FED3 Viz Manual

Written for version: v0.0.2 (beta)

Date of creation: April 27th, 2020

GitHub: https://github.com/earnestt1234/FED3_Viz

Welcome!

Welcome to FED3 Viz, a Python GUI for graphing data from FED3 devices. This manual will describe the basic functionalities of FED3 Viz and how to use them. It will also try to address any common confusions/errors that may pop up.

You can find the FED3 Viz landing page at GitHub; all changes to the program will be made and logged though GitHub.

If you do notice any inaccuracies, typos, misinformation, or missed content in this manual, please report the issue through GitHub - thanks!

Installation

On the FED3 Viz GitHub, there is an Installation.md markdown file which contains instructions on how to run FED3 Viz via either a) running the Python script or b) running a bundled application (from Windows or Mac). This manual will only cover the use of the application once installed.

Table of Contents

Tour

This section will introduce the layout of FED3 Viz, and define some areas of the application. FED3 Viz has four different panes, which can be selected by clicking the following tabs at the top of the application window.

- **Home Tab**
- **Plots Tab**
- **Settings Tab**
- **About Tab**

Home Tab

The **Home Tab** is the tab that is open when FED3 Viz starts up. On this tab, you can load FED3 data and create plots from them.

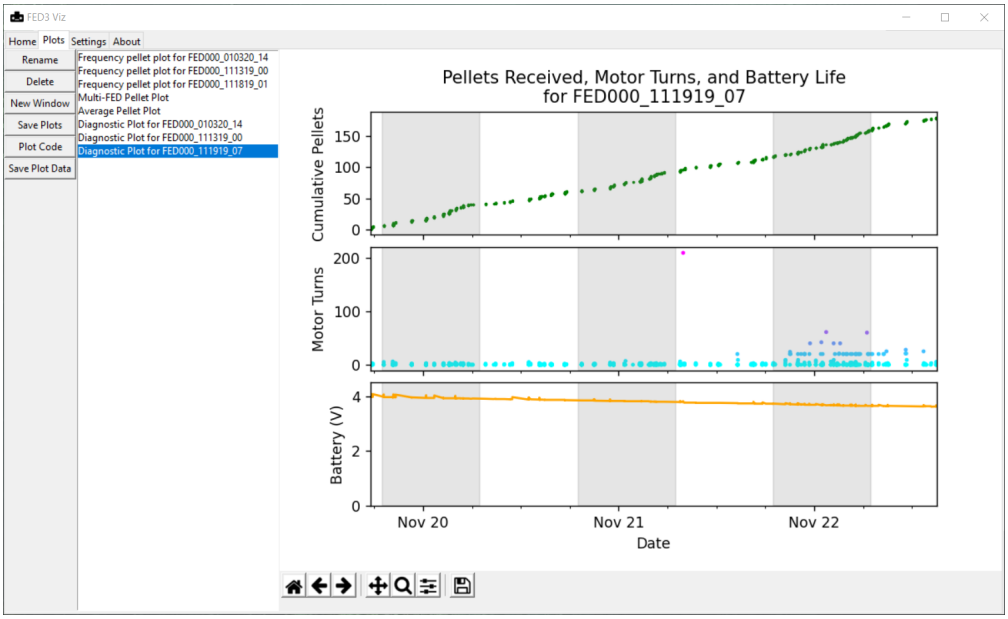
Elements of the Home Tab:

1. The **Info Bar** shows text describing button functions on the Home Tab. Hover the mouse over a button and the Info Bar will give a brief description of that button's function.
2. The top row of buttons, which are tools for loading and managing data files within FED3 Viz.
3. The **File View** is the largest element of the Home Tab. When a FED data file is loaded, it will appear as a row in the File View. Each column will show data associated with that data file.
4. The **Group View** lists all the currently loaded "groups," used for combining data from multiple FEDs (see the "Groups" section below).
5. The bottom row of buttons, which correspond to buttons used to create plots.

Whether or not a button is active depends on what data have been loaded into the application; for example, most plotting buttons must have some files selected in order to be active.

Plots Tab

The **Plots Tab** is used for selecting, viewing, and editing the plots that have been created.

