

Free Software – An Inspiration for Virtual Academy

Ales CEPEK and Jan PYTEL, Czech Republic

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ABSTRACT

Most of the nowadays projects from the field of Virtual Academy are oriented more or less towards the mass education on the bachelor and master level. This paper tries to present a different complementary approach focused on individual education and collaboration of selected master and PhD students. The inspiration comes from the field of Free Software projects, the well established and successful phenomenon which could hardly exist without Internet, where groups of programmers scattered all around the world are developing software.

Free software project GNU GaMa for adjustment of geodetic networks, with input data described in XML, is given as an concrete example. Free Software (or Open Source) projects need not be necessarily limited only to software development but generally can cover any professional project based on free information exchange; a suggested example is a planned collection of model geodetic networks described in XML.

Probably it is due to our different background (our country is still in a specific transitional period) that we put more emphasis on our PhD students' programs and the idea of Virtual Academy is more attractive to as the field for building professional international contacts and collaboration. Our PhD students will be responsible for our future development — from them our academics are going to be recruited in the coming years.

CONTACT

Ales Cepek and Jan Pytel
Dept. of Mapping and Cartography, CTU Prague
Thakurova 7, 166 29 Prague
Prague
CZECH REPUBLIC
Tel. + 420 2 2435 4657
Fax + 420 2 2435 5419
E-mail: cepek@fsv.cvut.cz , pytel@gama.fsv.cvut.cz
Web site: <http://www.gnu.org/software/gama/>

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1. ANOTHER MOTIVATION

In our paper we would like to look at the subject of Virtual Academy from a rather different point of view than usual. If we consider discussions and projects presented at FIG workshop and seminar in Helsinki last year, we can say that Virtual Academy is mainly associated with exploitation of technical facilities or communication tools (provided by the Internet today) and most of the nowadays projects from the field of Virtual Academy are oriented more or less towards the mass education on the bachelor or master level.

Probably it is due to our different background (our country is still in a specific transitional period) that we put more emphasis on our PhD students' programs and the idea of Virtual Academy is more attractive to us as the field for building professional international contacts and collaboration. Our PhD students will be responsible for our future development — from them our academics are going to be recruited in the coming years.

Possibilities of avoiding time consuming and routine tasks like testing students' knowledge or easy and effective communication are undoubtedly attractive and must be extensively supported and developed in education. But whatever fascinating might be the present technologies, they are not yet matured compared with traditional educational tools and courses. Technically speaking we have systems and educational programs today that are capable of serving almost unlimited number of students. Does it mean the end of the most of traditional universities and are they going to be replaced by several *virtual universities* equipped with sufficiently powerful hardware and sophisticated educational programs? Surely it does not because distinction of a university reflects first of all quality of its people, importance of its equipments is always secondary.

We are convinced that when thinking about Virtual Academy, more emphasis must be put on human communication and collaboration than on technical facilities. In this sense the best inspiration for Virtual Academy are successful Free Software projects like GNU and many others.

2. ABOUT GNU GaMa

The project GaMa (the acronym comes from Geodesy and Mapping) is a free software written in C++, released under the terms of GNU General Public Licence, aimed at geodetic networks adjustment.

<http://www.gnu.org/software/gama/>

It was started by Ales Cepek in 1998 but soon first students joined the project. The original idea was to start a project to demonstrate to students the capability and power of object

programming and at the same time to present and conserve practical experience and knowledge gained in previous years in the Research institute for geodesy (VUGTK Zdiby).

The project GaMa was strongly influenced by work of Frantisek Charamza, namely his research in the field of application of Gram-Schmidt orthogonalisation as a general numerical adjustment method (algorithm GSO). Without going into details we can say that GSO is an orthogonalisation algorithm that solves the adjustment without normal equations directly from the project equations and thus avoids possible numerical problems in the case of ill-conditioned systems (condition number of normal equations matrix is the square of the condition number of the design matrix). In the project GaMa Singular Value Decomposition algorithm (SVD) is used for numerical solution of the adjustment but GSO is also available as an alternative. Thanks to its object-oriented design GaMa is prepared to easily adopt other numerical methods like Cholesky decomposition of normal equations or some numerical solutions exploiting the sparse structure of the design matrix (but in our plans these enhancements have lower priority).

Originally the project was not expected to be presented outside our faculty so it was all in Czech from C++ names to the documentation. This version of the program allowed only uncorrelated horizontal directions and distances in local triangulation network to be adjusted. The project was first introduced to wider public at FIG Working Week 2000, 21-26 May, Prague (Cepek and Hnojil). Because it was proposed by Professor Henrik Haggren (from HUT Finland) that project GaMa should be presented in the following year at Workshop and Seminar in Helsinki, we have started working on changes necessary for GaMa to be acceptable outside local community of Czech users. Two major changes had to be done

- redefinition of Czech tags in XML input data into their English equivalents and
- implementation of new observation data structures to enable general adjustment of correlated observations.

