GPS and Total Stations Data Acquisition and Processing Methodology for Automatic Drawing of Topographic Plans Using ArcCOGO

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Key words: GPS, Total Station, ArcCOGO, Topographic Plan, GFF Format, Automatic Drawing.

ABSTRACT

GPS technology and total stations are being used extensively in the acquisition of surveying field data in Morocco. But available software do not meet the surveyor's need that is they do not cover many types of GPS and total stations data files, and also they do not perform automatic drawing of topographic plans. ArcCOGO is a module of ArcInfo that allows topographic calculations, structuring and archiving the results on COGO coverages. Unfortunately, ArcCOGO needs to be adapted to support different types of data files, data processing and automatic drawing tasks.

In this study, we present a methodology for data acquisition in the field, data processing to handle a variety of GPS and total stations data files, arranging data files into coverages, and processing the results to automatically draw topographic plans.

In order to achieve our needs, we develop a methodology based on the following points :

- Conceive a procedure for data acquisition and a codification method that will help in the automatic drawing of topographic plans.
- Read and convert data files from several total stations (Leica, Topcon, and Nikon).
- Import coordinate data files from GPS software (Ashtec, Trimble, Leica).
- Arrange data files into ArcCOGO coverages.
- Create point and line symbol tables that will be used for automatic drawing.
- Automatically generate topographic plans including page setup, layout and legend.

The proposed methodology responds to some surveying requirements in Morocco, and will help accelerate the process of drawing topographic plans. This methodology was applied in two different case studies for which the results were very satisfactory and did achieve the allowed calculations tolerances.

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1. INTRODUCTION

The electronic and computer technology have considerably changed the area of data acquisition and data processing. The use of electronic total stations and the progress of spatial positioning methods, such as the GPS, made collection of data very rapid. Consequently, reserved time for data acquisition in the field is reduced, a great number of sources of errors are decreased, results are obtained rapidly, and data quality is improved.
ArcCOGO is an ArcInfo module mainly designed for processing surveying data of various sources, such as some electronic field data, drawing files and GIS exchange files (ESRI, 2000c). ArcCOGO also permits structuring of these data into ArcInfo coverages.
Despite its powerful processing possibilities, ArcCOGO remains an interactive module that supposes preliminary knowledge of many ArcInfo concepts and commands. In addition, this module does not allow direct use of data of many total stations, nor the GPS post-processing data, finally it does not integrate specific tools for drawing topographic plans.

The objective of this article is to develop a methodology for data acquisition in the field, data processing to handle a variety of GPS and total stations data files, arranging data files into coverages, and processing the results to automatically draw topographic plans. An interface in AML programs is developed to simplify the COGO environment. The proposed methodology is based on the followings guidelines:

- Conceive a procedure for data acquisition and a codification method that will help in the automatic drawing of topographic plans.

- Read and convert data files from several total stations (Leica, Topcon, and Nikon).

- Import coordinate data files from GPS software (Ashtec, Trimble, Leica).

- Arrange data files into ArcCOGO coverages.

- Create point and line symbol tables that will be used for automatic drawing.

- Automatically generate topographic plans including page setup, layout and legend.

2. ARCCOGO BASIC CONCEPTS

2.1 Coverage

A coverage is the primary vector data storage within ArcInfo. It serves for storing the location, shape and attributes of geographic features (ESRI, 1999). A coverage contains both spatial and attribute data of geographical objects. In a coverage, objects are represented by classes of entities such as arcs, nodes, polygons, labels and annotations (ESRI, 2000a). The correspondence between descriptive and spatial data is assured by attribute tables. ArcInfo uses arc attribute table (AAT), point and polygon attribute tables (PAT).

2.2. COGO Coverage

ArcCOGO is an ArcInfo module designed for capturing survey data. It is used to support accurate coordinate geometry for data entry and manipulations (ESRI, 2000c). COGO coverages are a particular case of ArcInfo coverages, they represent the basic unit of work in COGO. COGO distinguishes two types of coverages : point COGO and arc COGO coverages.

