

USER GUIDE

CelloMap

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1 Introduction

The non-canonical analysis tool (CelloMap) is a tool with several uses. It's main feature is a non-canonical gene analysis. Yet this tool also boasts several other interesting functionalities such as differential expression analyses, customizable MA and Volcano plots which in turn allow to obtain significant gene sets according to a users custom parameters. Additionally, this tool is also capable of converting gene symbols to KEGG identifier (type hsa), see section 5 for more information. This guide will go over each functionality and explain how to best use CelloApp.

As can be seen in Figure 1, the application is split into several tabs. The information tab shows the user guide pdf file. The last tab 'Citation' is a simple tab which gives the citation information for the use of this tool. This guide will now go over the remaining tabs and explain their uses and how to use their functionalities them.

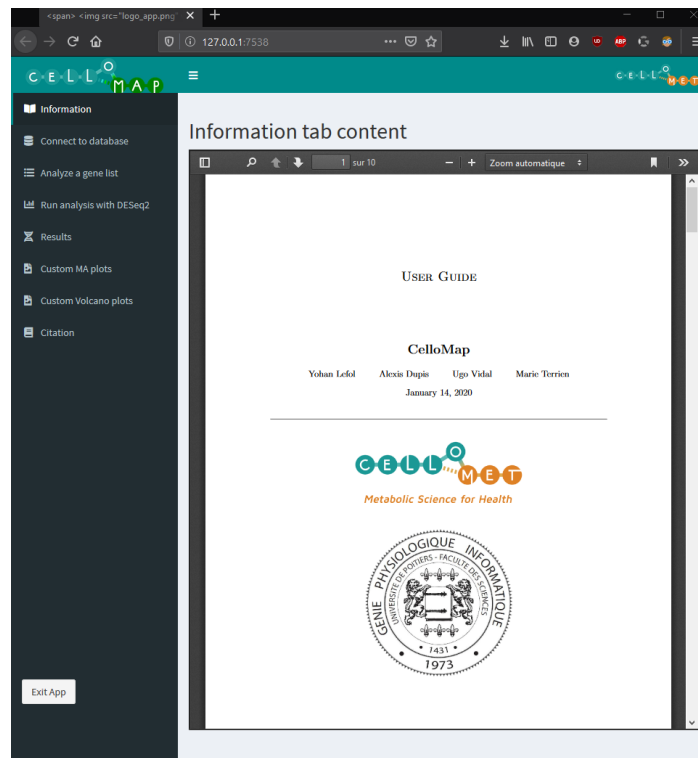


Figure 1: The main tab for the application.

2 Installation

HOW DOES THE INSTALLATION WORK.

3 Connection to database

The identification of non-canonical genes is the main aspect of this tool. Since the list of non-canonical genes is increasing as discoveries are being made, we could not 'hard code' a list of genes in the program as we wanted to ensure that the search list is being updated without having users re-download the application for each update. Therefore we implemented a database that can be updated by the owners of the tool (Cellomet) and that can be accessed remotely through this application. In order to establish this connection, a user needs to fill in the small questionnaire as seen in Figure 2, and click the 'Connect to database' button.

