

Development of a Tool for GIS Map Preparation Using Hand Held GPS Data

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Abstract: Use of map based information systems is becoming a common requirement for many uses. It is important for comparison of locations, identification of distance, establishment of networks, selection of routes etc. With the hand held GPS equipment becoming more affordable and reasonably accurate, the positions thus obtained require to be taken in to databases for meaningful and comparative applications. GIS software of present day are complex and require incorporation of suitable settings to prepare representative maps. This requires a reasonable knowledge of GIS and GIS software to develop spatial data layers from externally captured coordinates. In an environment where GIS resource persons are scarce, it is necessary to identify methods to overcome this problem of preparing GIS maps using GPS based field data as and when the field data from GPS are made available. Tool was developed using Visual Basic 6 programming language and ArcGIS. Once the captured coordinate are entered and appropriate topo sheet is selected, the ArcGIS software would upload a scanned image of the 1:50,000 topo sheet so that a user could identify and carryout associated computations or management activities. enables a non GIS expert to capture field data with a hand held GPS and support the creation of GIS maps in a very fast and accurate manner. This paper describes the tool planning, design and development which was carried out in a systematic manner. The tool which is provided as an independent software would load the ArcGIS software upon selection and then proceed with the interface operation that enables the field GIS data input through a computer terminal.

1. Introduction

Recently GPS and especially handheld GPS units have become affordable and hence popular among many people who desire to locate either themselves or their interests in relation to a global reference. A location thus identified requires to be plotted in a map to identify the geographic details related to that location. As such, it is important to have georeferenced maps in a GIS framework so that coordinates identified from the GPS could be plotted to scale. The GIS maps can be either based on scanned images, digitized drawings, satellite images or aerial photography. The handheld GPS data are known to possess a significant error ranging from 3 m to 15 m [1]. Therefore, it is important for a user to be aware of the accuracy when attempting to use such data. Most handheld GPS data are often used for location identification instead of map making. Once a person knows an approximate location then with reference to the other features given on a reliable map, the positioning accuracy could be improved. GIS software such as ArcGIS enables the plotting of a GPS coordinate on a map and then to present the plotted location with reference to a base map. The map could be either a topo map or a satellite image.

In case a person who requires to plot handheld GPS data to a ArcGIS map, it is necessary to have a training on the use of the ArcGIS software to enter and save data sets as GIS layers.

Though this appears as practicable in case of small-scale operations of field data collection, in a situation where a significant number of handheld GPS units are recording field data at many diverse locations, and there is a requirement to produce a number of maps at different places, the preparation of maps with the help of trained GIS software users dose not appear practical.

This is more so in a country like Sri Lanka where there are limited GIS resource persons and also where there are inadequate of training opportunities. Under these circumstances the

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decision makers or planners who require GIS map data, need to find alternatives to achieve their objective of carrying out GIS map preparation to the desired accuracy. A solution to this problem is to develop a simple user interface (UI), which would enable the entry of GPS data, activate a GIS platform, and then plot on a geographic layer to be compared with an acceptable map. Therefore it is very important and useful to develop a tool of this nature to produce maps with handheld GPS data but without the need of GIS software knowledge. This tool needs to be so designed that a user would be required to only be trained in GPS data capture and the entering of captured data in a simple to use Graphic Interface linked with the tool. The interface needs to ascertain reliability of data without leaving room for the occurrence of operator-errors such as mis-manipulation of layers or editing errors. With a suitably designed tool users would only require ensuring the accuracy of data entry to develop an accurate GIS dataset. In the present work, development of a tool for GIS map preparation using handheld GPS data is described. The planning, designing, development and accuracy checking is presented in a step-by-step manner. The tool development using Visual Basic 6 activates and carries out map preparation on a ArcGIS platform.

2. Objective

The objective of the work is to develop and test a tool which enables a non GIS expert to prepare a GIS map incorporating externally collected location coordinates.