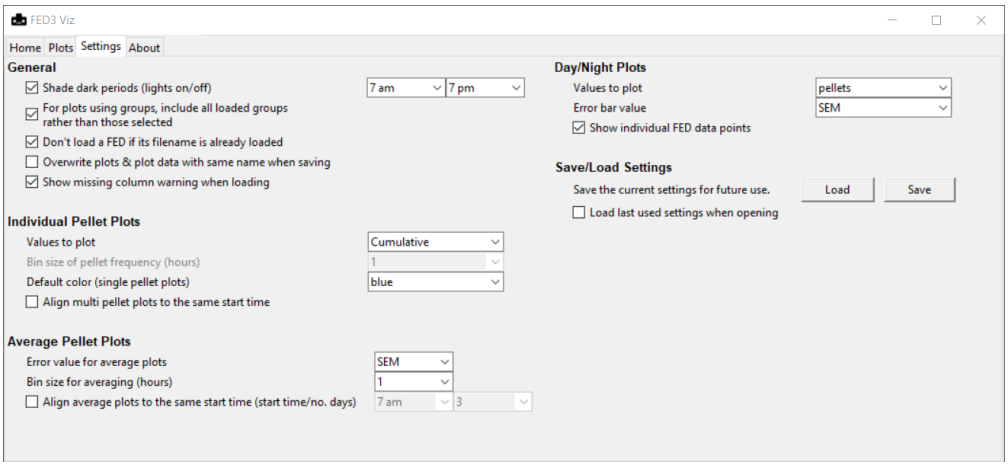


The Plots Tab is made up of three elements (from left to right):

- A column of buttons for working with plots
- A **Plot List** showing all the currently loaded plots
- A **Display Pane** which renders the plots. At the bottom of the Display Pane, there is a a **Navigation Toolbar** (included from `matplotlib`) used for editing the view of the plot on display.

Settings Tab

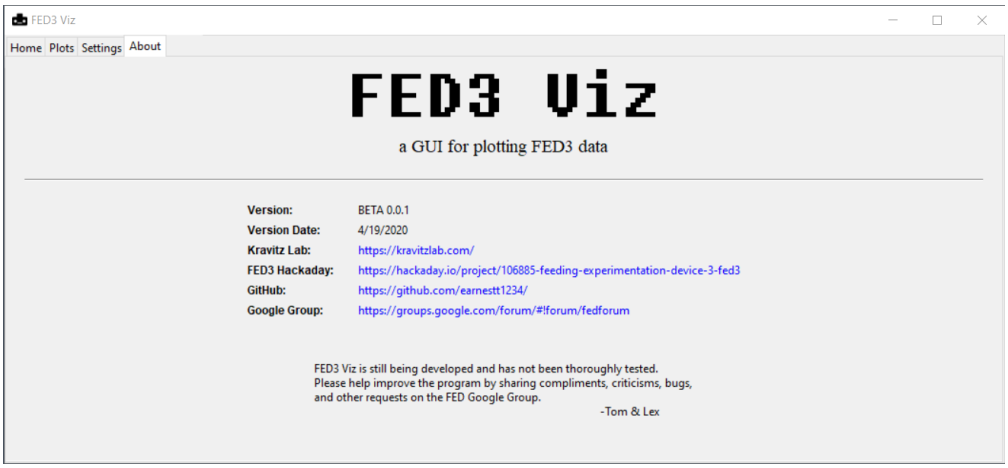
The **Settings Tab** offers controls for creating plots and preferences for the way FED3 Viz runs.



The Settings Tab is divided into different headered sections, corresponding to options for different plots. It starts with a **General** section (options for that affect the whole application or multiple plot types), and ends with a **Save/Load Settings** section (for preserving desired settings for future use).

About Tab

The **About Tab** shows the version number and date of FED3 Viz, as well as some FED3-related links.


FED3 Viz
Home
Plots
Settings
About
FED3 Viz
a GUI for plotting FED3 data
Version:
BETA 0.0.1
Version Date:
4/19/2020
Kravitz Lab:
https://kravitzlab.com/
FED3 Hackaday:
https://hackaday.io/project/106885-feeding-experimentation-device-3-fed3
GitHub:
https://github.com/earnestt1234/
Google Group:
https://groups.google.com/forum/#!forum/fedforum
FED3 Viz is still being developed and has not been thoroughly tested.
Please help improve the program by sharing compliments, criticisms, bugs,
and other requests on the FED Google Group.
-Tom & Lex

Loading Data

FED3 saves data as a `.csv` file on its internal SD card; these are the files used by FED3 Viz. You can access these files by ejecting the SD card and connecting it to your computer (**not** by connecting the FED to the computer via the micro-USB). They have the following naming structure:

FED{FED #}_{DATE}_{RECORDING #}.csv

- FED # = 3 digit device number
- Date = 6 digit date (month-day-year format)
- Recording # = 2 digit recording number

FED3 Viz will recognize these `.csv` files, as well as files converted into Excel (`.xlsx`) format. If the data have been changed out of one of these file types, they will have to be reconverted in order to be used by FED3 Viz.

