Title: Integration of GPS and GIS to Improve Crash Location Data Accuracy

Audience: ESRI User Conference

Authors: Haitao Wu, Thobias Sando, Renatus Mussa, John Sobanjo and Lisa Spainhour

GPS (Global Position System) has been identified as a useful tool for improving the accuracy of crash location data. Some agencies have implemented handheld GPS receivers for capturing crash location. Two main concerns are raised – (1) Human error due to manual filling of the GPS coordinates to the crash forms and (2) validation of the accuracy of GPS coordinates. To address the aforementioned concerns, GPS and GIS were integrated. GPS/GIS integration allows automatic population of crash location data in the crash form. This information could then be exported in the required fields either to the crash reporting software or the crash database. This paper presents the procedure that was used to integrate GPS and GIS in MapObjects Environment using Visual Basic programming. The paper also discusses the benefits that have been realized by comparing the quality of crash location data before and after GPS/GIS integration.

Introduction

Overview

The integration of Global Positioning System (GPS) and Geographic Information Systems (GIS) has been used in many applications. Transportation applications include fleet management, vehicle navigation, highway inventory systems and crash location identification (Mintsis, et al., 2003). The use of GPS for crash location is being implemented in various agencies after studies reported the accuracy improvements especially after removal of Selective Availability (Sando et al., 2004). The integration of GPS and GIS for crash location facilitates identification of the location (latitude and longitude) using a GPS receiver and then using latitude and longitude information captured by the GPS receiver to query street information that is needed in the crash report in the GIS database. This paper illustrates crash location methods and how the integration of GPS and GIS could improve the accuracy of crash location information.

Traditional Crash Location Methods

Traditionally, crash location is reported by an officer by using one of the following methods; (1) Visual estimation of the distance from a known reference, (2) Measuring the distance from the reference point using the car mileage, (3) Measuring the distance from the reference point using a tape measure, and (4) Measuring the distance from the reference point using an odometer. Of the above methods, the first method is the most used by police officers. The officer would estimate the distance of the crash location from a known reference, normally the nearest intersection. Clearly the estimation is subject to errors and may vary significantly from one officer to another. The farther the officer is from the intersection, the larger the location estimation error is expected.

Technological advancement calls for a need to revolutionize the way crash location data is obtained. Emerging of two technologies – Geographic Information Systems (GIS) and Global Positioning System (GPS) has revolutionized the method of collecting crash location.

GIS Technology

GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data. GIS used for accident reporting would include information on the road network with a methodology to identify all points on the road network. The system would include a map of the area that could be used by the officer to indicate the accident location and/or to verify whether the location is correct. It might also include road names and other features (e.g., nodes, utility poles, bridges, etc.) to assist in the identification of locations on the map. In order to identify the location of the map, the police officer would zoom to the extent that he/she can point on the location where the crash occurred. GIS has the ability to display the coordinates of the crash location which can be recorded and used to locate the crash on the map during safety analysis. It should be noted that the accuracy of the coordinates would depend on zooming, accurate pointing on the map and the size of the screen window among other factors.

GPS Technology

GPS reports the location of crashes using latitude and longitude coordinates recorded using satellite system. A GPS receiver captures signals from an orbiting network of GPS satellites. GPS can fairly accurately locate and report the plane coordinates for a crash location. It eliminates the possibility of overestimating or underestimating the distance of the crash from a known reference as done in the current practice. In order to obtain accurate location, the type of the GPS receiver is crucial. Differential GPS units provide more accurate results when compared to non-differential receivers. It should be noted that while some GPS units are vehicle based, portable GPS receivers are also available in the market. It is important to use the right type of a receiver to be used for accurate crash location. Necessary corrections should also be done to improve the accuracy of the receivers.

