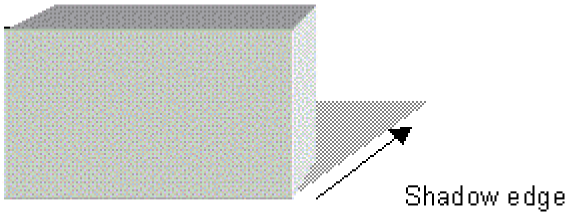
THEORY

Some planimetric features' shadow's angle, which made by sunlight is fixed by its place's Long/Lat and the time. Sun and shadow angle changes 0.25degree/min at same place and is in direct proportion to Long/Lat changes.

There are some formulas that calculate sun direction. I use Nagasawa formula. Nagasawa formula is in error by less than 0.005 degree. Use this value, fix the rotation of satellite image's Z axis, of which metadata is observe time and roughly observation area.

MODEL

I divide shadows on one IKONOS image [IKONOS] to two types. One is occurred by cube type planimetric feature, other is occurred by column [Figure.1, Figure.2]. Extract each edge's one end's and the other's XY coordinates. Calculate edge's angle to the image base.



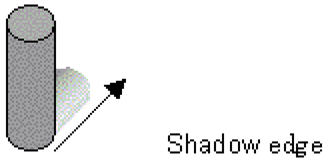


Figure.1. Cube type
School building

Figure.2. Column type
Lamp pillar (7~20m high)
GPS continuous observation station (5m high), etc.

REZULTS AND DISCUSSION

Two type shadows' angles show average 34.87(s 4.869) and 35.02(s 4.040) degree. Table.1 and Table.2 show the edge angle and edge length. Data is sorted by edge length.

Table.1. S1 shadow length and angle
Mean 34.87, $s^2$4.869 (degree)
33 edges

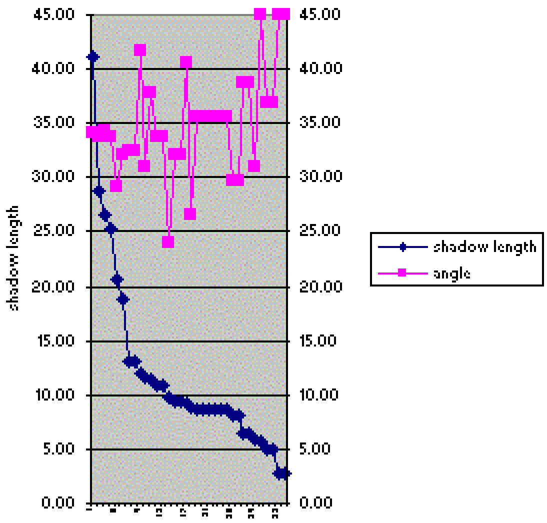
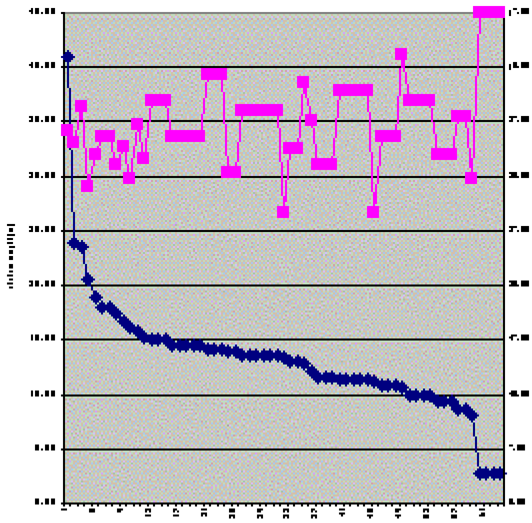


Table.2. S2 shadow length and angle
Mean35.02, s^2 4.040(degree)
63 edges



Two mean data, 34.87 and 35.02 match with the image and a margin is little. Variance is too big to population and expected value. I considered that the big variance is occurred by them.

1, There is limit that on pixel image, reproduct edge and calculate angle.
2, My miss reading when I get some shadows edge.
3, My hand's instability when I get some shadows edge.

The above tables show that long shadow's data is good and steady.

CONCLUSION

This problem that the numerical value is good but Variance is too big. I suggest two methods. One is using shadow of which planimetric feature's shape data and Long/Lat was minutely surveyed. Its edge's angel is reliable and probably be abele to search automatically in image. So it is abele to reproduce image for match of which planimetric feature and its shadow. This shadow image has angle and length. Or using the mean of unspecified shadows edges, of which be able to extract, too.

