GPP: A Program To Automate The Geophysical Data Processing

G. Kalokerinos

Institute of Computer Science. Foundation for Research & Technology - Hellas P.O. Box 1385 Heraklio, GR-711-10 Crete, GREECE, george@ics.forth.gr

E. Kokinou and A. Sarris

Laboratory of Geophysical-Satellite Remote Sensing & Archaeo-enviroment, Institute of Mediterranean Studies. Foundation for Research & Technology - Hellas, P.O. Box 119, Rethymnon 74100, Crete, GREECE, ekokinou@chania.teicrete.gr, asaris@ret.forthnet.gr

F. Vallianatos

Technological Educational Institute Crete, 3 Romanou Str. Chalepa, Chania, Crete, GR-73133 GREECE, fvallian@chania.teicrete.gr

ABSTRACT

The aim of this paper is to present a program archived for geophysical data processing. The development of the present software package is based on statistical criteria. The GPP package was evaluated by using magnetic, electromagnetic and soil resistance data containing high levels of noise. The efficiency of the GPP package was tested though comparison of the results with similar methodologies followed in a manual procedure using the Surfer tools.

The results archived using the GPP software are more than satisfactory, enabling the fast and high quality production of images even during the fieldwork activities.

1. INTRODUCTION

The widespread use of the geophysical research in archaeological sites (Sarris & Jones, 2000, Jones & Sarris, 2001) resulted in an increasing need of fast and high quality processing in situ.

The existing software packages (such as Surfer, Oasis, Geoplot, etc) provide a suite of tools for the statistical processing and mapping of the geophysical data, but they have been proved inefficient in the cases of noisy data. By the term noisy data is considered the presence of spikes, stripping and zig - zag effects, which disturb or even mask the detection of archaeological features. GPP package was developed in order to encounter these effects by means of minimizing the processing time and improving the resulting image quality of the geophysical measurements.

The data for the evaluation of the GPP package were collected in the context of the geophysical prospection campaigns from Istron, E. Crete (2003 field season) and Dodoni, Epeiros (Sarris, 2004).

The campaign program at the archaeological site of Istron (Priniatikos Pyrgos)[1] employed ground based survey techniques (magnetic, soil resistance and electromagnetic techniques), auger coring for studying the distribution of the magnetic susceptibility, aerial and satellite imagery for mapping the surface architectural remnants and GIS analysis. The ultimate goal of the campaign was to retrieve the surface and subsurface information context of the site and study the economic resources of the area in prehistoric and historical periods based on the analyses of the geomorphological settings and the regional geology and finds. In 2003 survey period, geophysical survey was expanded to a few vegetable gardens and olive tree fields to the east, west and southeast of the promontory. In some cases, recent cultivation practices and periodic flooding has disturbed the upper layers of the site.

In the archaeological site of Dodoni, geophysical research was focused around the

[1] A multi-disciplinary project implemented through the Institute for Mediterranean Studies – Foundation of Research and Technology, Hellas (F.O.R.T.H.), Demokritos Archaeometry Laboratory and the Mediterranean Section of the University of Pennsylvania Museum.

ancient theatre[2]. Magnetic, electromagnetic, soil resistance and GPR techniques covered an area of 16.000m^2. One of the goals of the research was the detection of the outline of the ancient stadium, which has been partially excavated. The stadium extends to the west of the theatre and was built at the end of the 3rd century B.C. A subsurface water and electric power network consisting of pipes and cables has heavily disturbed the upper layers of the area of interest creating increased noise levels in all geophysical datasets.
A number of different datasets were selected from the above areas in order to test the efficiency of the GPP tools. These included high resolution (0.5m) measurements of the vertical magnetic gradient with a Geoscan FM36 fluxgate gradiometer, soil resistance data obtained by a Geoscan RM15 resistivity meter with a Twin Probe configuration of electrodes and electromagnetic measurements acquired by a Geonics EM31 conductivity meter.