Namely the second point was luckily influenced by discussions with Henrik Haggren and his interest in possible future enhancements to enable adjustment of photogrammetric observations together with classical observation types. Implementation of data structures is the corner-stone of any software project. To implement a new observation type in our project, it is just needed to derive the new corresponding class and define a few virtual functions. The design of GaMa classes enables to implement adjustment of *any information* with given variance-covariance matrix that can be linearized in respect to coordinates and other unknown parameters.

In parallel with the above mentioned changes we worked on more enhancements and improvements necessary for making GaMa into GNU software. We succeeded to pass successfully GNU evaluation process and in last November GaMa was dubbed a GNU package.

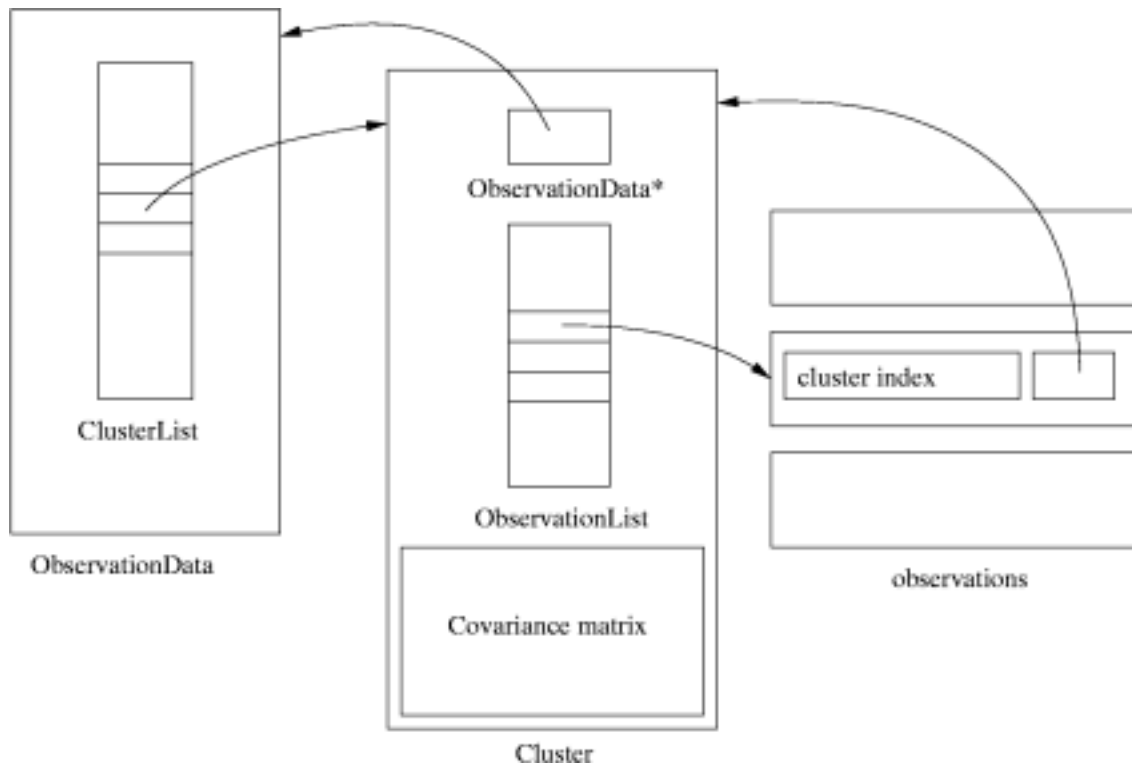


Figure 1: Basic observation data structures

Project GaMa comes with a concept of *cluster* to effectively handle possibly correlated observations of a general kind. In C++ terminology it is a container class that maintains a set of observations with common variance-covariance matrix (symmetric, band or diagonal) as depicted on fig. 1. Observations are independent on *point* data which are in the current version defined only for local geodetic network (adjustment on ellipsoid is one of our planned goals). Observation data structures have been designed to enable easy implementation of sparse matrix algorithms in the adjustment in future versions. Currently the following observation types are supported

- horizontal directions and distances,
- horizontal angles,
- slope distances and zenith angles,
- height differences,
- observed coordinates (used in *sequential adjustment* etc.) and
- observed coordinate differences (vectors).

To add a new observation type into the project it is necessary to define virtual functions for linearization and to derive appropriate class from **Cluster**. This way, for example, photogrammetric measurements could be incorporated and simultaneously adjusted together with classical surveying observables in a common three dimensional network.

