A new software for gravity gradiometry data forwarding and inversion

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Abstract. A new software has been developed specially for gravity gradiometry data forwarding and joint inversion. It is developed with hybrid programming technique and some powerful function libraries, including language of Python and C, Matplotlib, PyQt and so on. The software could help the users with graphical user interface, implement the data import/export and some management, the simple visualization in 2/3 dimension, modeling for gravity exploration data, and 3D density inversion. One of the advantages of this software is combining the popular development techniques to make the research of the forwarding and inversion easily, another one is simple secondary development, which allows the users to add their algorithms to the platform. The software is mainly used for the teaching and scientific research purposes, suitable for the geophysical scientists, engineers and graduate student.

1. Introduction
Gravity gradiometry data is an important kind of geophysical exploration data with high signal-noise ratio. The forwarding and inversion with gravity gradiometry data is always the research hot spot [2-5,7,8]. The work could help us in the resource investigation, mining and other fields. At present, the number of commercial software used for the forwarding and inversion with gravity gradiometry data is not many, the price of which is always expensive. On the other hand, many computer techniques have been used for the software development. For example, a software based on MATLAB [1] was developed and it includes data processing and mapping function, which is proved to be practical in the applications.

To achieve a more convenient way for the forwarding and inversion research, we develop a software named Gravity gradiometry data Forwarding and Inversion Software (GFI-Soft). GFI-Soft offers the data management, visualization and forwarding & inversion with graphical user interface (GUI). It also supports simple secondary development, so that the users could concentrate more on the algorithm itself instead of developing the software.

2. Software overview
GFI-Soft is developed with tool of Eric 6.0, and language of Python 3.6.0 and C. The libraries of Matplotlib 3.0.3 and PyQt 5.10.1 are used to implement the platform functionalities, such as data import and management, 2D/3D visualization and so on; the inversion module is implemented by dynamic link library (DLL) written in C. GFI-Soft could run on Windows 10, but it has not been tested on the other system, such as Windows XP, or 7; though it could not run on Linux now because of the adopted file form of “.dll”, GFI could be modified to do that.

After launching, the main window would be displayed (Figure 1). The data in the form of “.txt” and “.xls” could be imported into GFI-Soft with the wizards (Figure 2). In the wizards, the data could be
previewed; the data would be displayed in a table divided by the lines, any of data is allowed to be modified even deleted. All the data in GFI-Soft could be saved in the form of “.txt”. The data in the tables could be visualized in GFI-Soft (Figure 3): the users can choose any of the gradiometry tensors in each line to plot; the grid display could be implemented with functions in Matplotlib; the figures can be also saved, for example, 3D grid data in Figure 3 is an exported one. In the modeling module, we adopt the equations presented by Li and Chouteau [5] for the forwarding. The gravity anomaly can be also calculated by GFI-Soft. It is assumed that the models are consisted of a series of small prisms. The model could be constructed with GUI and displayed in 3D view (Figure 4). Similarly, the inversion in the software is also based on the prism-combination, it is assumed that the underground space is divided into a series of prisms. There are two inversion algorithms in GFI-Soft, including reweighted focusing inversion (RFI) [3] and inversion of probability tomography (IPT) [4]. The inversion parameters are imported with GUI, the inversion could be plotted also by GUI (Figure 5).

Figure 1. The main window of GFI-Software
Figure 2. Data import wizards and data divided by lines are displayed in the table.
Figure 3. GUI of plotting for 2D profile data, 2D grid data and exported 3D grid data

Figure 4. Forwarding wizards and 3D display of the model
As for the secondary development method, we take the idea of “Menu+Signal-Slot+Function”. The code of menu GUI is written with PyQt, the widget could edited by the inheritance feature; signal-slot is one of the important mechanisms in software development, combing GUI with the functionalities of geophysical algorithms, you can find more in the page 127-136 of the reference [6]; the interface of the algorithm functions could be written in Python or called in the way of DLL, it is suggested to compile the old codes to DLL and link them because that makes the exist codes added conveniently.

3. Application and test
GFI-Soft is applied for the synthetic data to test its practicability (Figure 6). Two same prisms are located in the inversion field. The results of RFI and IPT are named “InversionResult-1” and “InversionResult-2”, respectively. Besides 3D view, the results can be plotted in the profiles of three directions. Two profiles are chosen to display the results of IPT. Some related parameters can be found in Figure 5. From the results, it is seen that RFI results are more concentrated than that of IPT, the desired display effect is obtained.
4. Conclusions

GFI-Soft is a kind of software with GUI which could help geophysical researchers with forwarding and inversion implementation. Its practicability is proved in the application and test. In the next work, GFI-Soft would be improved by more advanced technique and richer functionality, even applied to all kinds of potential field data, it would be found on the Internet in the near future. We believe that GFI-Soft could be a popular tool for the potential exploration.

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