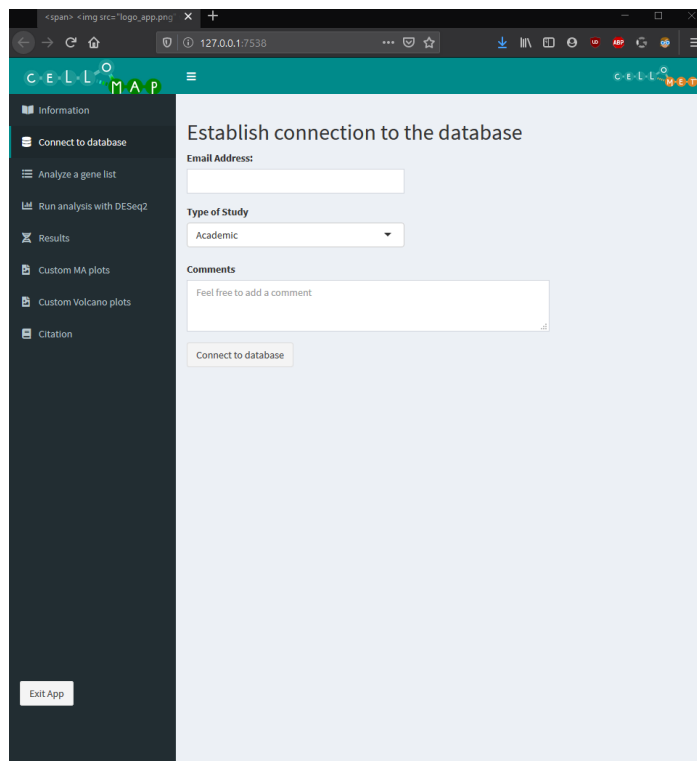
The image shows a web browser window displaying the 'Connect to database' tab of the Cellomet application. The browser's address bar shows the URL '127.0.0.1:7538'. The application's header is teal with the 'C-E-L-M-A-P' logo and a hamburger menu icon. A dark sidebar on the left contains a list of navigation options: 'Information', 'Connect to database' (which is highlighted), 'Analyze a gene list', 'Run analysis with DESeq2', 'Results', 'Custom MA plots', 'Custom Volcano plots', and 'Citation'. At the bottom of the sidebar is an 'Exit App' button. The main content area is light blue and titled 'Establish connection to the database'. It contains a form with three fields: 'Email Address' (a text input), 'Type of Study' (a dropdown menu currently showing 'Academic'), and 'Comments' (a text area with the placeholder text 'Feel free to add a comment'). Below these fields is a 'Connect to database' button.

Figure 2: The connect to database tab of the application.

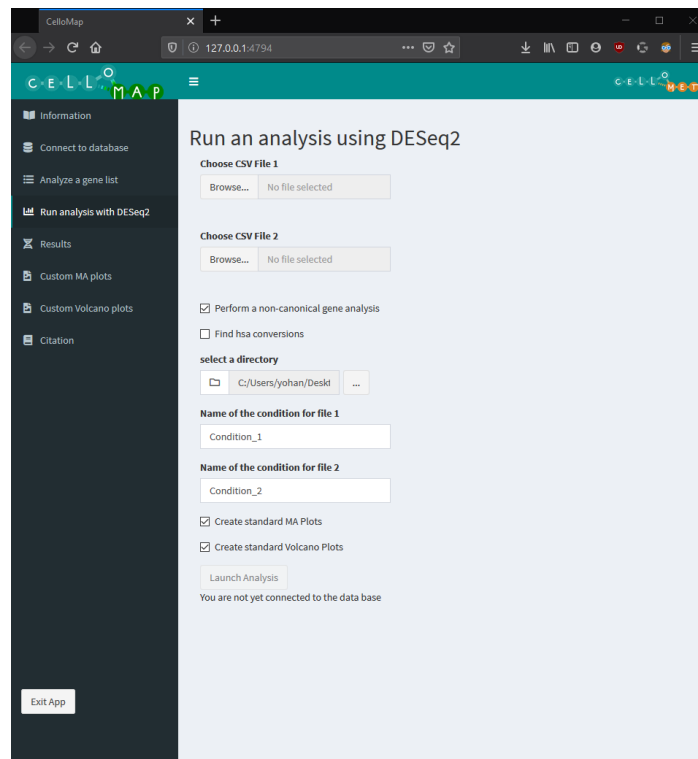
The database connection is only necessary if a non-canonical gene analysis or hsa conversion is to be performed, either individually or as part of a DESeq2 analysis. If this is not the users intentions, he does not need to establish a connection to the database.

4 DESeq2 analysis

DESeq2 is a powerfull tool which allows users to perform differential analyses using RNAseq 'COUNTS' data (Love, Huber, & Anders, 2014). However this tool requires a very specific data format. This part of the guide will go over the data format necessary to run a DESeq2 analysis, the added parameters specific to this application, and the results that are generated.

