GEOSPATIAL STREET-VIEW RETRIEVAL METHODOLOGY USING GEO-TAGGED PHOTOS

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Abstract: Recently, a generation of photo datasets becomes easier on internet and cloud services. However, conventional point based photo retrieval would be often irritable for users in a disaster monitoring and construction management. Therefore, an assistance of photo retrieval is required to improve efficiency in the monitoring and guidance. In this study, we focus on an improvement of photo browsing using geo-tag such as camera position and azimuth data taken from GPS and digital compasses mounted on a camera. Moreover, we have focused on a clustering of geo-tagged photos based on reverse-geocoding with a context such as "walking along a street". We conducted an experiment using 590 geo-tagged photos taken from a GPS camera with a digital compass. Then, we have confirmed that our algorithm can perform geospatial retrieval for a street-view photo browsing with the context.

INTRODUCTION

Recently, a generation of geo-tagged photo datasets becomes easier on internet and cloud services. However, when a large amount of photos are stored on internet, a photo would be difficult to be found on a general graphical user interface based on a click and view style. This style would be often irritable for users. Therefore, efficient photo retrieval is required. Particularly, the assistance of photo retrieval is required to achieve more prompt operations in a disaster monitoring and construction management. Conventional approaches in the photo retrieval assistance are based on date and time data. Moreover, location based photo retrieval can use position data in 'Point of Interest' on maps as retrieval information [3]. Additionally, semantic image retrieval is also one of approaches to find similar photos to an input photo [4]. However, when these approaches are applied to a photo browsing along streets or paths, one by one photo retrieval becomes complicated. Therefore, our purpose is a development of new photo retrieval methodology that people can browse a large number of photos with an assistance of photo retrieval. In this study, we focus on a possibility to improve a browsing of geo-tagged photos using azimuth data taken from digital compasses. Moreover, we have proposed a definition of a photo browsing with a context such as a route navigation or facility inspection for a disaster monitoring and construction management. Additionally, we have focused on a clustering of geo-tagged photos based on reverse-geocoding.

METHODOLOGY

Our algorithm consists of the following four steps. Firstly, metadata including a date, latitude, longitude, height, and azimuth are extracted from geo-tagged photos. Various data are recorded with Exchangeable Image File Format (Exif) in metadata sections on each photo file. In this study, location data (latitude and longitude) and azimuth data are extracted from the metadata to be used in our procedure.

Secondary, a path is input on a base map such as road maps and satellite images. The base map is required to be used as a background map to input a context based trajectory map such as vector data. Roads, railways or shorelines can be described as a context based trajectory on the base maps. In other words, because the base map is used in a map trace operation, both of raster data and vector data can be used as base maps. For example, geocoded paper maps and satellite images can be used as base maps directly. Moreover, internet maps and road maps for navigation can be also used as base maps. Additionally, when a situation is after disasters, we can use geocoded aerial photos or SAR data as base maps with damaged area estimation results [5].

Thirdly, photos along the input path are selected using the latitude and longitude values. In general, an accuracy of single GPS positioning is approximately 5m. Therefore, acquired location data with GPS camera would not often indicate actual positions on large-scale maps. Therefore, when the acquired location data using GPS camera are used in a geometrical operation, a map matching approach is required to keep a spatial continuity of locations. The map matching is expressed by the virtual shifting of the acquired geometrical points. The acquired points move to the nearest position on the nearest trajectory.

Then, recommended photo files are extracted from selected photos along the path using azimuth data. Finally, the recommended photo files selected from a large amount of photos can be browsed as a slideshow with a context along a street- view direction. Figure 1 shows a flow of the proposed methodology in this paper.