2. METHODOLOGY

One of the most challenging aspects of our work is addressing methodological issues in improving the processing time and the data quality.
The GPP package was developed on a LINUX platform by using GCC compiler and then was ported using Borland C compiler in order to be executed in a command (GCC) window in WINDOW NT environment.
The implementation of the GPP package is sequential. The grid size may vary from a few dozen of points to a few thousands points. As an input it accepts geophysical data in an ASCII format (X,Y,Z columns) and then a series of interactive statistical processes is followed.
In the next paragraphs we describe the basic operations of the GPP package.
Preprocessing In general, the GPP package runs by creating a file list of the files to be processed. In case there is a need of reversing the X and Y columns (in order to bring grids in the right alignment with respect to the north), the Preprocessing option (Fig. 1) is chosen. Thereinafter the geometry of the grid is checked and Mean and Standard Deviation values are computed. Maximum and minimum values of the measurements, Mean, Standard deviation, X and Y coordinates and X and Y sampling interval are displayed. At his phase of the processing peak values can be muted and the benchmark relocated by shifting the X, Y coordinates. The preprocessed file is saved as *_PR.dat file.
Main Processing constitutes the core phase of the processing and manipulation of the data. The Main Processing procedure (Fig. 2) is divided in three steps. In the first step (Level correction) the dynamic range of all files is specified according to the Grid Level Correction factor. Thereinafter the de-spiking technique can be applied according to the noise level. In case of noisy data the De-spiking Factor must be smaller than one standard deviation in order to smooth the data. In case of less noisy data the De-spiking Factor can be greater than one standard deviation. Finally, Line Equalization is applied to the data in order to avoid stripping effects.
The Level corrected file is saved as *_L0.dat file, while the Level corrected and de-spiked file as *_L1.dat file. The Level corrected, De-spiked and Line equalized file is saved as *_L2.dat. Preprocessing and Processing reports are generated by the end of each procedure.
Secondary options of the GPP package include re-sampling of the data by any step in X and Y direction and exclusion of the dummy values. GPP is also able to make a mosaic of grids at any stage of processing (preprocessed and main processed grids).

3. EVALUATION OF THE GPP PACKAGE

Selected geophysical data collected from the archaeological sites of Istron (Priniatikos Pyrgos) and Dodoni were chosen in order to test the validity and the efficiency of the GPP routines. Most of the selected datasets suffered from increased levels of noise.
Magnetic data were collected by 7 grids located SE of Priniatikos Pyrgos (Fig. 3). The area lies in the vicinity of a high voltage power supply

[2] The geophysical campaign at Dodoni was carried out by the Laboratory of Geophysical-Satellite Remote Sensing and Archaeo-environment (IMS-FORTH) under the auspices of the Committee for the Protection and Restoration of Monuments of the Archaeological Site of Dodoni.

pillar. Concentration of surface shards suggests the past occupation of the site during the Roman period. Original data suffered from a level difference between the individual grids. An elevation difference between the southern and the northern sections of the sites has also imposed problems in the connection among the geophysical grids. Furthermore, a linear trend is present within a few grids. Processing by means of the GPP tools managed to eliminate the internal differences among the grids and produce a uniform mosaic, which outlines a number of features. Two parallel anomalies along the NW-SE directions (along the northern and southern sections) meet a perpendicular linear anomaly to the SE suggesting the existence of a possible structure of dimensions about 30x30m.

In another field close to the coast (east of the Priniatikos Pyrgos promontory) (Fig. 4), geophysical data collected by magnetic, resistivity and EM techniques exhibited extreme level of noise due to recent clearance and construction activities. A trend towards low resistivity values is shown to the northern section of the soil resistance data, probably originating by the proximity of the grids to the coast line. De-spiking techniques, Line equalization and Re-sampling in the spatial domain removed the most intensive anomalies caused by non - archaeological features. The resulting anomalies to the south section of the area could be correlated to surface architectural remnants which are obvious to the south.

In a different situation, both magnetic (Fig. 5a,) and electromagnetic (Fig. 5c) measurements acquired west of the ancient stadium in Dodoni were masked by the intensive anomalies originating by water pipes and electrical cables located within a meter below the current surface. Extreme values caused by the existence of widely lain debris and metal fragments and linear and non-linear instrumental drift in both directions made processing of the data a difficult task. The resulting maps following the processing steps of GPP (Figs. 5b & 5d), indicate a drastic improvement of the data quality, which made it possible to recognize some subtle anomalies to the SW section of the area, probably related to a cluster of architectural relics.

4. CONCLUSIONS

GPP utilities proved satisfactory for the type of enhancement required by the geophysical data resulting from the shallow depth prospection of archaeological sites. Interactive de-spiking by means of statistical processing of the original measurements seems to be a flexible technique in order to remove peak values that masked specific areas in their vicinity, while line equalization (in one or two directions) smoothes the grid and makes easier the detection of archaeological features. Finally, re-sampling techniques comprise a useful tool in removing stripping effects.