Loading FEDs

The **Load Button** of the Home Tab is used for loading data into FED3 Viz; this button is always active. Clicking it will bring up a file dialog where one or more FED3 files can be selected to import.

How FEDs Are Loaded

FED3 Viz will attempt to load every file `.csv` or `.xlsx` file selected by the Load Button file dialogue using a Python library for working with tabular data (`pandas`). The loading process first tries to parse the file to find columns matching the standard FED3 data columns (as of the time of writing this manual).

Standard FED3 Data Columns:

- MM:DD:YYYY hh:mm:ss
- Device_Name
- Battery_Voltage
- Motor_Turns
- Session_Type
- Event
- Active_Poke
- Left_Poke
- Right_Poke
- Pellet_Count
- Retrieval_Time

These columns are looked for **by name, not the content or type of data in the column**. If all correctly found, these columns will be used to try and generate additional variables used for plotting (elapsed time, pellets as a binary entries, etc.). By default, files with the same name will not be reloaded (even if they reside in different folders); to load duplicate file names, untick **Settings > General > Don't load a FED if it's filename is already loaded**.

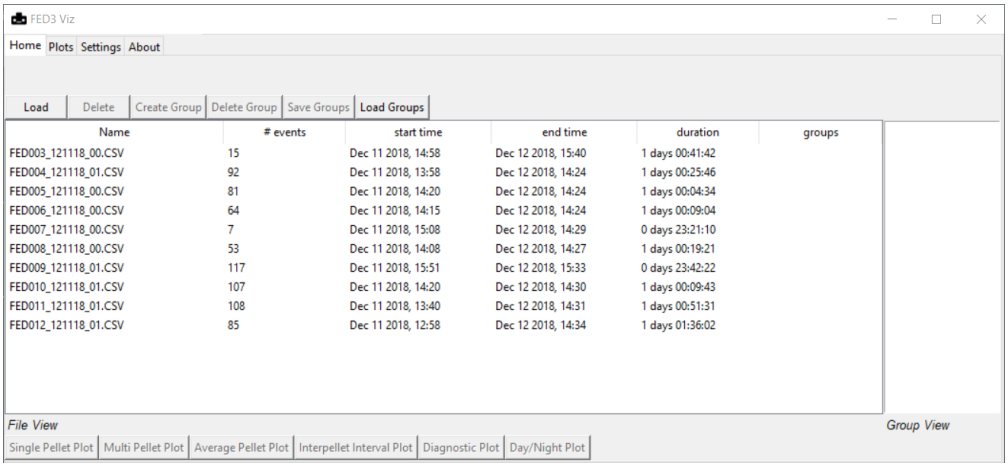
Loading Errors

An error message pop-up may be raised if there are any issues encountered during the loading process. The two major types of errors are:

- Unrecognized: the file(s) was not recognized as FED3 data. This error means that the program failed to load the data. This can occur from attempts to read non `.csv` or `.xlsx` files, or from correct file types that differ significantly from the standard FED3 file format. This error can not be suppressed.
- Missing Data: the file(s) is missing at least one of the default columns. This means that the file was loaded, but it may be missing some columns which are used by FED3 Viz for plotting; it is meant to serve as a warning that some plots may be unavailable or may produce unexpected results. This error can occur when the raw data has been edited to remove or rename columns, or when using an earlier version of FED3 Arduino code. This error can be suppressed by unticking **Settings > General > Show missing column warning when loading.**

Further discussion of problems with loading may be brought up in the FAQ as the application develops. Additionally, the description of each plot in the "Plots" section below will list the data columns required by each plot.