3. Methodology

3.1. General

The methodology used for the study is shown by the process Flowchart in Figure 1. Since the tool need to be used by non GIS experts, the design looked at the options available for the tool to work as an extension. An extensive literature survey did not reveal the availability of a tool which would function as an extension, load ArcGIS, input external data, create a shape file and at the same time write input data written to a spread sheet of a different platform. Therefore efforts were taken to carryout external operations [2][3], communicating data form

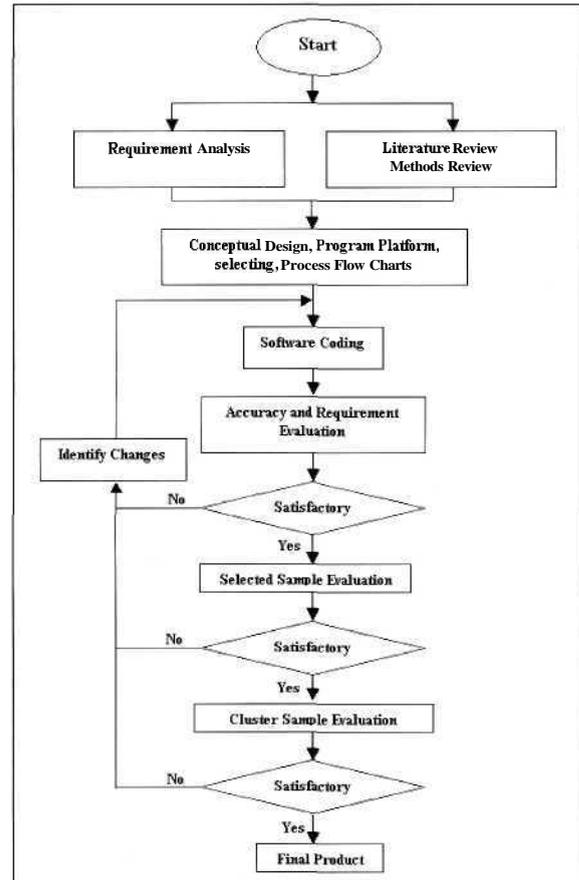


Figure 1- Methodology Flowchart

ArcGIS to a VBA and vice versa [2] [3], exporting information to a spread sheet [4][5][6] etc., through a tool which would initiate action independent of ArcGIS.

3.2. Requirement Analysis

A user need assessment was carried out and using a simple questionnaire to capture the needs of the tool [7]. A self-identified 20 GPS, GIS users were taken as the sample to assess the requirements. Questionnaire attempted to identify the type of GPS data recording personnel, adequacy of GPS software available for map preparation on GIS platforms, capability GPS users for map preparation in ArcGIS, and type of a tool desirable to prepare maps using GPS data. Survey questionnaire revealed that an 80% of respondents requested an independent tool for a Graphical User Interface (GUI) to carryout the task in ArcGIS. 30% of the participants requested the capability to view the captured points on a GIS map layer. 40% of the surveyed indicated that the support should be extended to view the GPS captured points not only on a map layer but also on a

background map which is either the 1:50,000 topo sheet or a satellite image.

3.3. Development of Tool G2G

The process flow of the tool is shown in the Figure 2. The tool, which is to enable plotting GPS data on to a GIS was named G2G.

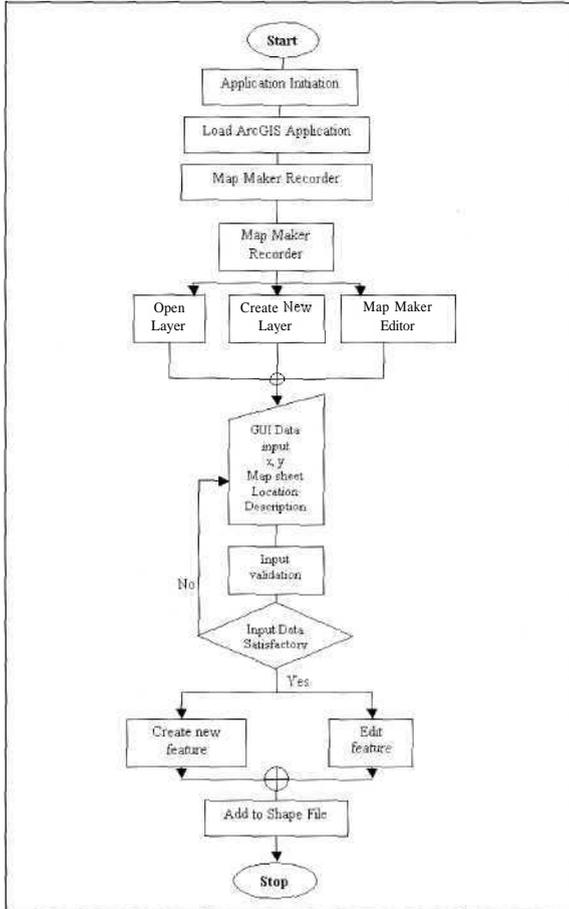


Figure2- G2G Operation Sequence.