4.1 Tab layout

As seen in Figure 3, there are several requirements for the the DESeq2 analysis. First we observe that two csv files are needed, these will be the two files representing the two conditions that will be analyzed. We then observe a small check box which asks if the user want to perform a non-canonical gene analysis. Checking this box also enables the possibility of checking the hsa conversion box. If the non-canonical analysis box remains checked, the user will have to be connected to the database and the non-canonical gene analysis will be run with the list of significant genes isolated by the DESeq2 analysis (explained below). A user can also select a directory, this will be the folder in which the several DESeq2 results will be saved. There are then two text boxes which can be customized to be whatever text a user wishes, the content of these text boxes is used to name the files that will be produced by the analysis. Condition 1 represents File 1 and Condition 2 represents File 2. Lastly there are two check boxes that check if the user would like to create the standard MA and Volcano plots. If checked, two types of each plot will be made, one type with text, and the other without text. The plots generated will be with standard values, however a user will be able to take the differential expression data obtained from the DESeq2 analysis and make his own customized MA and Volcano plots with the custom plot tabs, see section 7 for more details.



The screenshot shows the CelloMap web application interface. The browser address bar displays '127.0.0.1:4794'. The application has a teal header with the 'CelloMap' logo and navigation icons. A dark sidebar on the left contains a menu with options: Information, Connect to database, Analyze a gene list, Run analysis with DESeq2 (highlighted), Results, Custom MA plots, Custom Volcano plots, and Citation. The main content area is titled 'Run an analysis using DESeq2' and includes the following elements:

- Two file selection sections: 'Choose CSV File 1' and 'Choose CSV File 2', each with a 'Browse...' button and a 'No file selected' status.
- A checked checkbox for 'Perform a non-canonical gene analysis'.
- An unchecked checkbox for 'Find hsa conversions'.
- A 'select a directory' section with a file explorer icon and a text input showing 'C:/Users/yohan/Desktop'.
- Two text input fields for 'Name of the condition for file 1' (containing 'Condition_1') and 'Name of the condition for file 2' (containing 'Condition_2').
- Two checked checkboxes for 'Create standard MA Plots' and 'Create standard Volcano Plots'.
- A 'Launch Analysis' button.
- A status message at the bottom: 'You are not yet connected to the data base'.

An 'Exit App' button is located at the bottom of the sidebar.

Figure 3: The main screen for the DESeq2 analysis tab.

4.2 Data format

As previously stated, DESeq2 requires a rather specific data format. We will be using Figure 4 to explain the format. This format is presented as a CSV file, meaning a comma separated vector, or more simply put, a file in which the different elements/values are separated by a comma. In order to better explain the data format and what a csv file really is, an excel representation of Figure 4 has been created and is shown in Figure 5

```
Genes,01daeea0-2a6d-450e-b541-5e403e998637,05a38163-a505-4f97-b2a3-7430c49b14f4,
TSPAN6,4280,5096,1949,2711,1669,3992,5499,5770,794,4039,4943,4236,20
TNMD,4,8,2,3,2,7,14,5,2,26,17,58,4,8,3,1933,2,27,31,2,10,1
DPM1,1293,1019,440,1088,844,1271,1137,1546,440,1549,1319,1374,753,1
SCYL3,728,563,127,458,650,542,651,742,161,596,811,453,547,551,519
C1orf112,565,342,123,223,480,517,500,745,151,478,477,184,270,378,3
```

Figure 4: The data format for a DESeq2 analysis.

When comparing both Figure 4 and Figure 5 we can clearly observe that the commas create the 'separation' of the values. The first column represents the genes, it is important to note that these genes are in gene symbols and not another type of format such as Ensembl. DESeq2 will perform the analysis regardless of the type of gene name used however **a non-canonical gene analysis can only be performed with gene symbols**. As such it is advised to use gene symbols in the data in order to fully benefit from this tool. Next we have the other columns which represents the different sequencings. In this example, the second column shows the RNAseq 'COUNTS' results of patient #1 and the third column shows the same but for patient #2.

	A	B	C
1	Genes	01daeea0-2a6d-450e-b541-5e403e998637	05a38163-a505-4f97-b2a3-7430c49b14f4
2	TSPAN6	4280	5096
3	TNMD	4	8
4	DPM1	1293	1019
5	SCYL3	728	563
6	C1orf112	565	342

Figure 5: A simplified view of the DESeq2 data format.

That's it, that is the data format required. As previously mentioned, two files are necessary, i.e: one file per condition. An easy example to explain this would be the comparative study of young vs old pulmonary cancer patients. In order to do such an analysis, we would have file #1 contain all of the patients in the 'young' category and file #2 would contain all the patients of the 'old' category. Of course both files must respect the data format. This means that both files will require the 'Genes' column and both must be in the same order of gene apparition.