File View



Loaded FED data can be inspected on the File View of the Home Tab. Each loaded FED will correspond to a row in the File View, where column entries will correspond to properties of the file:

- Name: the name & extension of the file
- # events: how many events were logged by the device, either Pokes or Pellets (essentially the number of rows in the data file)
- start time: the date and time of the start of the recording
- end time: the date and time of the end of the recording
- duration: the amount of time between the first and last logged event
- groups: any user-defined groups associated with the recording

When more than one file is loaded, the files can be sorted by clicking on the column headers of the File View. A single click will sort the column in order (alphabetical/smallest>largest/shortest>longest), while a double-click will reverse the order.

Deleting FEDs

FEDs can be removed from the application by using the **Delete Button** of the Home Tab. The Delete Button will only be active when one or multiple FEDs are highlighted in the File View.

Groups

Groups are user-defined labels for aggerating data from multiple FED recordings. Plots which utilize Groups will show data from each Group as a separate curve or bar. Groups can be compare data from mice in multiple experimental groups, or from mice before and after an intervention.

Creating Groups

To create a Group:

- Select one or more FEDs from the File View
- Click the **Create Group Button**
- In the text box on the pop-up window, enter a name for the Group. Group names need to be unique, and repeated names will not be enterable.
- Click OK

The Groups associated with each loaded data file will be shown in the "groups" column of the File View. Additionally, all currently loaded Groups are viewable in the **Group View** of the Home Tab. Selecting a group will highlight all its members.

FEDs do not have to be grouped uniquely; one FED can be part of multiple groups.

There is currently no ability to edit the members of a Group once it has been created. Rather, this can be achieved by creating a new Group with the desired members.

Deleting Groups:

To delete a Group:

- Select one or more Groups from the Group View
- click the **Delete Group Button**

Groups will also be removed if all of its members (FED files) are deleted.

Saving Groups:

Groups can be saved and loaded for relabeling devices over multiple uses of FED3 Viz. Groups can be loaded from anywhere, but have a default location which depends on the installation method:

- **Windows or Mac Executable:** `fed3viz/groups/`
- **Python Script** (i.e. GitHub source code): `FED3_Viz/FED3_Viz/groups/`

To save the currently loaded groups, click the **Save Groups Button** on the Home Tab. This will bring up a file dialogue with the default Groups file location. Group files are saved in `.csv` format.

Groups can then be reloaded with the **Load Groups Button**; at least one FED file must be loaded for the button to be active. Clicking the button will prompt the user to select a Group file to load.

Group files associated **file names** with **Group names**. In this way, files that are moved around the computer will still be recognized. However, **files with changed names will not be re-grouped**. Additionally, if a new file matches a name in the Groups file, it will be Grouped, even if it was not the original file used to create the group.

Plots

The general steps to create a plot are:

- Select the desired settings from the Settings Tab (if applicable)
- Select the FED files to include in the plot
- Press a plot button from the bottom row of the Home Tab

This section will go through the plot buttons currently available in the Home Tab and describe the plots they create.

There are a couple settings which apply to multiple plots:

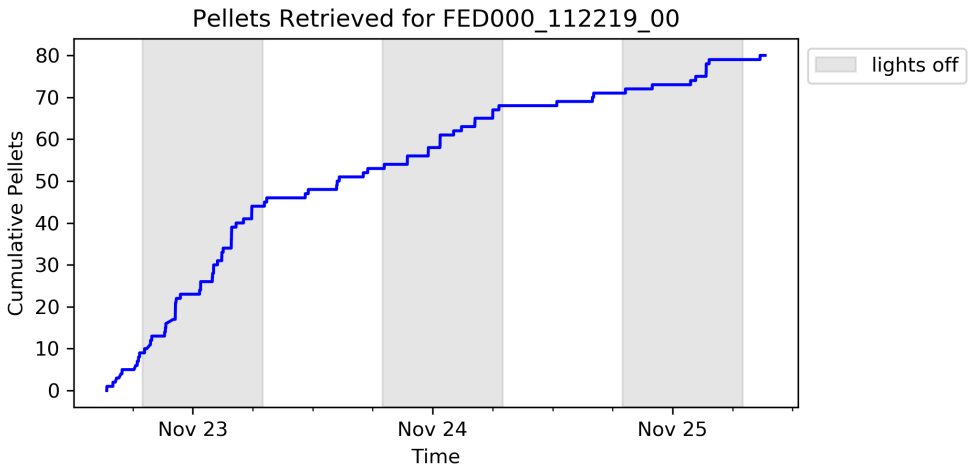
- *Shading dark periods*: When enabled, applicable plots will have a light gray shading during periods when the lights are off - this can help for detecting circadian patterns of activity. This setting can be toggled from **Settings > General > Shade dark periods (lights on/off)**. The start and and time of the dark period can be selected using the dropdown menus next to this setting. Plots which make use of this feature will include a 🌚 symbol in their description
- *Using Groups*: Some plots aggregate data and rely on Groups. By default, plots which rely on Groups will **plot all Groups present in the Group View**; you can instead use the Group View to select which Groups to include by unticking **Settings > General > For plots using groups, include all loaded groups rather than those selected**. Plots that utilize groups will be tagged with a 📎 symbol in their description.
- *Handling multiple selections*: For plots that don't use Groups, the data to plot depends on which loaded FED data are highlighted. More than one file can be highlighted at once, and there are two main ways the program deals with this. Buttons that combine the highlighted files into one graph are marked by 📊, while buttons that create multiple plots (one for each highlighted file) are marked by 📊📊📊.