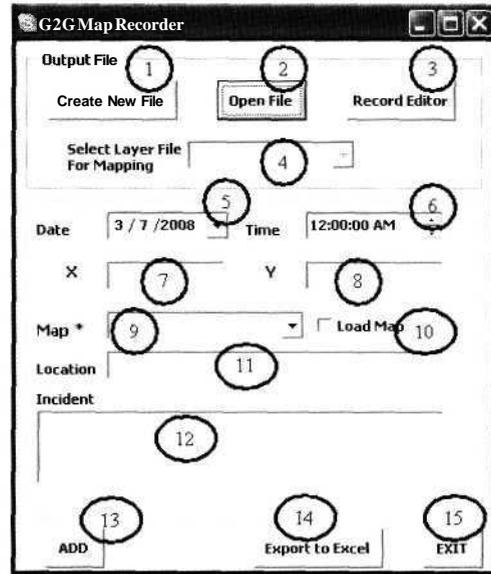


Figure 3 - G2G Map Recorder GUI

The G2G tool initially uses MS Visual Basic Language Version 6 to modify ArcGIS registry to initiate G2G module action within the ArcGIS environment. At initiation, a data input form to commence either a new recording or to carry out editing of previous data is placed as the active window. New data entering mode highlights a form called the G2G Map Recorder to complete the task up to adding a shape file whereas adding new points by editing an existing dataset could be completed with the second input form named G2G Editor. The two forms are shown in Figure 3 and Figure 4.

The forms were designed as component container using VB6. Order of components in each form shown in Figure 3, Figure 4 was

Table 1 - Function of G2G Map Recorder GUI

Label	Description
1.	Creation of a new shapefile in an identified destination to commence data entry and add to layer list (Enable multiple file creation)
2.	Locate shapefile already created to commence data entry and add to layer list
3.	Selection of G2G Editor GUI to commence editing in an existing data file
4.	Selecting target working layer file from the loaded list of layers for data mapping *
5.	Input date for the records Capture system Date or enter correct date for record.
6.	Input time for the records Capture system time or enter correct time for record.
7,8.	Input x and y coordinates (Captured by GPS or other wise) *
9.	Select TOPO sheet to check matching of input coordinate. (If an unmatched, displays warning message)
10.	Option to load/ unload selected layer to ArcGIS
11.	Input Location Name
12.	Input a Description related to input GPS coordinate
13.	Input data recording and map loading; Press after each fresh entry
14.	Export selected layer data to MS Excel
15.	Exit Application

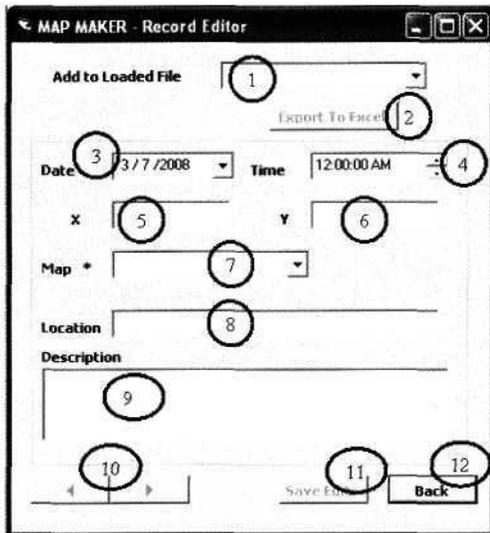


Figure 4 - G2G Editor GUI

arranged keeping to the sequence of workflow. Form design and coding were done systematically adhering to the guidelines for developing user interface for getting effective usability. Cognitive directions were given priority, while consistency and simplicity were also treated as important. [7], [8]

The G2G Map Recorder GUI functionalities and G2G Editor Functionalities are shown in Table 1 and Table 2. The GUI development incorporated input masking to ensure that only numerical data could be entered for field data input columns. Coding was done to detect an erroneous map selection at the end of each data

Table 2 - Function of G2G Editor GUI

Label	Description
1.	Select layer file from layer list for editing already Entered data
2.	Export data set of selected shapefile to MS Excel file
3.	Load date value from available record and allow to edit
4.	Load time value from available record and allow to edit
5,6.	Load the x and y coordinates from file and permit editing
7.	Selects TOPO sheet for record matching
8.	Load Location data of record and permit editing
9.	Load Description data of a record and permit editing
10.	Navigation button to browse for records of loaded file for editing
11.	Confirm action to save editing of each record
12.	Return to G2G Map Recorder GUI

entry. In order to ensure speedy operations with a shape file, the coding adopted a stepwise initiation of processing during form completion.