ArcInfo provides a program named FDCONVERT that converts total station data files to the Generic GFF format. However, this program supports only some formats, namely Geodimeter GEODAT 400, Lietz /Sokkisha SDR24, Distomat and Wild/Leitz GRE3 or GRE4.

Although efficient, this module does not integrate neither data from some total stations, like Nikon, Topcon and Leica, nor those from GPS coordinate data files. Furthermore, this module does not support cartographic aspects for direct drawing of plans such as the use of symbols, layout, page set up and plans output.

In the following, we will present a methodology for reading and processing data from three kinds of total stations and from post-processing of three GPS data. All these data will be used to automatically generate topographic planimetric plans using COGO functionalities.

3. METHODOLOGY FOR DATA ACQUISITION AND ARRANGEMENT

3.1. Procedure for data acquisition in the field

In this methodology, we have proposed a method for details codification and a procedure for data collection in the field. Each observed point is designated by two elements : an alphanumeric name for its identification and a numerical code for its description.

This codification method is used for the automatic recognition of any type of details, to help automatically construct objects of coverages from field data, and to support the use of symbols.

We have adopted two lists of codes for most details frequently met on the terrain, one for point features and another for linear features. Table 1,at the end of this article, shows some examples of these symbols and codes.

Point codes are formed of one part of two characters. While linear codes are constituted of two parts, the first part is composed of two characters, it informs both on the type and the physical nature of the detail. The second part is an order number that allows distinction between details of the same nature.

As an example, Wells are coded PU, points of a road axis are coded AX1, AX2, AX3,..etc. Furthermore, we have adopted the code REF for a reference point, the code STA for occupied station, the code TVB for a backsight station and TVF for foresight point.

In this procedure we should respect the following rules:

- Respect the codification method adopted for collected points of details
- Respect the course direction for linear details and contours, while going from the first point of the detail to the last one.

3.2. Data Files Arrangement

Once data are transferred in the computer, they are ASCII observation files or coordinate files, but in GPS or to total stations formats. These files should be arranged in the ESRI Generic Fielddata Format (GFF format) used by ArcCOGO. GFF Files can contain description data for occupied stations, observations and coordinates. Observations can be height, horizontal and vertical circle readings, distances, …etc (ESRI, 2000c). For this purpose, we have established some AML programs that read total station files (Leica, Nikon, Topcon) and the post-processing GPS files (Ashtech, Trimble, Leica), and convert them to the generic format GFF.

3.2.1. Arrangement of Total Station Leica Data Files

Total station Leica data files obtained after transfer are well structured. Our program forms a GFF file that contains all susceptible measures to be taken on the terrain such as the name of the reference point, the name of the sighted point, horizontal and vertical circle readings, slope distance, height, coordinates and codes.

3.2.2. Arrangement of Total Station Topcon Data files

Total station Topcon data are recorded as chains of characters separated by the character "under-score (_) " and a special character for the identification of the type of data (Topcon). The arrangement of these files passes through three steps:

- Division of lines of the transferred data file into three blocks : observations, coordinates and other information.

- Substitution of Topcon's delimiters by other characters not used by AML.

- testing the blocks and arranging data using the GFF format (station, sighted point, horizontal angle, vertical angle, coordinates,…).

3.2.3. Arrangement of Total Station Nikon Data Files

The Nikon data files present a heading for each recording; and data are separated by commas. Nikon transferred data are not ready to be exploited directly by COGO. The conversion program structures data in a GFF format to be used by COGO.

3.2.4. Arrangement of GPS Data Files

We have developed a set of programs that allow the reorganization of three different GPS data files (Ashtec, Trimble and Leica). Each program generates a GFF file of coordinates. Each line of this file contains the following data: the code CRD; name of point; plane coordinates X,Y; orthometrique height H and point's code.