Integrated GIS/GPS technology

The use of GIS and GPS together takes advantage of both technologies for verification of the crash location. The results of this study indicate that using GIS and GPS together may make it possible to take advantage of the best features of both technologies. One of the more time-consuming aspects of using the GIS was locating and zooming into the accident location. The use of a GIS provides a means for officers to check the accuracy of the location, as recorded by the GPS and assigned to a roadway by the GIS, and provides a means to adjust the location, if necessary. The use of a GIS with GPS may also make it easier to use a GPS signal that is not differentially corrected due to the ability to visually adjust the crash location by visual correlation of the crash location to other features on the map.

Hardware and Software Platforms

Hardware requirements for the GIS/GPS integration are not complicated. Different types of GPS receivers can be connected to the laptop computer using either USB connection or Serial communication Port. The varied types of GPS receivers ranging from Differential Corrected GPS receivers, WAAS (Wide Area Augmented System) Corrected GPS receivers and uncorrected GPS receivers were tested. Most types of GPS receivers tested were found to be NMEA (National Marine Electronic Association) data format compatible hence capable of transmitting GPS coordinates and other information directly to the computer with little programming. It was found that the amount of GPS variables that one can download directly to the computer depends on the type of the GPS receiver. However, the most important GPS information, i.e. Latitude and Longitude could be downloaded in all GPS receivers. Figure 1 shows graphical presentation of the necessary hardware required for the integration of GIS/GPS. The GPS receiver receives the signals from the satellites then decodes and calculates the Latitude/Longitude and other GPS data. The computer communicates with the GPS receiver via Serial Com or USB. The Field Unit (portable laptop mounted on the policeman's patrol car which is running TraCS) will send all crash information to TraCS Work Station when the shift ends. Thus, the accurate crash location will go to the TraCS database.

The Field Unit is running GPSSnap (VB/MapObjects) program to receive the GPS information from GPS receiver and generate an .ini file for TraCS. TraCS will call external search engine to retrieve the updated information into TraCS form and keep the data.