4. Tool testing

Tool testing was carried out in three stages. Initial internal evaluations were carried out to test the flow, process and accuracy of computations [8]. Accuracy to testing of the tool included the checks on validity range for inputs, compatibility with the topographic survey sheet, numeric or text nature of input and the number of possible digits per coordinate. Mapping accuracy of input coordinates was checked by extracting coordinates of plotted point to the layer attribute Table. Once evaluations of the software satisfied internal accuracy testing, user requirements were tested with a self selected sample of known GIS users who were aware of the objective of the tool development and who were both conversant in ArcGIS and GPS. The third evaluation as shown in Figure 1 was conducted with a set of 20 clustered users. Results of the clustered evaluation [10] was carried out to capture user satisfaction with respect to overall software quality. The degree of perceived usefulness and perceived ease of use were assessed with the elements indicated in the Davis approach [7]. Identification of the degree of user productivity revealed that the installation steps to be followed were often skipped and as a result the users were unable to proceed further thereby showing poor results. As a result, the coding was further developed to modify the registry file and BAT file ensuring automatic activation of ArcGIS and tool simultaneously. From the series of success measures cited in literature, user survey incorporated several questions to assess the degree of (i) user understanding of interaction with the system. (ii) Ease of which choices can be made. (iii) Skilled application of system (iv) improvement in choice performance, and (v) Improvement of the ease with which choice can be made.

Once the accuracy of input and plotting coordinates were ascertained, evaluations were made with regards to the relative positioning of coordinates on a georeferenced topographic map sheet or a satellite imagery. Trial GPS coordinates picked from known locations around Colombo were plotted to identify the

variation of plotted point and the map location.

Tool testing was carried out by attempting to plot coordinates pertaining to locations identified on hard copy maps. Nine points with one each from a single topographic survey sheet of 1:50,000 was identified and the tool was used to enter the data for a comparison with GIS outputs. Thereafter field GPS points were plotted and checked for accuracy.

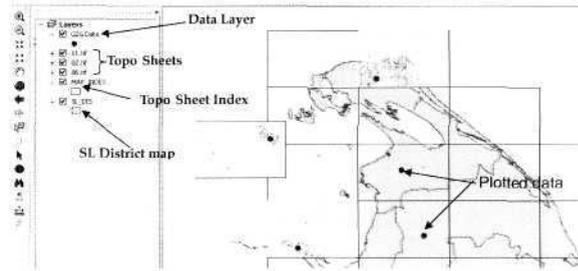


Figure 5 - Plotted GPS locations with background map option

5. Results and Discussions

1. Tool evaluation was carried out through a user survey with a 20 person clustered sample. The questions used for evaluation, results of scores given to each question, frequency of responses are shown in Table 6-1 to 6-6. Results were very satisfactory with a clear indication of the tool achieving the development of objectives.
2. A sample of map produced by the tool on ArcGIS platform is shown in Figure 5. Coordinates of nine points selected from 1: 50, 000 hard copies were fed to the tool and were compared at different zoom levels. At 1: 50,000 scale, no error could be observed in any of the points. However upon zooming at different scales it was noted that there was a disparity. The differences observed on screen are shown in Figure 6. The hard copy identified points were the grid crossing on the 1: 50,000 topographic map. Therefore, it was easier to capture the mismatches on screen. ARCGIS coordinates of map grid points were obtained and comparisons were carried out with the input values. The errors in the input and on screen outputs are shown in Table 3. The errors changed

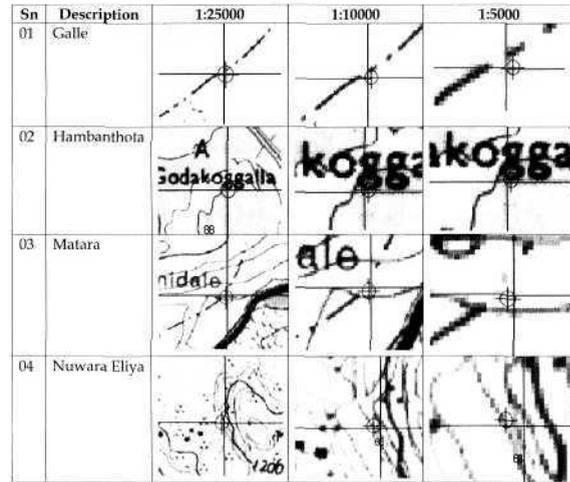


Figure 6 - Relative positioning of plotted point and topo Grid location of four selected locations and different zoom scales.

between 7.2 and 22.5 m. Upon detailed investigation it was revealed that the input data recording in the attribute table was without any error. The errors identified were identified as georeferencing errors observed in the scanned maps.