The full processing of the geophysical data by GPP package in situ can be proved a useful tool to the interpreters and research designers.

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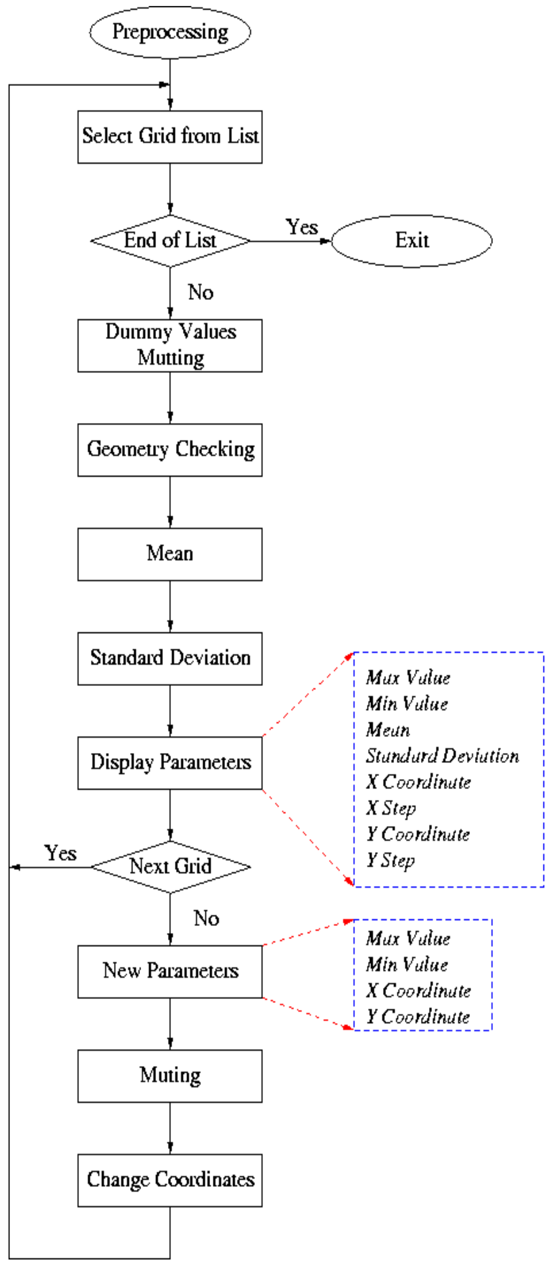

Figure 1. Procedure of the Preprocessing option.

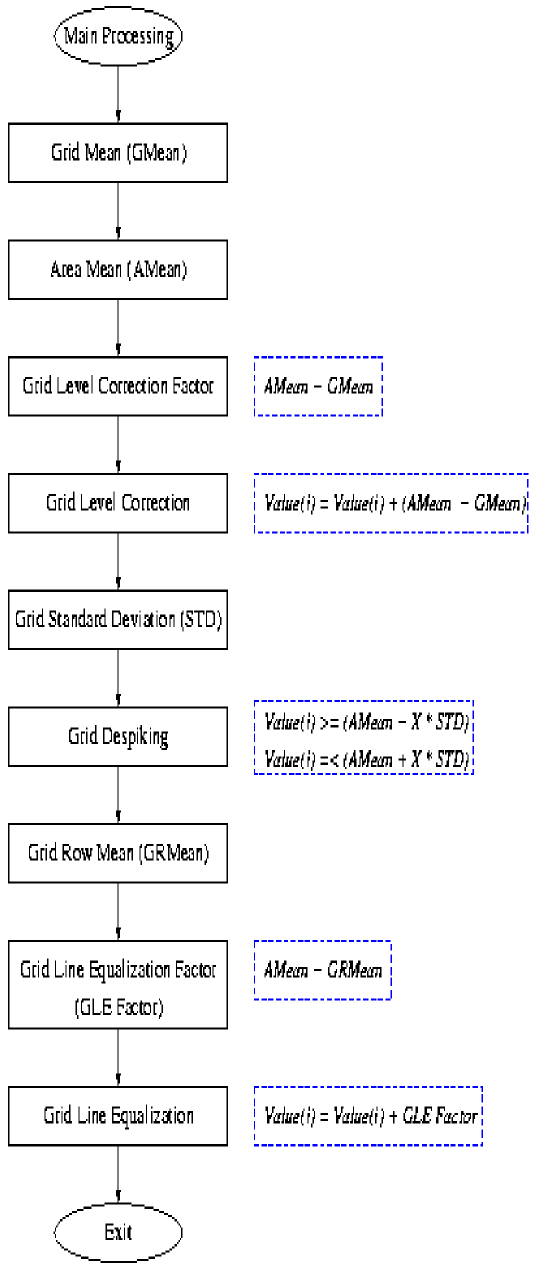

Figure 2. Procedure of the main processing option.