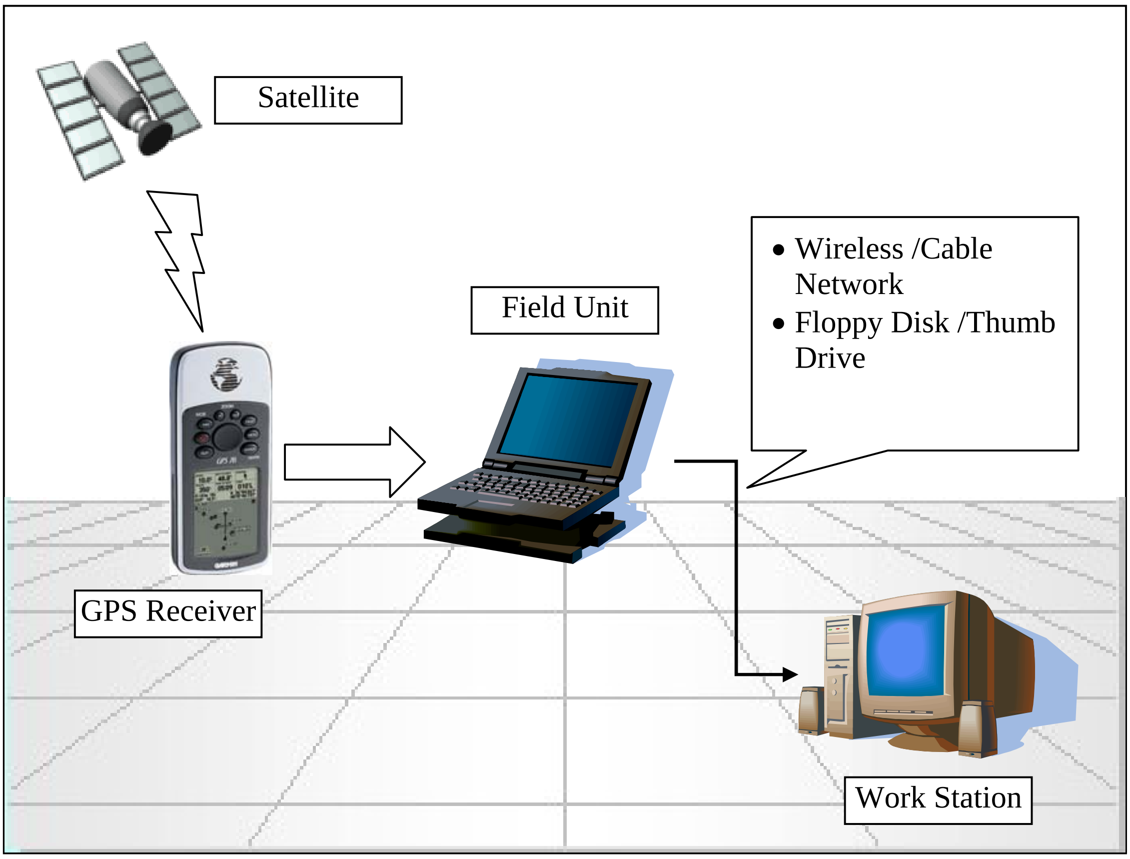

Figure 1: Hardware for GPS/GIS Integration

Streamline Data Extraction

Automatic download of location data is allowed by some GPS units. It should be noted though that the format of the data is different from one GPS unit to another but the format of the sentences are same according to NEMA standard. Figure 2 shows a sample of raw data from one unit (Garmin 76). Data of interest can then be extracted from the raw data shown in Figure 2. The data of interest may include Latitude & Longitude (bold text in row 3), PDOP and HDOP (bold text in row 4), and satellites locked with their corresponding signal strengths (rows 5, 6 and 7).

```
$GPRMC,185628,A,3025.2482,N,08419.0071,W,0.0,0.0,180504,3.6,W,A*1C
$GPRMB,A,9.99,R,TOUR1,TOUR2,3459.0450,N,07623.7220,W,485.027,53.5,,V,A*41
$GPGGA,185628,3025.2482,N,08419.0071,W,1,05,1.9,41.5,M,-29.6,M,,*47
$GPGSA,A,3,,,09,,,17,,21,,26,29,,2.2,1.9,1.0*38
$GPGSV,3,1,12,03,00,325,00,06,34,205,00,09,31,141,39,10,07,073,00*7E
$GPGSV,3,2,12,15,15,315,00,17,19,120,31,18,46,304,00,21,62,333,35*7D
$GPGSV,3,3,12,22,19,278,00,26,46,040,50,29,33,040,43,35,42,130,00*72
$GPGLL,3025.2482,N,08419.0071,W,185628,A,A*5F
$GPBOD,6.8,T,10.4,M,TOUR2,TOUR1*7F
```

Figure 2: Raw Data from Garmin GPS 76S.

To get the raw data (Figure 2) from GPS, we can take use of some utility software such as MS HyperTerminal which is frequently used to connect remote computer or hardware device such as Modem. The above raw data correspond to NEMA standard and we programmed to retrieve the GPS information from any receivers which are made according to NEMA standard.

GPS/GIS Integration Procedure

Figure 3 shows the procedure of GPS/GIS integration. The backend program keeps receiving raw data from one of serial port which the GPS receiver is using. Then it retrieves the Latitude/Longitude and HDOP value from the GPS receiver. Then the program puts the values to the history buffer, after averaging it generates the averaged GPS coordinates values. Then the program snaps the point to the closest point on the closest street, gets the street's name and the nearest street's name and calculates the distance from this snapped point to the intersection. Since the GSP receiver is not really in the location of the crash sometimes, the program also provides an option for the user to manually select the point—which normally is close to where the GPS receiver is.

Data Post-Processing

To improve the accuracy of measuring of GPS, also to reduce the deviation between the tests, we use the averaged GPS data: the Last-N Averaging and Minimum-N-HDOP Averaging. The Last-N Averaging strategy use simple mathematic average of latest N readings of Latitude/Longitude. As well as the Minimum-N-HDOP Averaging strategy use Horizontal Dilution of Position (HDOP) as weight, and use the Latitude/Longitude with minimum HDOP value to calculate the weighted averaged value as the test result.