4.3 launching the analysis

Once all necessary files have been uploaded, a user can click the 'launch analysis' button, at which point a pop-up will appear indicating the the analysis is being performed. This pop-up will lock the application preventing any further use, this is done to avoid the application from crashing if too many actions are performed at once. It is important to note that a DESeq2 analysis can be very quick just as it may take several hours. The length of the analysis depends on the size of the files used as well as the computing strength of the users computer. If a user is using a old computer, it may be advised to let the computer run the analysis without doing anything else on the side.

If an error occurs during the analysis, another pop-up will appear stating that there was an error and that the user can read about the error in the error_log.txt that was created. Using the information from the error log, the user should consult section 8 in order to solve the issue.

Once the analysis is done and if no error has occurred, the pop-up message will be replaced by a different pop-up message indicating that the analysis is done, the pop-up message will also remind the user of the location of the results.

4.4 Results obtained

Several results can be obtained from this analysis, some are obtained regardless of user input, others will only appear if a user has asked for those results to be produced.

4.4.1 Main results

A DESeq2 analysis generates three standard results:

- `diffexpr_results condition_1 vs condition_1 .csv`
A differential expression file
- `condition_1vscondition_1_RESULTS_VOLCANO.csv`
A differential expression file for the significant genes
- `gene_list_ condition_1 vs condition_1 _Most_Significant.txt`
A list of the significant genes obtained

It is important to note that the significant genes were obtained by filtering the main differential expression file for standard significance parameters while using a volcano plot to visualize the significant genes. The standard significance algorithm is the following:

$$padj < 0.05 \ \& \ abs(log2FoldChange) > 2$$

This equation indicates that genes which have a Padj value below 0.05 and a log2FoldChange above 2 or below -2 are considered to be significant. A user can also generate his own list of significant genes by modifying these parameters in the custom volcano plot tab. This is further explained in section 7 of this guide.

4.4.2 Figures generated

If a user has selected that he wanted standard MA and Volcano plots, there will be four png files in the results folder: Two MA plots, one with text and the other without text, the same applies for the volcano plot. The plots with texts are much larger in order to accommodate for the additional text next to the points representing significant genes. If a user wishes to modify these plots and create his own set, it can be easily be done in the custom plot tabs, further explained in section 7 of this guide.

4.4.3 Non-canonical gene analysis

If a user had selected that he wanted a non-canonical gene analysis to be performed, there will be three extra text files in the results folder. That is, if any non-canonical genes were found within the significant genes list. More information can be obtained in section 5 of this guide.

5 Gene list analysis

This tab allows users to perform a non-canonical gene analysis and a gene symbol to hsa identifier conversion with a simple gene list file. The hsa file enables the possibility of using the KEGG Mapper tool, we also describe the use of the MERAV tool in this section.

The only obligation that this file must respect is that the genes must be in a column with a column header named 'Genes'. If the file entered is correct, a table will appear showing that specific column as seen in Figure 6. If this does not occur, a text will appear, stating that a different file should be chosen.

Considering that the requirement for this analysis is a single column carrying the name of 'Genes', possible files can be the significant gene list obtained from the DESeq2 analysis, or the significant differential expression results obtained from either the DESeq2 analysis or the downloading of the data from custom plots in section 7. A user could also create his own gene list file.

5.1 KEGG Mapper

By checking the 'Find hsa conversions' checkbox in the CelloMap tool, a conversion script will automatically be run along with a non-canonical gene analysis. This conversion will allow users to run a KEGG mapping analysis using the file generated from the conversion. KEGG Mapper is a mapping tool that will search and find any pathways associated to a list of identifiers provided (Kanehisa & Sato, 2019). It will then allow the user to view every pathway found while highlighting the gene that was in the original list. To perform the analysis, follow these steps, also seen in Figure 7. IT is worth mentioning that the speed at which the conversion occurs depends on internet stability and speed as well as the amount of genes that need to be converted. It is recommended to have a stable internet connection to perform the hsa conversion.