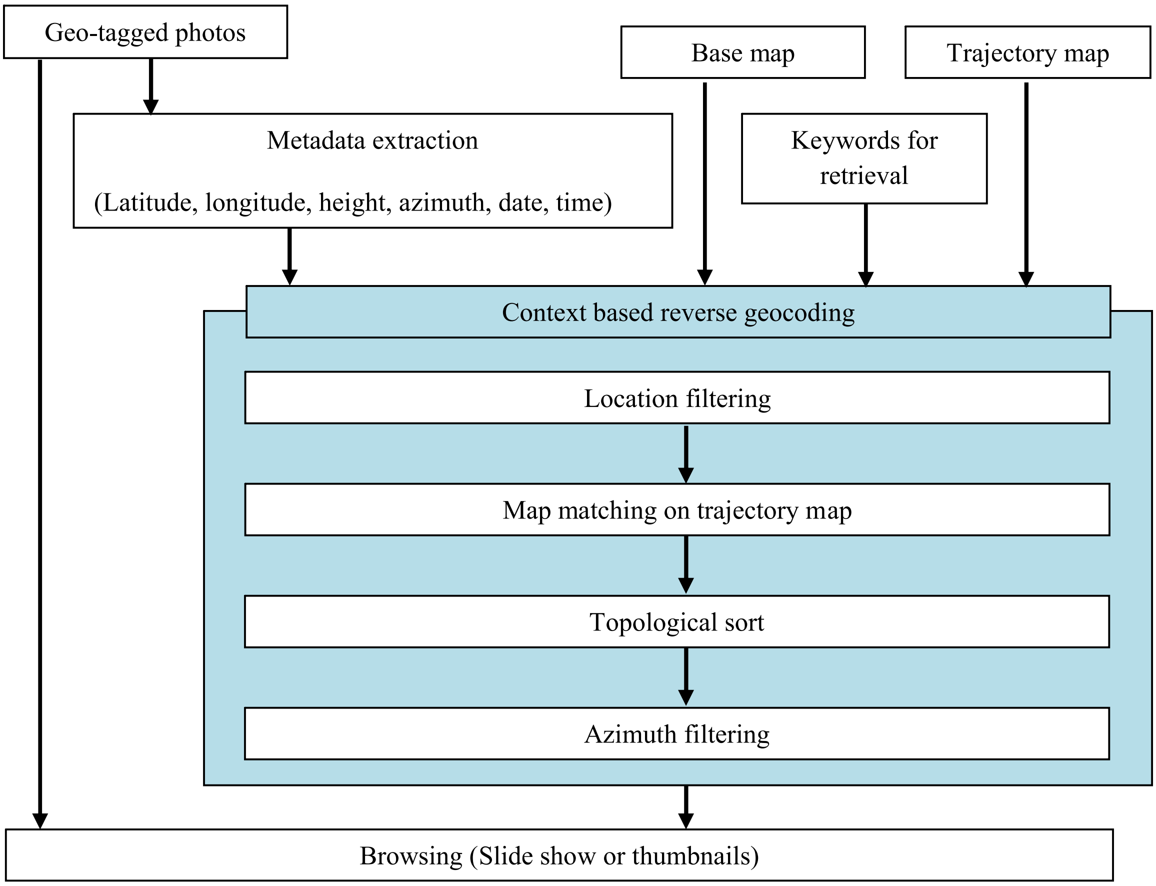

Figure 1: Overall structure

Figure 2 shows the map matching procedure as an example. Firstly, a nearest trajectory line is detected from a photo captured point L. Secondary, map matched point is estimated on the detected trajectory line.
First, vertex points of input trajectory as a context are defined as point A, B and C. A center point of line AB is described as point M_1. A center point of line BC is also described as point M_2. Then, a length of line LM_1 is compared with a length of line LM_2. Shorter line LM_2 means that the trajectory line BC is a nearer line from point L. Therefore, the trajectory line BC is selected as. Here, a perpendicular line is drawn from the point L to the line BC, and an intersection O_2 is estimated as a matched point.