Single Pellet Plot

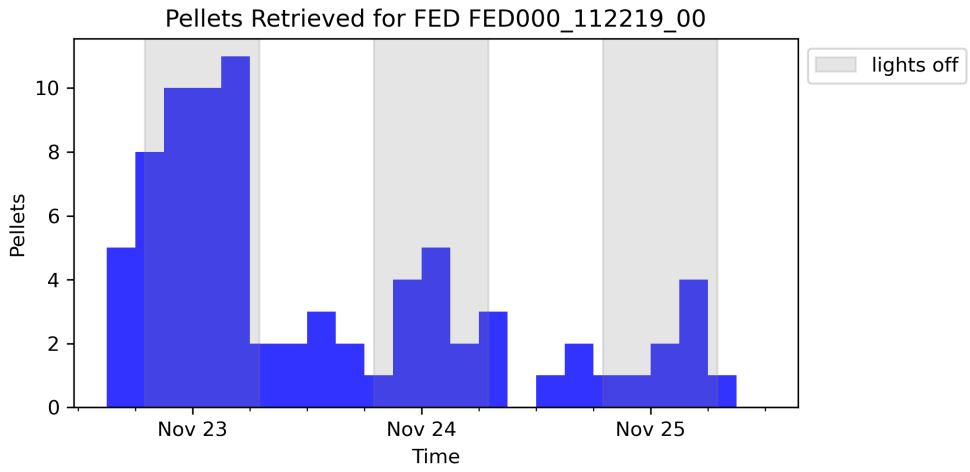
Dependent columns = MM:DD:YYYY hh:mm:ss, Pellet_Count

Can use night shading 🌚

Creates one plot for each highlighted file 📊📊📊



This plot shows the pellets retrieved over time for a single data file. By default, the raw *Pellet_Count* column (the cumulative total) is plotted against the timestamps (**Settings > Individual Pellet Plots > Values to plot > Cumulative**). This can be changed to show the sum of pellets retrieved at a specified bin size using **Settings > Individual Pellet Plots > Values to plot > Frequency** and **Settings > Individual Pellet Plots > Bin size of pellet frequency (hours):**



Highlighting a single

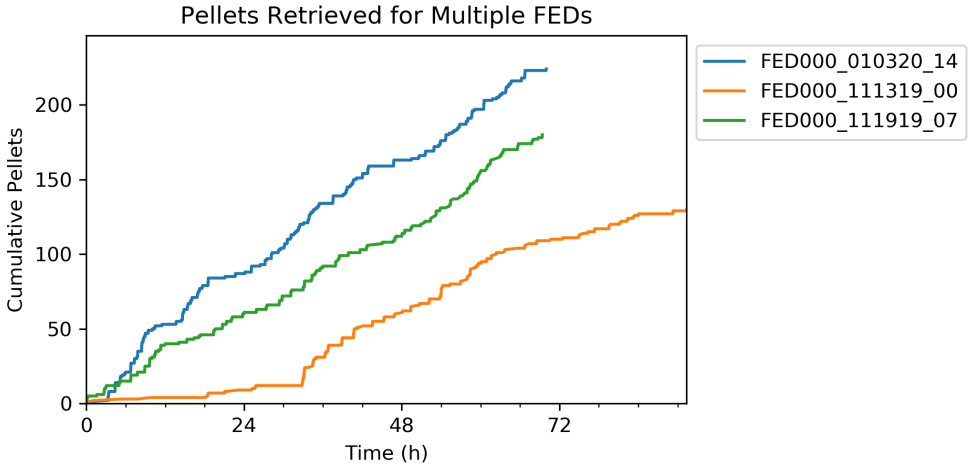
The color of these plots can be set, also (**Settings > Individual Pellet Plots > Default color (single pellet plots)**).