1. Go to the website: https://www.kegg.jp/kegg/tool/map_pathway2.html
2. Make sure that the search mode is **Organism-specific** with the letter **hsa** in the text box

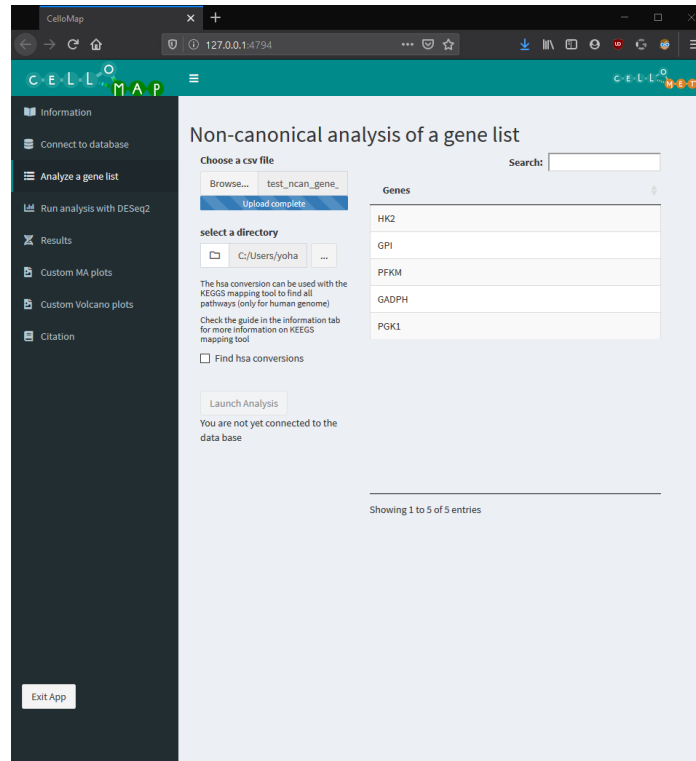


Figure 6: The gene list analysis tab once a correct file has been uploaded.

3. Upload the file created by CelloMap, the file will be called **hsa_ID.txt**
4. Launch the analysis and wait a few seconds/minutes

5.2 Metabolic GENe RAPid Visualizer (MERAV)

An alternative to the KEGG Mapper is Metabolic GENe RAPid Visualizer (MERAV), this tool was designed to analyze **human** gene expression across a large variety of arrays. All of the arrays were normalized together to generate a gene expression database composed of several types of human tissue (Shaul et al., 2015). This tool offers two types of searches:

1. Search expression levels in one or several genes
This search will provide the user with the ability to search the database for the expression of a given gene(s).
2. Search all genes expression levels in one or more cell types
This search will provide the user with the ability to search the database for the expression of a given array.

CelloMap creates a significant gene file that can be used with the first type of search, the one relating to finding gene expressions. To perform the search, follow these steps, also seen in Figure 8.

