

GeneAnswers, Integrated Interpretation of Genes

Gang Feng^{‡*}, Pan Du^{††}, Warren A. Kibbe^{‡‡}, Simon Lin^{‡§}

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[‡]Northwestern University Biomedical Informatics Center
Northwestern University, Chicago, IL, 60611, USA

1 Overview of GeneAnswers

Microarray techniques have been widely employed in genomic scale studies for more than one decade. The standard analysis of microarray data is to filter out a group of genes from thousands of probes by certain statistical criteria. These genes are usually called significantly differentially expressed genes. Recently, next generation sequencing (NGS) is gradually adopted to explore gene transcription, methylation, etc. Also a gene list can be obtained by NGS preliminary data analysis. However, this type of information is not enough to understand the potential linkage between identified genes and interested functions. The integrated functional and pathway analysis with gene expression data would be very helpful for researchers to interpret the relationship between the identified genes and proposed biological or medical functions and pathways.

The *GeneAnswers* package provides an integrated solution for a group of genes and specified categories (biological or medical functions, such as Gene Ontology, Disease Ontology, KEGG, etc) to reveal the potential relationship between them by means of statistical methods, and make user-friendly network visualization to interpret the results. Besides the package has a function to combine gene expression profile and category analysis together by outputting concept-gene cross tables, keywords query on NCBI Entrez Gene and application of human based Disease ontology analysis of given genes from other species can help people to understand or discover potential connection between genes and functions.

2 Citation

For the people using *GeneAnswers* package, please cite the following papers in your publications.

* For DOLite:

*g-feng (at) northwestern.edu

†dupan (at) northwestern.edu

‡wakibbe (at) northwestern.edu

§s-lin2 (at) northwestern.edu

Du, P., Feng, G., Flatow, J., Song, J., Holko, M., Kibbe, W.A. and Lin, S.M., (2009) 'From disease ontology to disease-ontology lite: statistical methods to adapt a general-purpose ontology for the test of gene-ontology associations', *Bioinformatics* 25(12):i63-8

* For GeneAnswers:

Feng, G., Du, P., Krett, N.L., Tessel, M., Rosen, S., Kibbe, W.A., and Lin, S.M., (submitted) 'Bioconductor Methods to Visualize Gene-list Annotations',
Thanks for your help!

3 Installation of GeneAnswers package

In order to install the *GeneAnswers* package, the user needs to first install R, some related Bioconductor packages. You can easily install them by the following codes.

```
if (!requireNamespace("BiocManager", quietly=TRUE))
  install.packages("BiocManager")
BiocManager::install("GeneAnswers")
```

For the users want to install the latest developing version of *GeneAnswers*, which can be downloaded from the developing section of Bioconductor website. Some additional packages might be required to be installed because of the update the Bioconductor. These packages can also be found from the developing section of Bioconductor website. You can also directly install the source packages from the Bioconductor website by specify the developing version number, which can be found at the Bioconductor website. Suppose the developing version is 2.5, to install the latest *GeneAnswers* package in the Bioconductor developing version, you can use the following command:

```
install.packages("GeneAnswers", repos="http://www.bioconductor.org/packages/2.5/bioc", type=
```

4 Object models of major classes

The *GeneAnswers* package has one major class: **GeneAnswers**. It includes the following slots:

1. *geneInput*: a data frame containing gene Entrez IDs with or without any related values. The values could be foldChange, p value, or other values. These data can be used for concept-gene network. Genes with positive values will be represented as red nodes, while negative value genes are green nodes.
2. *testType*: statistical test method. Current version supports hypergeometric test to test relationship between genes and specified categories.
3. *pvalueT*: the cutoff of statistical test. Any categories will not be reported if the p value is more than the cutoff.
4. *genesInCategory*: a list containing genes belonging to categories. The names of the list are categories.
5. *geneExpProfile*: a data frame to store gene expression data. If not available, it could be NULL.
6. *annLib*: annotation database used for statistical test.
7. *categoryType*: functional or medical category used for statistical test.

8. *enrichmentInfo*: a data frame containing filtered categories with statistical results by specified pvalueT.

The figure, 'Flow chart of GeneAnswers', shows how *GeneAnswers* package works. A group of genes are essential. We use unique Entrez gene IDs to represent genes. Any relative feature values of these genes can also be optional input information, like fold changes, p values, etc. If the gene expression profile of these genes are available, it can be considered as input, too. Since we want to find the potential connections between genes and categories, category type is also need to be specified. *GeneAnswers* currently supports Gene Ontology (GO), Pathway (KEGG) and developing Disease Ontology (DOLite) in our team. Furthermore, *GeneAnswers* supports Entrez eUtils so that users can make customized annotation library based on interested keywords. If users have own annotation library, *GeneAnswers* can use it to build relationship between it and given genes.

Besides usual barplot and pie chart of top categories, *GeneAnswers* also provides four types of visualization. One is concepts-genes network, which show the concepts and genes on a network layout. The second one is concepts-genes cross table that integrated gene expression profile and corresponding categories together. The third one is a concepts-network shows connections between categories only. The last one is a table, which contains all of information of categories and genes. Combining all of these presentations can be helpful to find and explain the possible linkages between genes and categories.