3. Field observations were carried out to capture and plot four known road junctions with handheld GPS (Table 4). Result

Table 3 - Relative positions of pints spread over Sri Lanka map

SNO	Description	Topo sheet Ref	Point		MAP		Deference (m)
			X	Y	X	Y	
1	Point Padro	2	135000	505000	135018	504989	21.1
2	Kokilai	18	201000	415000	201007	415005	8.6
3	Wilpattu	24	110000	365000	109990	364990	14.1
4	Padirippu	51	300000	265000	300009	264996	9.8
5	Colombo	66	101000	190000	100992	189992	11.3
6	Nuwara Eliya	68	175000	180000	175021	179992	22.5
7	Pothuvil	71	310000	185000	309990	184998	10.2
8	Galle	90	150000	90000	149990	89996	10.8
9	Hambanthota	88	225000	110000	224996	109994	7.2

Table 4 - Comparison of GPS field data and known locations identified on topomap

Item	Description	GPS		MAP		Deference with actual location (m)
		X1	Y1	X2	Y2	
1	Malabe Junction	109559	189345	109542	189341	17.5
2	Koswaththa Junction	106710	189829	106706	189816	13.6
3	Henathikubura Junction	106491	190620	106498	190596	25
4	Abagahandiya Junction	104550	190489	104528	190469	29.7

Table 5 - Result after extracting Shapefile points to its attributes

SNO	Description	Topo sheet Ref	Point		MAP		Deference (m)
			X	Y	X	Y	
1	PointPadro	2	135000	505000	135000	505000	0
2	Kokilai	18	201000	415000	201000	415000	0
3	Wilpattu	24	110000	365000	110000	365000	0
4	Padirippu	51	300000	265000	300000	265000	0
5	Colombo	66	101000	190000	101000	190000	0
6	Nuwara Eliya	68	175000	180000	175000	180000	0
7	Pothuvil	71	310000	185000	310000	185000	0
8	Galle	90	150000	90000	150000	90000	0
9	Hambanthota	88	225000	110000	225000	110000	0

indicated a difference in mapped points showing accuracy values varying between 13.6 m and 29.7 m. As discussed previously accuracy of the points which were observed could be due to issues pertaining to the georeferencing of maps as well as the accuracy of handheld GPS instrument.

tool development and the user satisfaction testing are suitable for guidance to similar work.

6. Conclusions

1. A systematic methodology with appropriate user evaluations enabled the development of G2G tool to prepare GIS maps from externally collected geographic coordinates.
2. Accuracy checking and tool evaluations with suitable users is very important to develop a user friendly tool.
3. The developed tool identified that the accuracy details plotted through the G2G interface depends on the accuracy of reference maps and also on the methodology used for data capture.
4. G2G GIS tool successfully achieved the capability to commence action as an independent module and then to activate ArcGIS to develop a new point theme to be visualized on a selected background map.
5. The structured methodology adopted for



Table 6 - User Survey Responses

6-1 OS Problems during installation		
Score	Frequency	%
0	5	25
40	6	30
60	4	20
80	3	15
100	2	10
	20	100

6-2 Software easy to understand		
Score	Frequency	%
0	0	0
40	0	0
60	3	15
80	11	55
100	6	30
	20	100

6-3 Tool leads to expected result		
Score	Frequency	%
0	0	0
40	1	5
60	5	25
80	0	0
100	14	70
		100

6-4 Tool reduces workload		
Score	Frequency	%
0	0	0
40	1	5
60	3	15
80	11	55
100	5	25
		100

6-5 This tool is the only one that has satisfied		
Score	Frequency	%
0	0	0
40	1	5
60	3	15
80	9	45
100	7	35
		100

6-6 Concepts of the GUI fitting to common platform/tool concept?		
Score	Frequency	%
0	0	0
40	1	5
60	2	10
80	11	55
100	6	30
		100

7. Acknowledgment

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