- Last N Averaging:

$$\text{Latitude Averaged} = \frac{\sum_{i=1}^{N} Latitude(i)}{N}$$

- Minimum-N-HDOP Averaging:

$$\text{Latitude Averaged} = \frac{\sum_{i=1}^{N} (Latitude(i) * HDOP(i))}{\sum_{i=1}^{N} HDOP(i)}$$

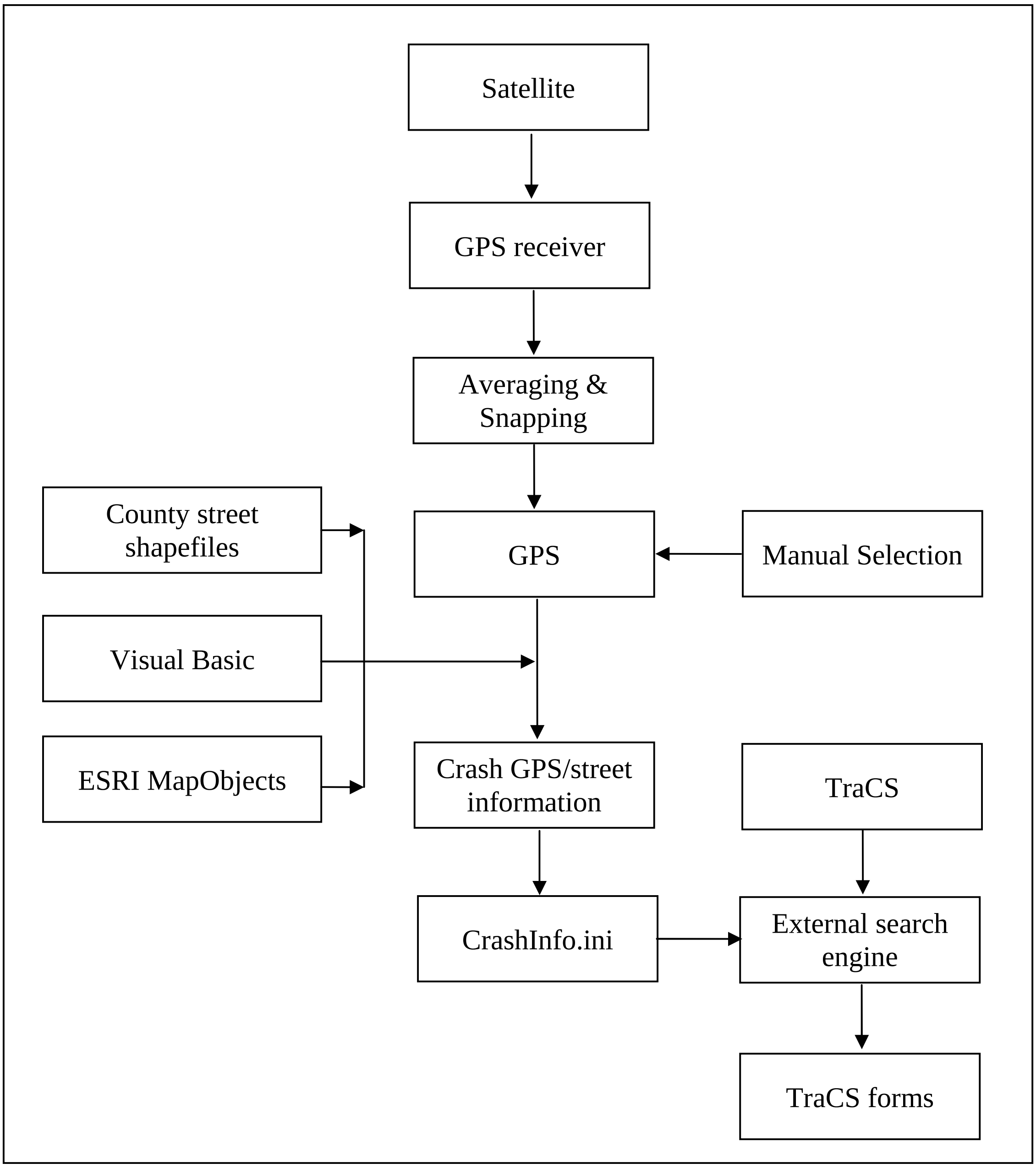

Figure 3: Streamline Chart: Crash GPS/GIS Integration

Integrating GPS/GIS

MapObjects 2.2 software was embedded in Visual Basic 6.0 software to integrate GPS and GIS. The coordinates recorded from GPS receiver after extracting streamline data and filtering using filtering techniques explained above were used to show the location of the crash on the map (Figure 4). The code was written to snap the location to the nearest street segment and then return the name of the street where the crash occurred, the name of the nearest intersecting street and the distance to the nearest intersecting street. Figure 4 illustrates the type of information queried from the street shapefile attribute table.