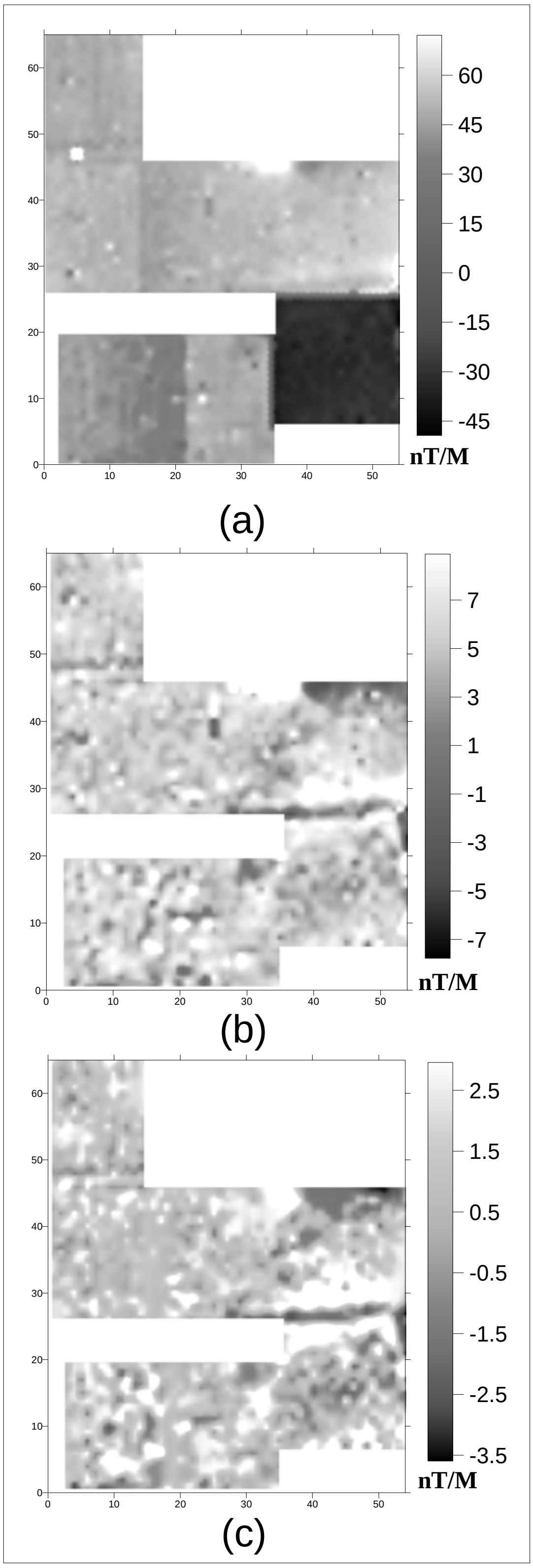

Figure 3: Raw magnetic data (Vertical magnetic gradient, nT/m) collected in the area of Istron, (b) Manually processed magnetic data by using Surfer tools, (b) Automatic processing of the magnetic data by using GPP package.