Multi Pellet Plot

Dependent Columns = MM:DD:YYYY hh:mm:ss, Pellet_Count

Can use night shading 🎛️

Combines all highlighted files into a single plot 📊



Multi Pellet Plots are basically Single Pellet Plots, but individual devices are plotted as separate lines. As above, either the cumulative amount or binned frequency of pellet retrieval can be plotted.

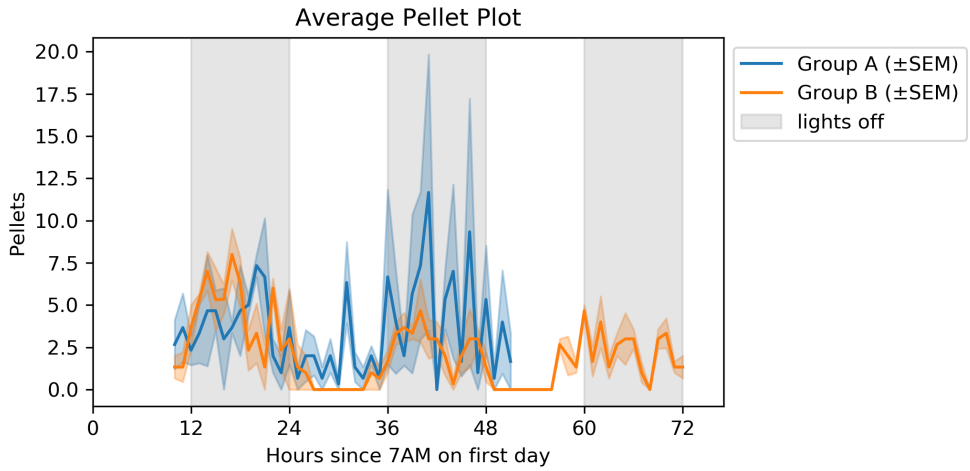
The only additional setting is **Settings > Individual Pellet Plots > Align multi pellet plots to the same start time**. When ticked (as above), pellets will be plotted against the *elapsed time* (since each device started); this prevents shading of dark periods. When unticked (default), the *absolute date/time* will be preserved, so FEDs which were recorded at different times will not overlap.

Average Pellet Plot

Dependent Columns = MM:DD:YYYY hh:mm:ss, Pellet_Count

Can use night shading 🎛

Uses groups 📎



Average Pellet Plots average the pellets retrieved for each file in a Group. Each group in the plot is plotted as a separate line. Average Pellet Plots can only be plotted using a binned frequency of pellet retrieval.

Settings specific to these plots are under **Settings > Average Pellet Plots > Average Pellet Plots:**

- **Error value for average plots**: how to show the spread of data within each group. Options are standard error of the mean (SEM), standard deviation (STD), raw data (each file shown as a lighter line surrounding the mean line), or None.
- **Bin size for averaging (hours):** how frequently to average data (must be done as pellets are logged to the second)
- **Align average plots to the same start time:** When unticked (default), the program only average over *absolute date & time*; i.e. only FEDs that were active at the same time can be averaged, and averaging can only be done for the window of time where **all** FEDs in the Groups are active. When ticked, the data are aligned such that the same hours of the day are averaged for each Group. This opens up two more options:
  - **Start time**: the time of day to start taking an average - data before this time on the first day of recording will be ignored
  - **No. days**: how many days to try and average data for, since the **Start time** on the first day.