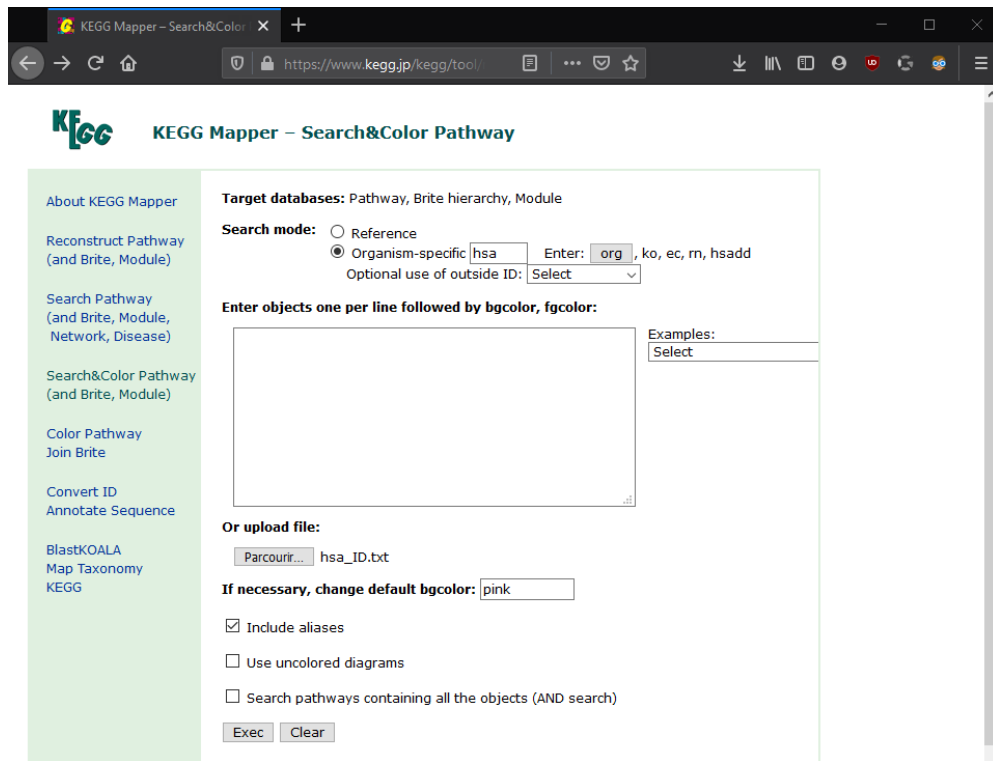


Figure 7: The set-up for the KEGG Mapper tool

1. Go to the website: <http://merav.wi.mit.edu/>
2. Once on the website, click the 'Search expression levels...' link.
3. Load the gene search box
To do this, copy paste all the genes from the significant gene file generated from DESeq2 or the one inputted in the gene list analysis. The main thing to watch out for is to not include the column name 'Genes'. If it is included, it's not a problem, it will simply be considered a gene symbol and will not be found by the search, this will not prevent the tool from searching for the other genes.
4. Set the parameters to your liking
5. If help is required, follow this link: <http://merav.wi.mit.edu/help/help.html>

5.3 Non-canonical gene analysis

The non-canonical analysis will cross check the provided gene list with our database, and depending on if it finds non-canonical genes within the gene list, three text files will be created.

1. `canonic_results.txt`
This file will contain the non-canonical gene symbols and names along with their **canonical** function and location.

Figure 8: The set-up for the MERAV search tool

2. non_canonical_results.txt

This file will contain the non-canonical gene symbols and names along with their **non-canonical** function and location.

3. references.txt

This file will contain the gene symbol and name of non-canonical genes and the references that were used to determine their canonical and non-canonical functions within this database.

Each text file was created with the intention to be read by Microsoft excel. The text files need to be opened in excel and the separator/delimiter must be declared as ‘Tab’. Once opened, it is recommended to use the ‘wrap text’ and ‘AutoFit Row Height’ in the alignment and cell format sections of excel. This will ensure that the table is legible.

6 Results

The results tab, seen in Figure 9, shows the results of a non-canonical gene analysis within the application itself. There isn’t much to be said about this tab, it is only for visualization. Every registered non-canonical genes are registered in a database hosted on Cellomet.com which can be accessed, updated and generally modified by the owner of Cellomet. For any questions regarding the non-canonical genes, their function, localization etc. Please contact Cellomet via their website (Rodrigue Rossignol, 2020).

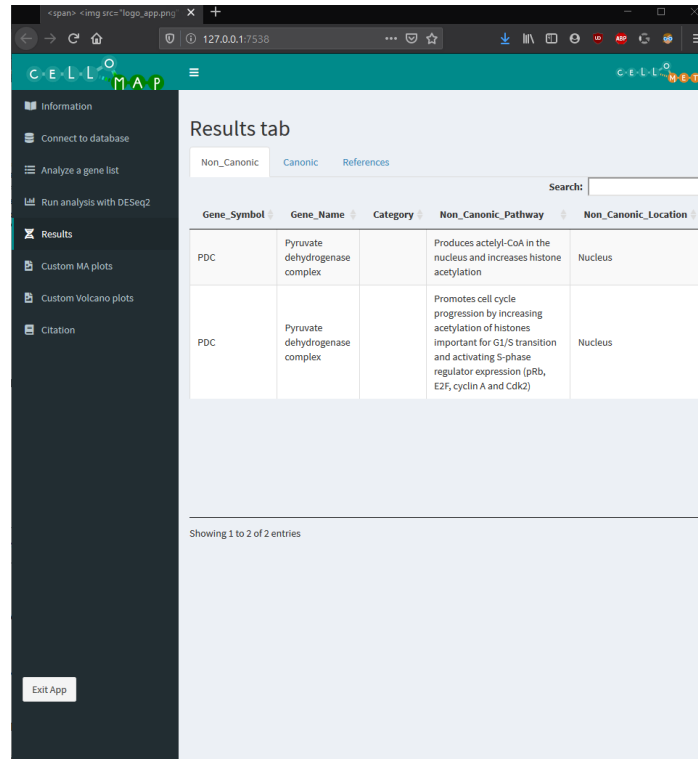


Figure 9: The results tab after a non canonical gene list analysis.