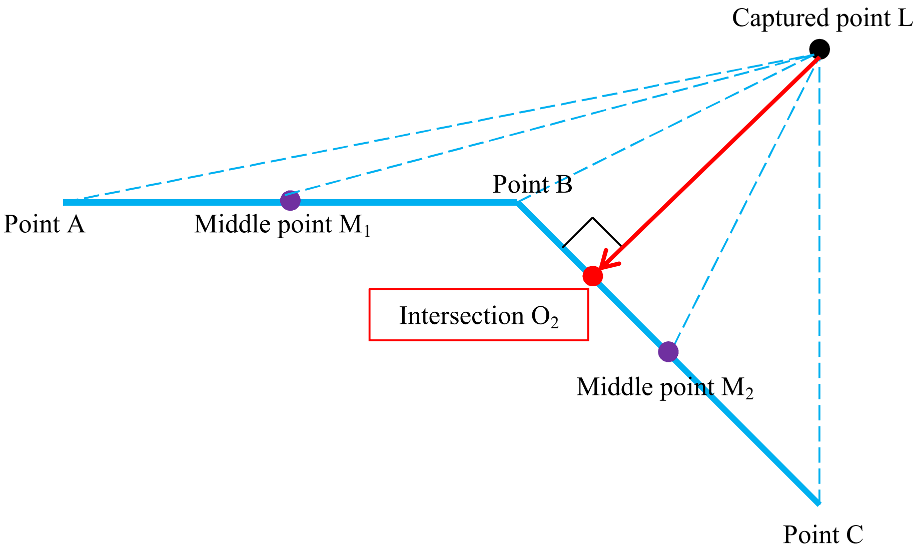

Figure 2: Map matching procedure

Azimuth filtering

Geo-tagged photos are sorted to be browsed with a spatial continuity on a trajectory as a context. Moreover, sorted photos are filtered using a combination of azimuth data and a field of view at each viewpoint as an azimuth filtering. Figure 3 shows an example of the azimuth filtering when an angle of field of view is set as 180 degrees. The angle is a parameter in the photo retrieval. When the angle is narrowed, geo-tagged photos are selected along the browsing path with a straight ahead view.