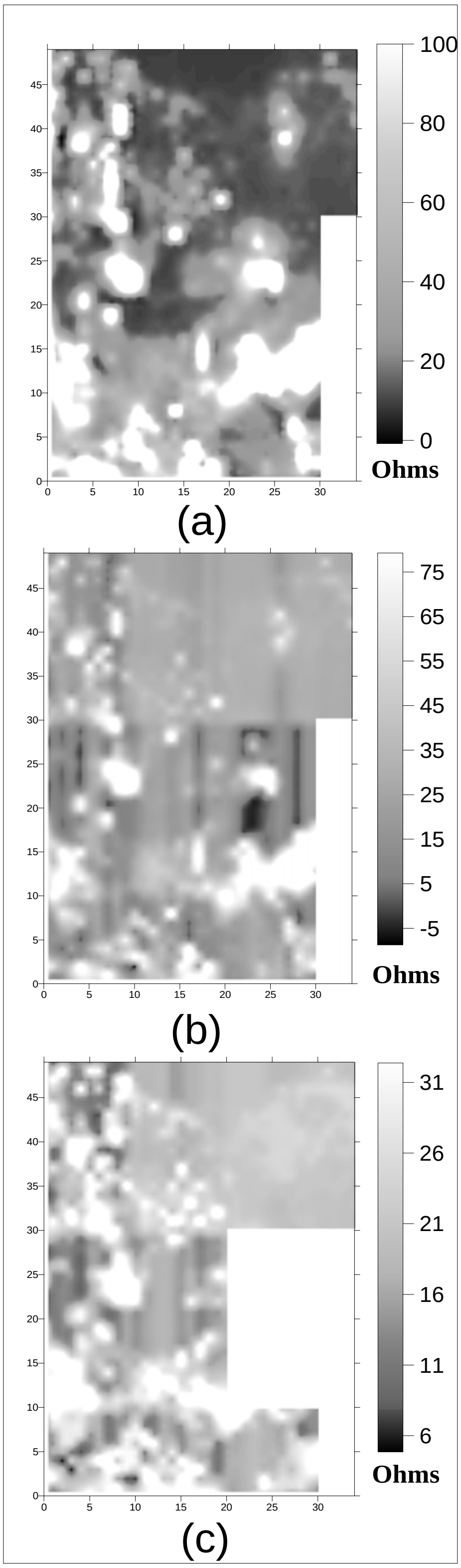

Figure 4: (a) Raw soil resistance data (Ohms) collected in the area of Istron, (b) Manually processed data by using Surfer tools, (b) Automatic processing of the magnetic data by using GPP package.

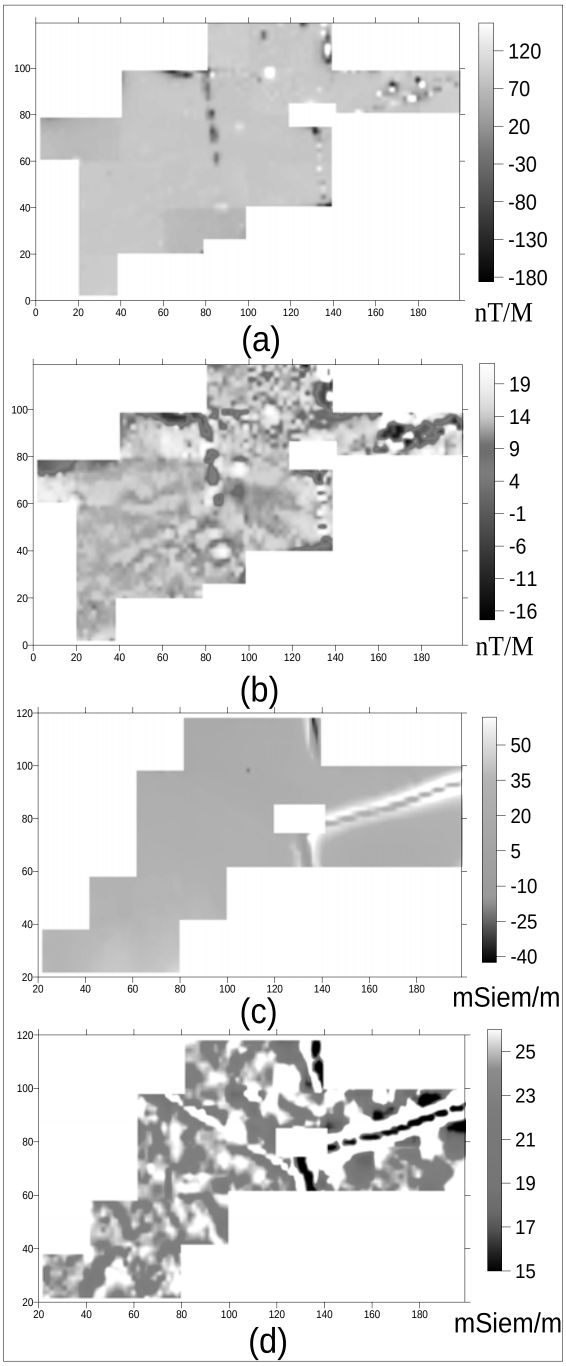

Figure 5: (a) Initial magnetic data (vertical magnetic gradient, nT/m) collected in the area of Dodoni in Epirus, (b) Automatic processing of the magnetic data by using GPP package, (c) Raw electromagnetic data (mSiemens/m) collected in the same area of interest, (d) Automatic processing of the electromagnetic data. by using GPP package.