7 Custom MA and Volcano plots

This application allows users to create their own custom figures, and from these figures, significant gene data can be downloaded. There are two possible figures, MA plots and Volcano plots, each plot type has its own tab, however they behave very similarly, the volcano plot tab can be seen in Figure 10. The main thing to know about these tabs is that a differential expression file is required, like the one obtained from DESeq2 analyses. The columns required are the 'Genes' column, the 'baseMean' column, the 'log2FoldChange' column, the 'pvalue' column, and the 'padj' column, each written the same way as they are written in the guide. The file must also be a csv file. Aside that, each element of the different tabs is self explanatory. After each parameter modification, the create plot button needs to be clicked again. When a plot is loading, the rest of the application is locked to prevent the application from crashing due to a potential large number of buffered actions. On every button click the plot must be reloaded from scratch, this factor should be taken into consideration if a user is using a large differential expression files.

8 Common errors

1. Failed to connect to database

This may occur from time to time, the ideal is to wait and try again later. The database we are using can have a maximum of fifteen connections at a time, as such, CelloMap

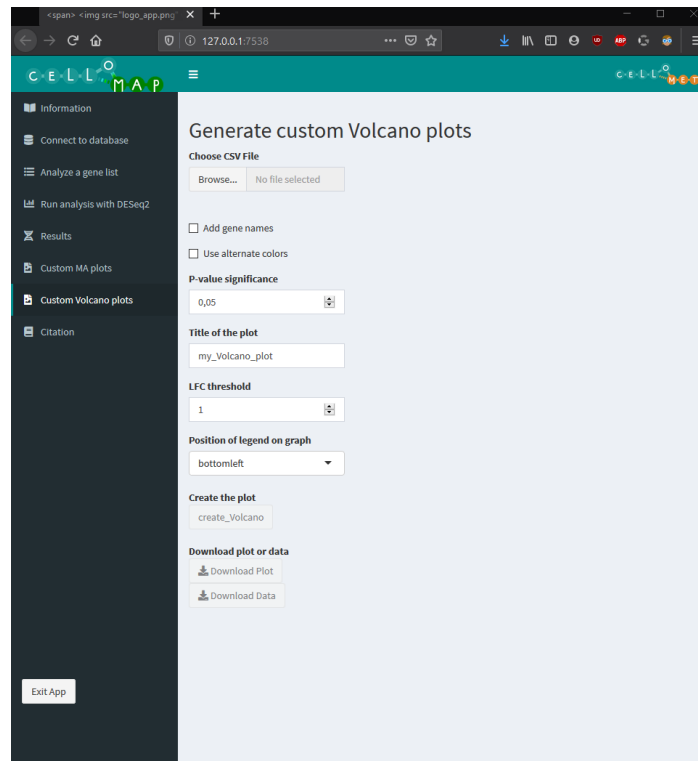


Figure 10: The tab to create a custom volcano plot.

was created in a way that it utilizes the connection as little as possible. As in, it only applies the connection right before it needs it and removes the connection once it is done. This time frame lasts no more than thirty seconds. That said, if retrying several times has not solved the issue, it is recommended to contact one CelloMap's developer at the following email address: yohan.lefol@gmail.com.

2. **Error in DESeqDataSet(se, design = design, ignoreRank): design has a single variable, with all samples having the same value. use instead a design of ' 1'.** **estimateSizeFactors, rlog and the VST can then be used**

This error may occur when only one condition is named, as well as randomly. It is a simple bug where DESeq2 finds only one variable and thus cannot proceed with its intended process. To correct this issue, simply try again, make sure that two conditions are named and that both csv files are properly uploaded to the application.

References

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- Love, M. I., Huber, W., & Anders, S. (2014). Moderated estimation of fold change and dispersion for rna-seq data with deseq2. *Genome biology*, 15(12), 550.

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- Shaul, Y. D., Yuan, B., Thiru, P., Nutter-Upham, A., McCallum, S., Lanzkron, C., ... Sabatini, D. M. (2015). Merav: a tool for comparing gene expression across human tissues and cell types. *Nucleic acids research*, 44(D1), D560–D566.