3.3. Construction of COGO Coverages

Passing from the GFF file to COGO coverages we need a set of parameters and options to calculate COGO attributes and construct coverages' objects. For this purpose, we have developed a program which generates an AML file of sub-commands FIELDDATA. The execution of this program calls a sheet and a set of dialogue boxes to be filled out. The result is a file of executable FIELDDATA commands. The former contains parameters like units, angle and distance formats, tolerances and commands that will automatically construct objects of coverages.

4. DRAWING TOPOGRAPHIC PLAN

In our application the drawing procedure can be either automatic or interactive.

4.1. Automatic Procedure

The automatic procedure is assured by a program that creates a view and sets up the page of the drawing. Its execution necessitates tables, pre-established files and user's information for the drawing. Figure 1 illustrates different steps of this procedure.

4.1.1. Files of Symbols

Two symbol files are created, the first one is for point symbols, it has the extension "mrk"; the second one is for line symbols, it has the extension "lin". These files have been created in such a manner to respect drawing conventions adopted in Morocco. Within each file, symbols are identified by a number of three digits, the first digit designates the nature of the feature: number (1) is used for point features and number (2) for line features. The two other digits represent the order of the symbol in the file.

4.1.2. Tables of Conversion

Conversion tables are INFO files constituted of two fields, one for details' codes and the other for symbols' numbers. These tables provide the symbol to be used for each code in the GFF file. These tables are automatically generated by a program that permits:

- extracting and sorting codes from generic files and their classification in alphabetical order
- creating INFO exchange files (extension "e00") that contain definitions of tables, and the correspondence between the codes and their symbols
- importing exchange files and creating conversion tables.

4.1.3. Legend Files

Legend files are generated with the extension "Key", they are used for drawing the plan's legend.

4.1.4. Page set up information

Information on setup are put in by the user via a dialogue box. Requested information is: coverages, output file, scale, state, county, title, date.

4.2. Interactive procedure

This method uses the module Arctools of ArcInfo. The plan is compiled object by object. Each element of the plan (view, north, scale,...) is saved in a file. The establishment of the plan begins with an extended view from constructed COGO coverages. Then, the other components are made up via Arctools editors.