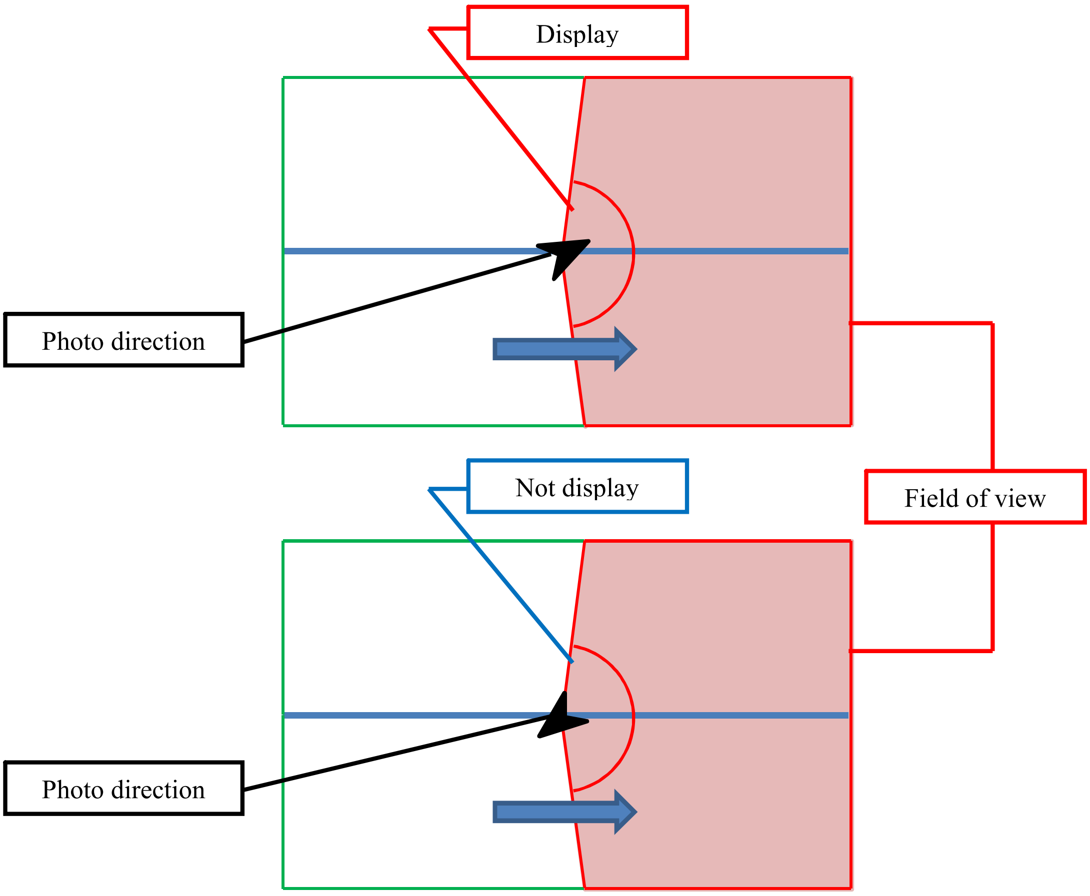

Figure 3: Direction filtering

EXPERIMENT

We used a GPS digital camera (SONY, Cyber-shot DSC-HX5V), as shown in Figure 4. Moreover, a configuration of the camera in our experiment is shown in Table 1. When a photo is captured, location data and azimuth data are recorded at the same time using a GPS receiver and digital compass mounted on the camera.

Figure 4: GPS digital camera (SONY Cyber-shot DSC-HX5V)

Table 1: A configuration of GPS camera in our experiment

Name	SONY Cyber-shot DSC-HX5V
Pixels	1920 pixel * 1080 pixel
Data format	JPEG
Additional installed sensors	GPS receiver, Digital compass

A study area was around our campus and a railway station near our campus. Geo-tagged 590 photos were captured at random along a road between our campus and the station. Moreover, OpenStreetMap was used as a base map. Additionally, a trajectory map was input from the station to our campus on the base map.
Firstly, geo-tagged photos were projected into the base map using location data based on WGS-84 coordinate system. Secondary, map matching was applied to location data of geo-tagged photos to estimate the nearest point on the trajectory line. Thirdly, a spatial sorting and azimuth filtering were applied to the estimated location data of geo-tagged photos along the trajectory. Finally, selected photos were visualized as a slide show with a context along street-view direction. Additionally, a view angle of two patterns was conducted in the azimuth filtering.

RESULTS

Map matching on trajectory map

Figure 5, Figure 6 and Figure 7 show results in the map matching procedure using a trajectory map. Figure 5 and Figure 6 show results after location data projection. Black points indicate projected location data of geo-tagged photos on the OpenStreetMap around a station and our campus. A blue line indicates an input trajectory map. Figure 7 shows a result after the map matching procedure. We confirmed that each projected location data shift to the trajectory map. Moreover, the location data after the map matching were sorted along the trajectory from the station to our campus.