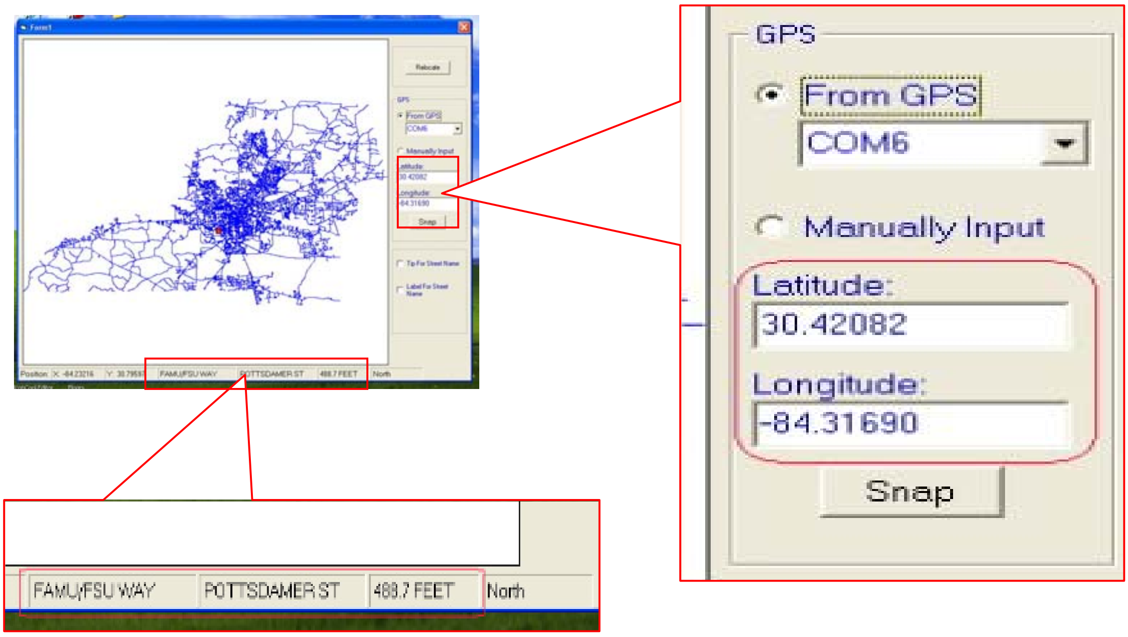

Figure 4: GPS/GIS integration

Integrating GIS and TraCS

The final step in integration of GPS with GIS and GIS with TraCS (Traffic and Criminal Software) is inputting the crash location information in the crash form. The GIS tool was used to generate CrashInfo.ini file. TraCS uses External Search Engine utility to import crash location information from CrashInfo.ini file. The information that was exported from GIS to TraCS via CrashInfo.ini file using search engine utility includes name of the street where the crash occurs, the name of the nearest intersecting street, and the distance from the location of the crash to the nearest intersection. Latitude and longitude information was also exported to TraCS form. The crash location information derived from GIS is shown in Figure 5. Figure 5 shows the time location and latitude/longitude sections of the crash reports.