2.1 XML INPUT DATA

The primary motivation for usage of Extensible Markup Language (XML) in project GaMa was to define structured input data for adjustment of local geodetic network. Extensible Markup Language <http://www.w3.org/TR/REC-xml>

describes a class of data objects called XML documents and is generally expected to be one of the most important communication standards in the near future. The data are described (similarly to HTML) with a set of XML user defined markup tags. What is probably the most important feature of XML is the fact that we can relatively easily define a grammar for our data (a class of XML documents) and thus we can validate them, even independently of our application. This grammar is known as a *document type definition*, or DTD.

Document type definition for GaMa XML input data format is <http://www.gnu.org/software/gama/gama-xml.dtd>

DTD is not the the only one possible schema for defining XML syntax and generally not even the best one but it is quite sufficient for relatively simple syntax of GaMa input, as shown in the following short (but complete) example.

```
<?xml version="1.0" ?>
<!DOCTYPE gama-xml SYSTEM "gama-xml.dtd">
<gama-xml version="2.0">
<network>
<points-observations>
<point id= "1" y="644498.590" x="1054980.484" fix="xy" />
<point id= "2" y="643654.101" x="1054933.801" adj="XY" />
<point id="407" y="644025.978" x="1054821.167" adj="xy" />

<obs from="1">
  <direction to="2" val="0.0000" stdev="10.0" />
  <direction to="407" val="382.8182" stdev="10.0" />
  <distance to="2" val="845.777" stdev="5.0" />
  <distance to="407" val="498.750" stdev="5.0" />
</obs>

<obs from="2">
  <direction to="1" val="0.0000" stdev="10.0" />
  <direction to="407" val="22.2376" stdev="10.0" />
  <distance to="407" val="388.562" stdev="5.0" />
</obs>

<obs from="407">
  <direction to="1" val="0.0000" stdev="10.0" />
  <direction to="2" val="239.4204" stdev="10.0" />
</obs>
</points-observations>
</network>
</gama-xml>
```

Most of the this example can surely be understood intuitively without bothering about the syntax but formal parsing XML is not a trivial task. Without going into technical details let us just note that GaMa is using expat parser version 1.1 written by James Clark

2.2 Rosinante

XML is replacement for ASCII data files and can be viewed or edited with a text editor or simply printed. There are many tools available for XML processing like viewing or transforming it into HTML or even editing but a typical user would never edit XML input manually as a raw text file.

Project GaMa was started at the beginning with main focus on development of a platform independent C++ library (GaMaLib) with only a simple command line tool (program gama) for processing XML input data. Our primary platform is GNU/Linux and to help our users to use GaMa adjustment we have been running a mail-server and a web interface (WebGaMa) based on PHP scripting language.