I suggest pillar like GPS continuous observation station (Figure.3.). Our GPS continuous observation station is too short to use this, now. For the result , edge length need up to 15m. But GPS continuous observation station comes out well in aerial image (Figure.4.).

I show the shortest pillar length on each latitude (Table.3.). Its length shows minimum 15m on 10:30 the summer solstice. Planimetric feature’s shadow shows shortest one on 12:00 local time the summer solstice. But many satellites has sun synchronous and semi-recurrent orbit. And their observation time is about local time 10 o’clock and 14 o’clock.

Figure.3. GPS continuous observation station station JAPAN

Figure.4. Shadow of GPS continuous observation on aerial photo.

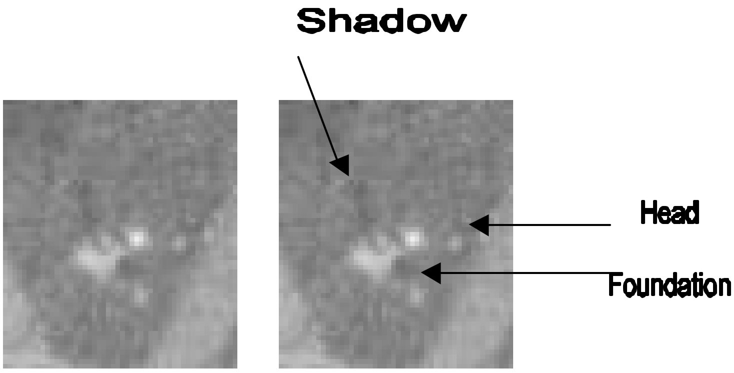
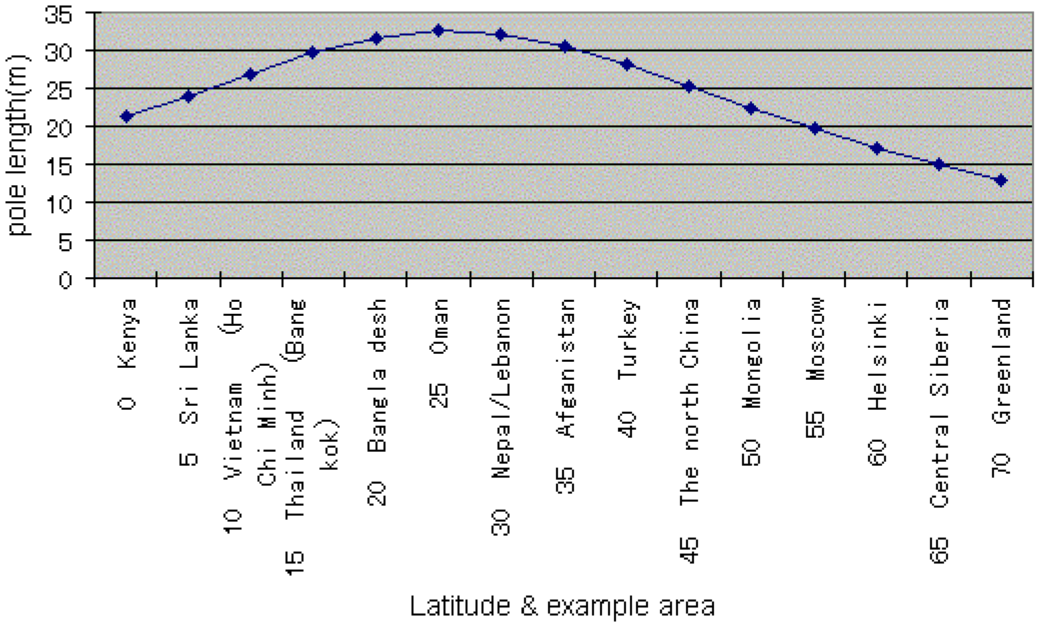


Table.3. needed pole length (the summer solstice, shadow shows minimum 15m)



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[5] IKONOS image, Tukuba city Ibaragi pref. Japan (suburbs area), Time: 2.Mar.2000, 1:13 GMT, 11km^2 , Product pixel size XY: 1m, © JSI., Source Image ID: 2000030201133000000011625135, http://ikonos.sfc.keio.ac.jp