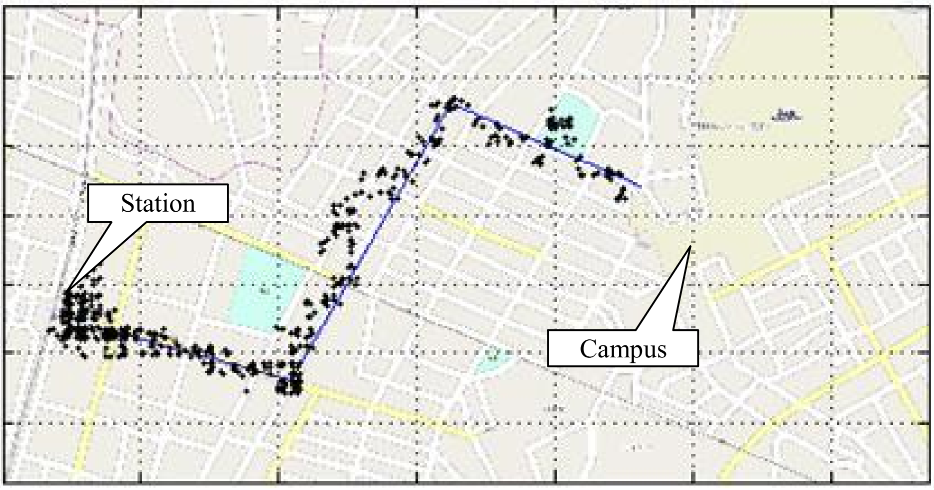

Figure 5: Location data around the station and our campus

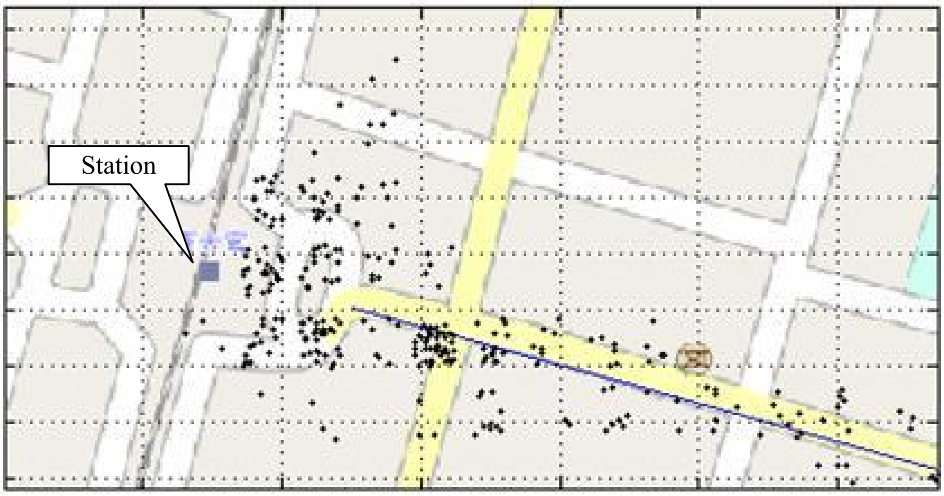

Figure 6: Location data around the station

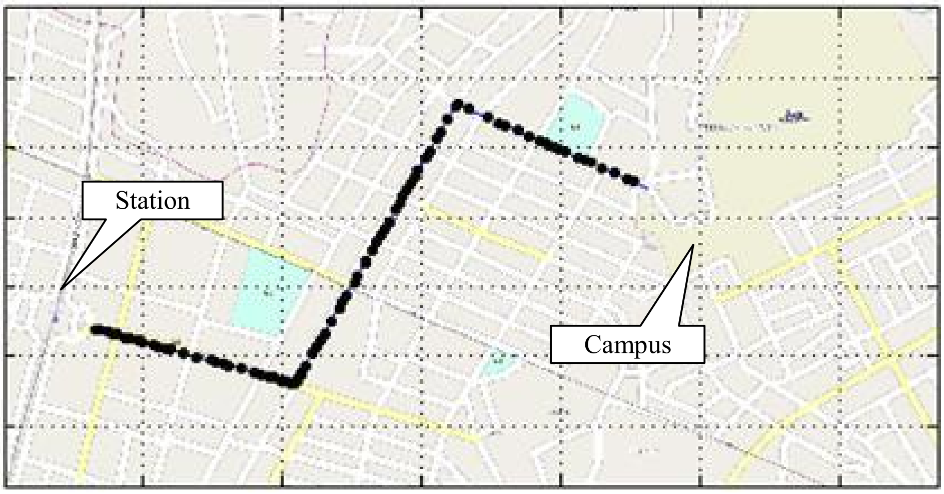

Figure 7: Filtered location data after map matching using trajectory map

Filtering using direction information

Figure 8 shows a result of azimuth filtering. A vertical axis indicates an azimuth angle. A horizontal axis indicates a distance or camera position from the station along the trajectory map. A red line shows an azimuth angle of the trajectory line. A blue range between two blue broken lines shows a field of view 180 degrees. A green range of the diagonal line between two green lines shows a field of view 60 degrees. A blue hatched area delimited by two blue broken lines means the viewing angle 180 degrees. Moreover, a green hatched area delimited by two green lines means the viewing angle 60 degrees.

We conducted an azimuth filtering using direction information taken from GPS camera. Figure 9 shows that the location data were selected based on the direction along the trajectory map after the azimuth filtering using. The points in a yellow range are selected as filtered data in Figure 8.