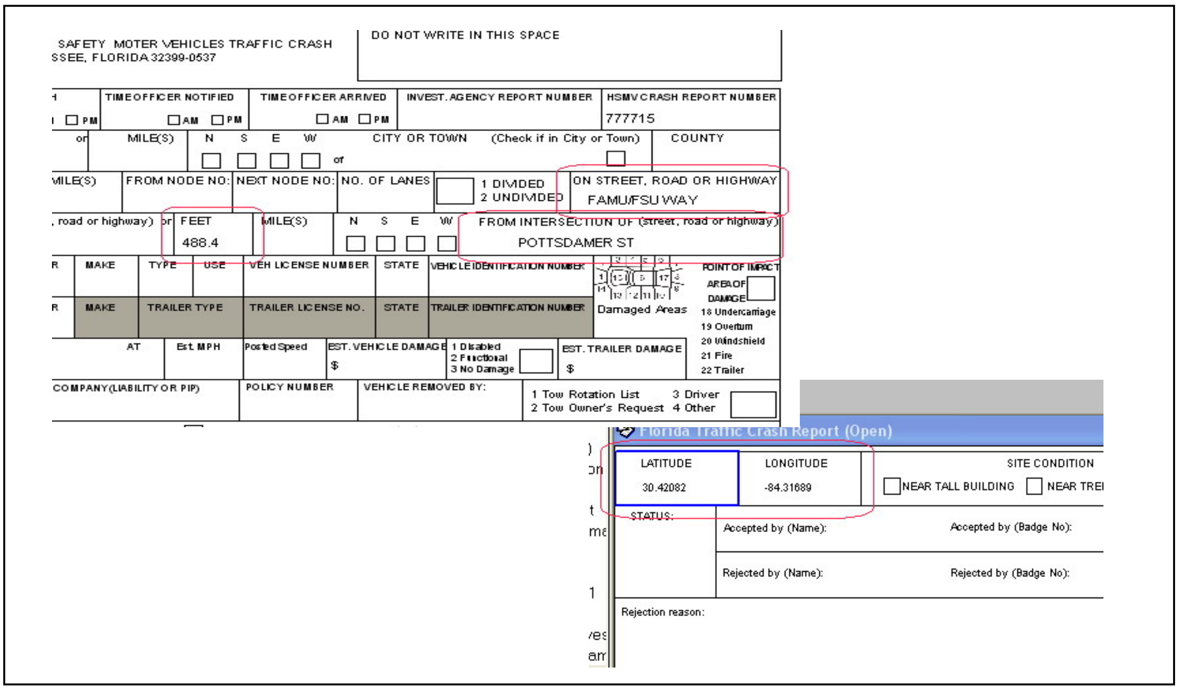

Figure 5: GIS Integration with TraCS

Conclusion and Recommendations

The procedure that was used to integrate GPS and GIS using MapObjects 2.2 software and Visual Basic programming has been presented. Several benefits of integrating GPS and GIS have been realized. The benefits include (1) completeness of the crash information data, (2) uniformity in reporting street names, (3) elimination of human error that might be caused by manually recording the coordinates (latitude/longitude)), (4) correct spellings of the street names due to the fact that the street names are taken directly from the attribute table, and (5) time saving due to automation of filling key information needed for the crash location. It is recommended that a thorough study be conducted to quantify the benefits that have been realized.

References

Mintsis, G., Basbas, S., Papaioannou, P., Taxiltaris, C., and Tziavos, I.N. Applications of GPS technology in the land transportation system., in *Europen Journal of Operational Research* 152 (2004), 399-409.

Sando, T., Mussa, R., Sobanjo, J., and Spainhour, L. GPS Usability in Crash Location. Presented at the *74th Annual Meeting of the Institute of Transportation Engineers*, Orlando, Florida, 2004.