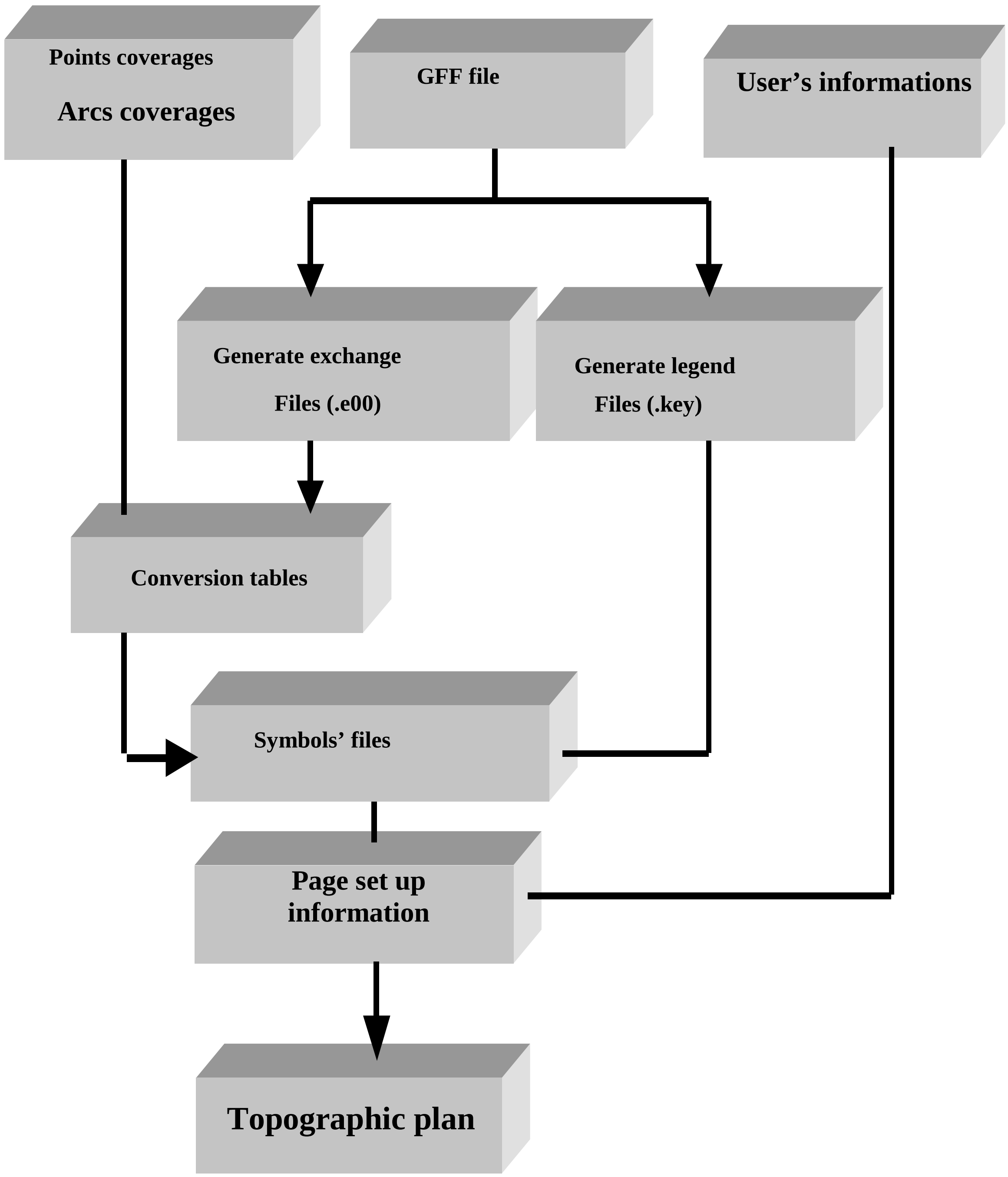


Figure 1 : Steps of the automatic procedure

5. PRESENTATION OF DATA AND RESULTS

To validate the established programs, we realized two case studies. The first concerns the establishment of a plan of the department of geodesy and surveying. Data are collected using a total station Leica TPS1100 (Saïdi and Baaya, 2001). The second concerns the processing of a post-processing data from a GPS Ashtec receiver. Field data for this second case were carried out in the framework of another study realized by Salimi and Souhaili (Salimi and Souhaili, 2000).

For each study case, using the steps of the methodology described above, we obtain the following results:

- A point COGO coverage
- An arc COGO coverage
- A planimetric topographic plan.

Figure 2 presents the drawing obtained by the automatic procedure for the first case study.

The results obtained using this methodology were very satisfactory and did achieve the allowed calculation tolerances. The proposed methodology responds to some surveying requirements in Morocco, and will certainly help accelerate the process of drawing topographic plans.

6. CONCLUSION

In this study we have presented a methodology that uses the module COGO of ArcInfo for the establishment of topographic plans using total stations data and post-processing GPS data. For this purpose, we have developed an interface that can be used within COGO environment (Saïdi and Baaya, 2001). Thus the user is not constrained to know COGO commands, neither should he go through ArcInfo modules to process data for topographic plans establishment.

Nevertheless, the following aspects could improve this interface:

- integrate cadastral plan drawing according to Moroccan standards
- integrate leveling data using ArcTIN functionalities.