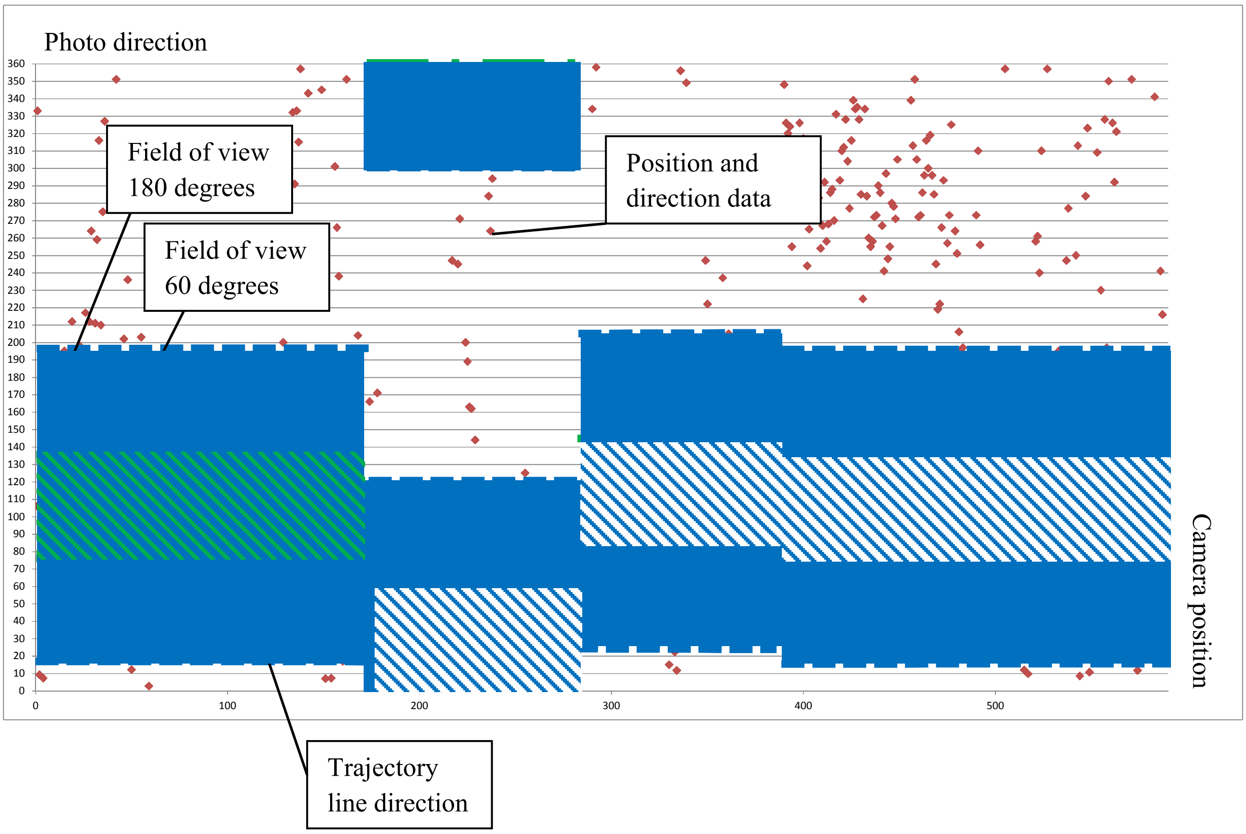

Figure 8: Azimuth filtering results graph

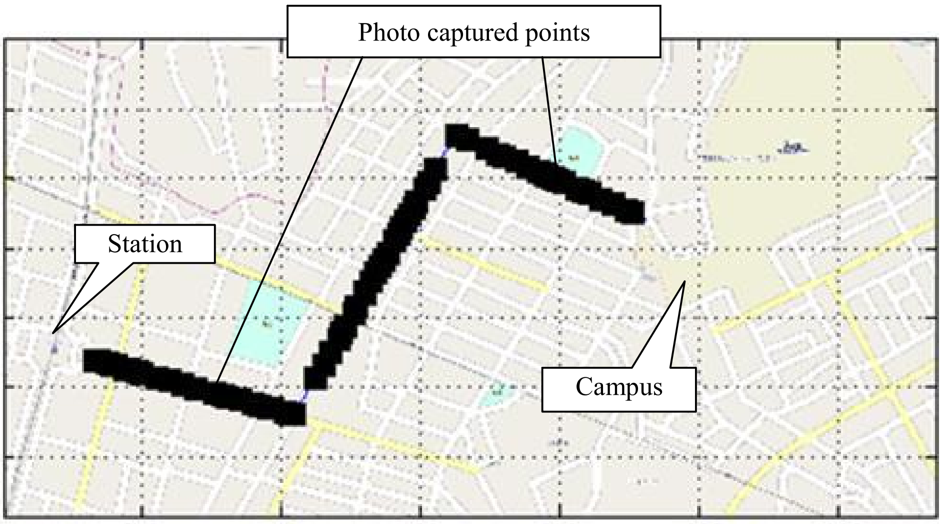

Figure 9: Azimuth filtering results from station to our campus

DISCUSSION

An azimuth filtering was applied to location data along a trajectory from the station to our campus in Figure 9. Here, the azimuth filtering was also applied to location data along the trajectory with an inverse topology from our campus to the station, as shown in Figure 10. The result in Figure 9 includes more selected points than the result in Figure 10. In other words, a result of this comparison shows that more photos exist from the station to our campus in our experiment. Thus, these results indicate that the azimuth filtering has performed well.