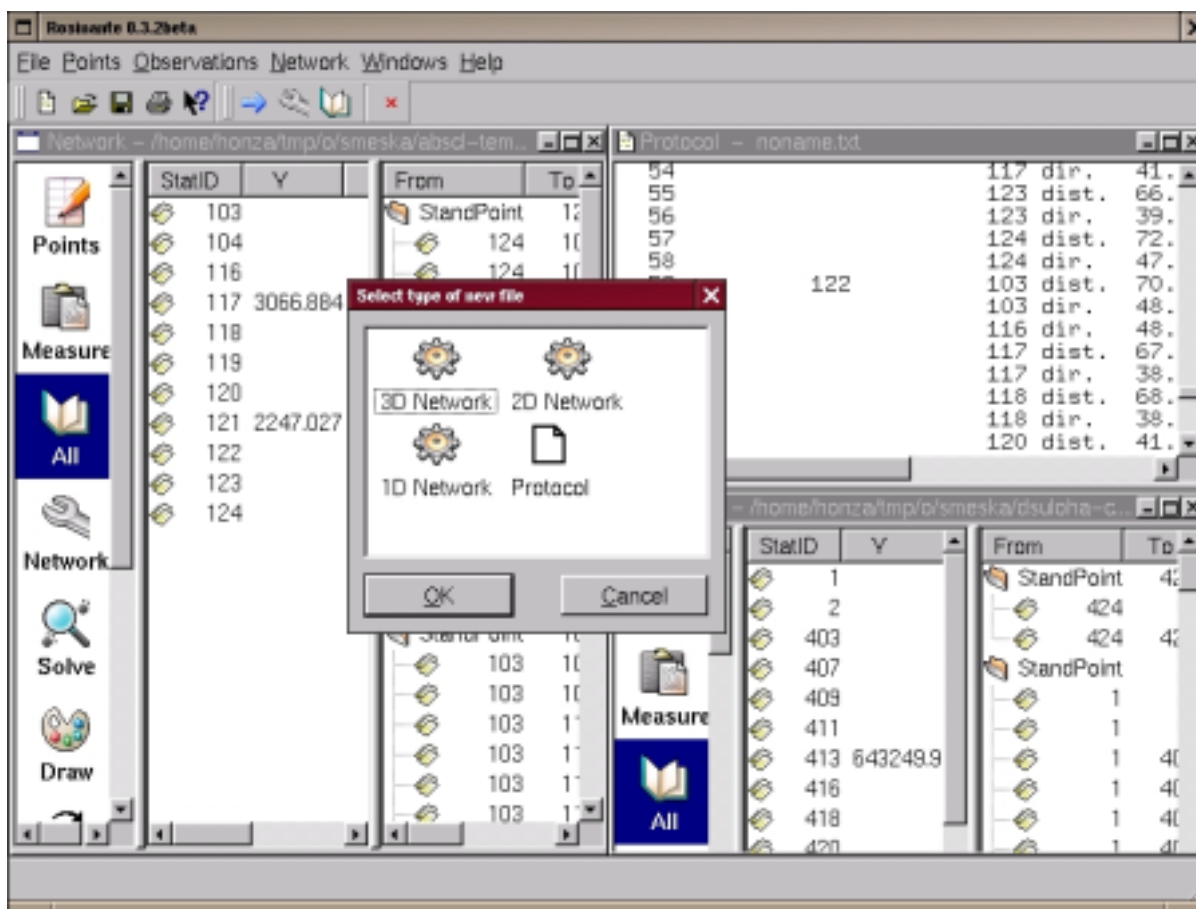


Figure 2: Rosinante the Qt based GUI for GNU GaMa

We were considering a possibility of presenting our adjustment as a web-based application implemented with C++ CGI scripts but this way proved to be impractical and for various reasons we did not want use Java language. As majority of our potential users comes from Microsoft Windows platform we came with a windows application (GaMaWed) built with Borland C++ Builder. Actually, we wanted to be prepared in advance for the case when Inprise/Borland would port their C++ Builder to Linux; but until now only Kylix is available. Anyway, none of these was a satisfying solution.

It was in the midst of the last year when Jan Pytel (a student from our faculty) definitely decided to write a graphical user interface (GUI) for GaMa based on Qt graphical library <http://www.troltech.no/>

First beta versions of his program Rosinante were available on November, it has become a part of GaMa project and you can see an example screen-shot at fig. 2.

What should be stressed is that Rosinante is platform independent GUI; the Qt library has been ported to Linux, MS Windows and MacOS. C++ Qt library is one of the best graphical libraries available, for example it used in Borland Kylix or Linux KDE, and for Linux it is available free. Talking about Virtual University, we present here Rosinante as a model example how students could be involved and actively contribute to the project.

3. TO DO

To conclude our paper we briefly summarise what is still missing in the project GaMa and has to be done and what are our plans for its future development.

- Our project is prepared for producing outputs in any language which can be expressed in the UTF-8 encoding (Unicode). Technically it is done by separating all texts into XML files, with possibly different input encodings, from which the corresponding C++ functions for dynamic language switching and UTF-8 strings are generated. This, we believe, is a possible ground for a students' international project (one doesn't have to be programmer to participate).
- Naturally, adjustment results should also be available in XML format as well as the input data are, this is one of our plans. This point was deliberately postponed because we have not decided yet whether to define an *ad hoc* GaMa XML adjustment output format or to use a more general scheme inspired by the Borland XML general data packets.
- Another goal of our project is to gather a collection of model geodetic networks and to present them with their adjustment results on the web — XML is the best tool for such a purpose. A lack of a collection of reliable model data that could be used for debugging and testing (namely in the case of 3D networks) was one of the troubles we had to cope with. Typically examples given in textbooks on geodetic adjustment and least squares are trivial and useful only as a demonstrations and can not be used in software development.

- This year we plan to add to Rosinante a *plug-in* for graphical output described in Scalable Vector Graphics (SVG); a general graphical format based on XML.
- Closely related to GaMa is our another project aimed at processing of levelling observations, namely the project of general XML format for describing levelling data from various recording units.
- A major enhancement planned for GaMa is implementation of adjustment in a global coordinate system together with classes for handling cartographic projections (that could be added as plug-ins)

Project GaMa is a GNU software, anybody can use it without paying a fee, all source codes are available under GPL licence and the more, it is platform independent and currently runs on GNU/Linux as well as on Microsoft Windows (we hope to get a volunteer to port it to MacOS operating system).

Starting this year we have included GNU GaMa/Rosinante into one of our undergraduate courses in which our students are introduced into basic geodetic software used at our faculty. At the current stage Rosinante is ready to be used in areas from basic surveying computations (intersections, traverses, etc) to the adjustment of special measurements of 3D networks in engineering geodesy.

REFERENCES

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BIOGRAPHICAL NOTES

Ales Cepek is Assoc. Professor at the Dept. of Mapping and Cartography, CTU Prague, Jan Pytel is his student. For more information see their CVs at <http://gama.fsv.cvut.cz/~cepek/cv/> and <http://gama.fsv.cvut.cz/~pytel/cv/>.