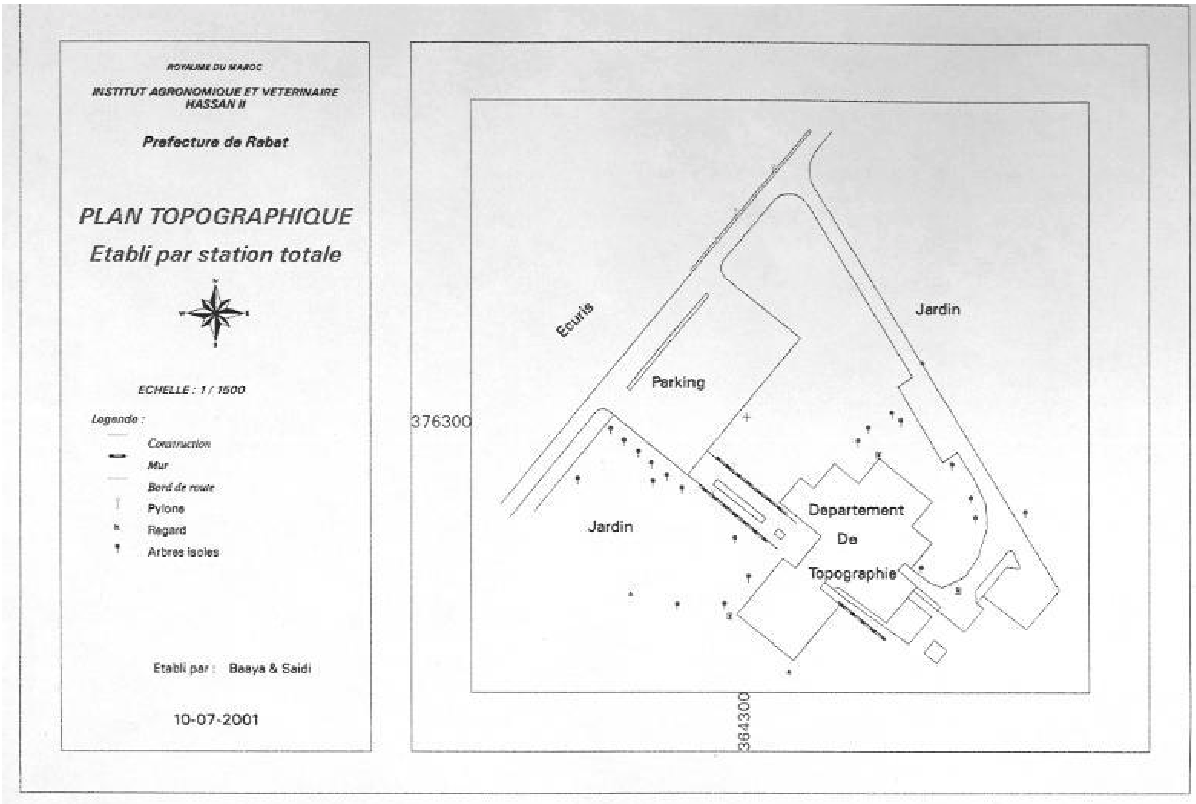


Figure 2. Drawing of topographic plan obtained by the automatic procedure

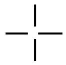
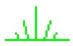
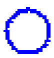
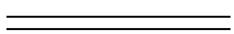
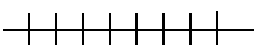
Symbol	Name of detail	Number	Code
	Antenna	123	AN
	Tree	110	AR
	Boundary mark	133	BM
	Panted boundary	101	BP
	Bush	168	BU
	Cactus	159	CA
	Water tower	112	CE

Table 1. Examples of point and line symbols and codes

	Road axis	201	AX
	Canal	221	CL
	Railway	226	CF
	Fence	225	CR
	Cliff	220	FA
	Electric line	232	LE

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Topcon, manuel d'utilisation, Station totale electronique GTS-6

BIOGRAPHICAL NOTES

El Hassane Semlali

<u>Qualification and career</u>

1979: Diploma of engineer in surveying from IAV Hassan II, Rabat, Morocco
1986: Master of Science from Ohio State University, Columbus, USA
1999: Doctorate of Sciences from the University of Liege, Belgium.
1986-1995: Assistant professor at the department of geodesy and surveying, Institut Agronomique et Veterinaire Hassan II, Rabat, Morocco.
1999 to know: Professor and searcher at the same department

<u>Principal areas of interest are</u> : GIS, geodesy and surveying.

<u>Publications</u>: data base design, errorr propagation in GIS, parcel redistribustion methodology, GIS in land consolidation, cadastral systems

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Membership of the « Association Nationale des Ingénieurs Topograpohes »

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