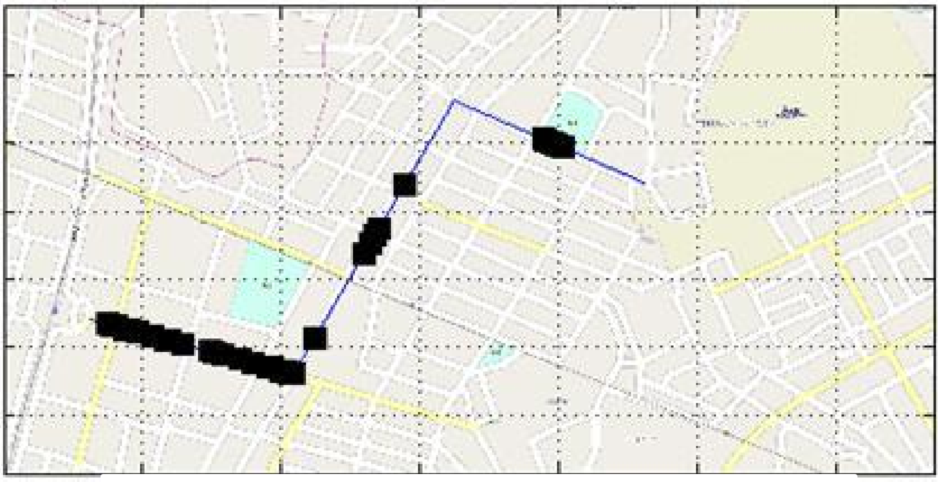

Figure 10: Azimuth filtering results from our campus to station

However, unnecessary photos for navigation such as a street side photos exist in this current stage. Therefore, the angle of view should be narrowed to reject unnecessary photos from selected photos, as shown in Figure 11. Thus, the angle of view was narrowed from 180 degrees to 60 degrees along the trajectory map from our campus to the station, as shown in Figure 12. Then, we have confirmed that unnecessary photos were rejected to improve the photo retrieval performance. In a practical use, a parameter in the field of view should be adjusted as a gain of geo-tagged photos filtering.

Figure 11: Necessary photos and unnecessary photos

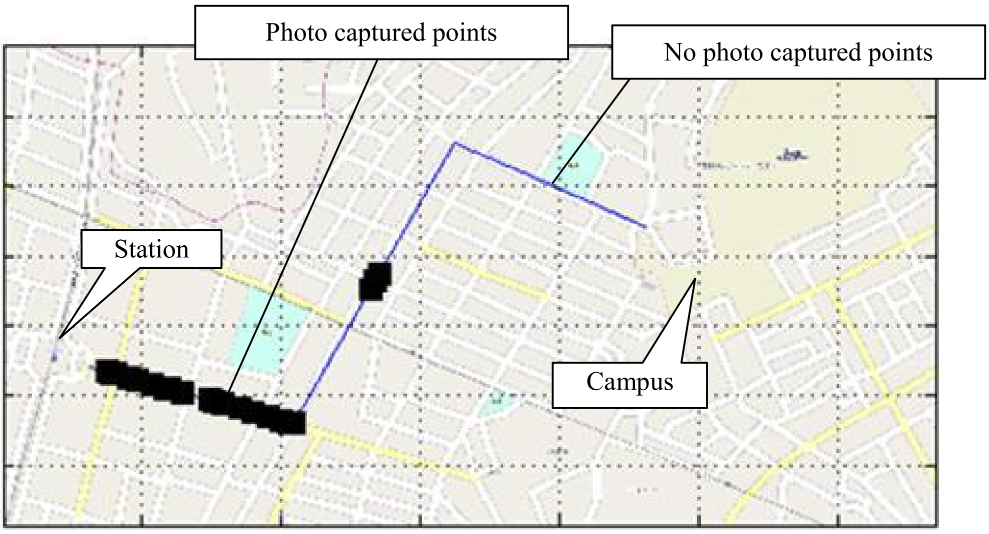

Figure 12: Azimuth filtering results with narrowed field of view

In this study, a raster map was used as a base map. Thus, the satellite images and the scanned paper map can be also used as a base map. Furthermore, since the base map is used to input a vector based trajectory map, a general vector map is also available.

Although the trajectory map was given parameters in our experiment, the trajectory can be input with a free context in a photo browsing. However, the input trajectory map was only straight lines in our experiments. Actual roads, railways and shorelines consist of straight lines and curved lines. Therefore, the input trajectory map also requires integrating curved line.

A filtering direction in the azimuth filtering can be changed. In our experiment, the filtering direction was set along roads. However, when the filtering direction is set vertically along roads, street side navigation for a facility management can be conducted. Thus, our proposed methodology has a potential for applications in various fields.

CONCLUSION

In this study, we have developed a geo-tagged photo retrieval methodology that users can browse photos with a context such as a street-view. This assistance of photo retrieval would improve efficiency in a disaster monitoring and construction management.

In addition, we have confirmed that a spatial photo selection along roads is available with a combination of a location, photo capture direction and arbitrary field of view at each captured point.

Our future works include a practical use in the disaster monitoring and construction management. Our future works also include a map matching using curved trajectories and more massive POI data processing.

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