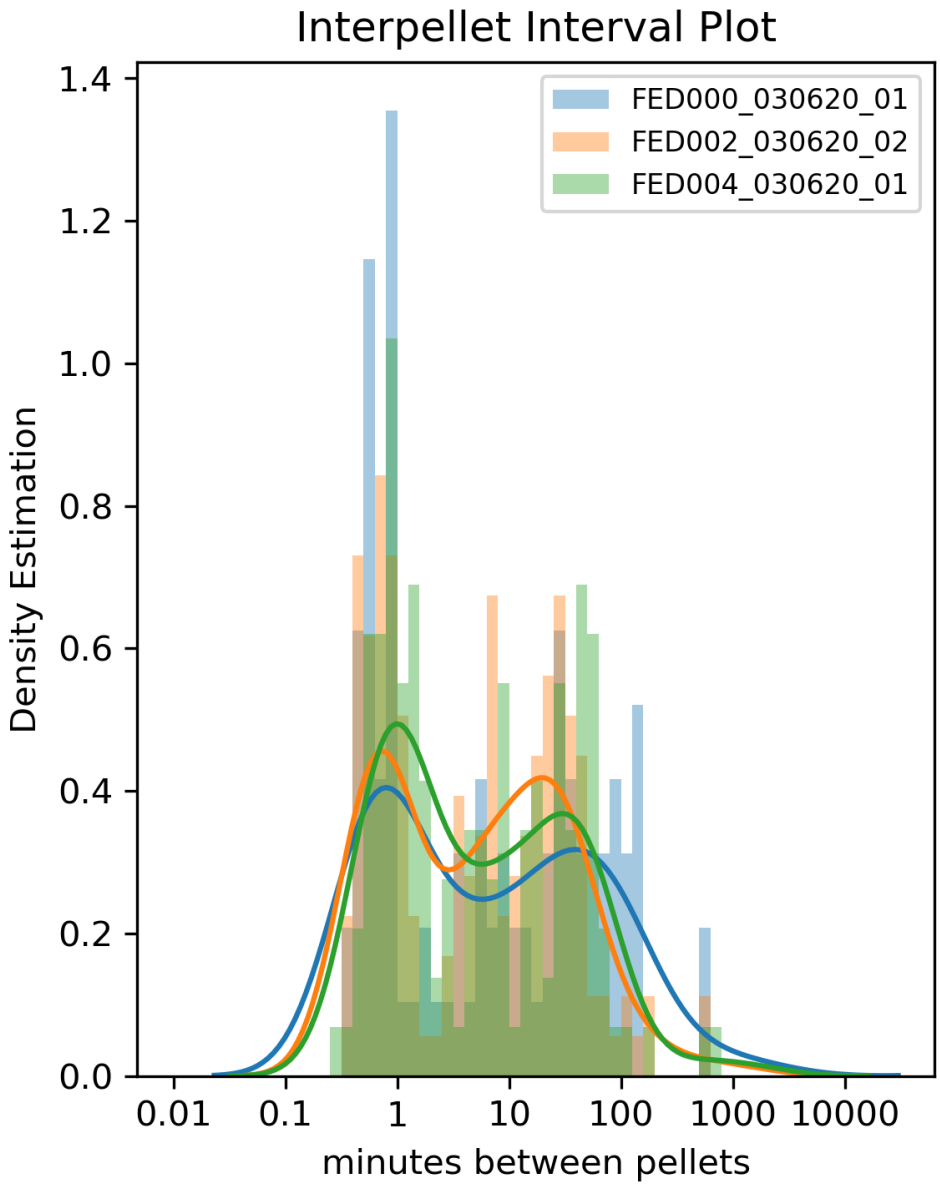
  If the box is unticked, and the Groups selected have no periods when all their members are active, a warning will be raised, directing the user to try making the aligned version of the plot.

Interpellet Interval Plot

NOTE: These plots only use the KDE version in v0.0.2; future updates will allow the KDE curve to be removed (see below)

Dependent Columns = MM:DD:YYYY hh:mm:ss, Pellet_Count

Combines all highlighted files into a single plot 📊



The Interpellet Interval Plot is a histogram where the values counted are the time between each pellet retrieval event. This plot can give you a sense of how the mouse feeds or earns pellets, and it show changes in meal or eating frequencies.

This plot is a fairly unaltered use of `seaborn.distplot`. The only option, **Settings > Interpellet Interval Plots > Use kernel density estimation** toggles the `kde` argument of this function:

- When ticked, a kernel density estimation (KDE) is used to model the probability density function of the interepellet intervals. The density estimation is plotted on the y-axis: the

area under the whole curve of the KDE is 1, and the area under a certain portion estimates the probability of observations occurring within that portion.
- When unticked, a raw histogram is parted, the KDE line is removed, and the y-axis represents counts in each bin.

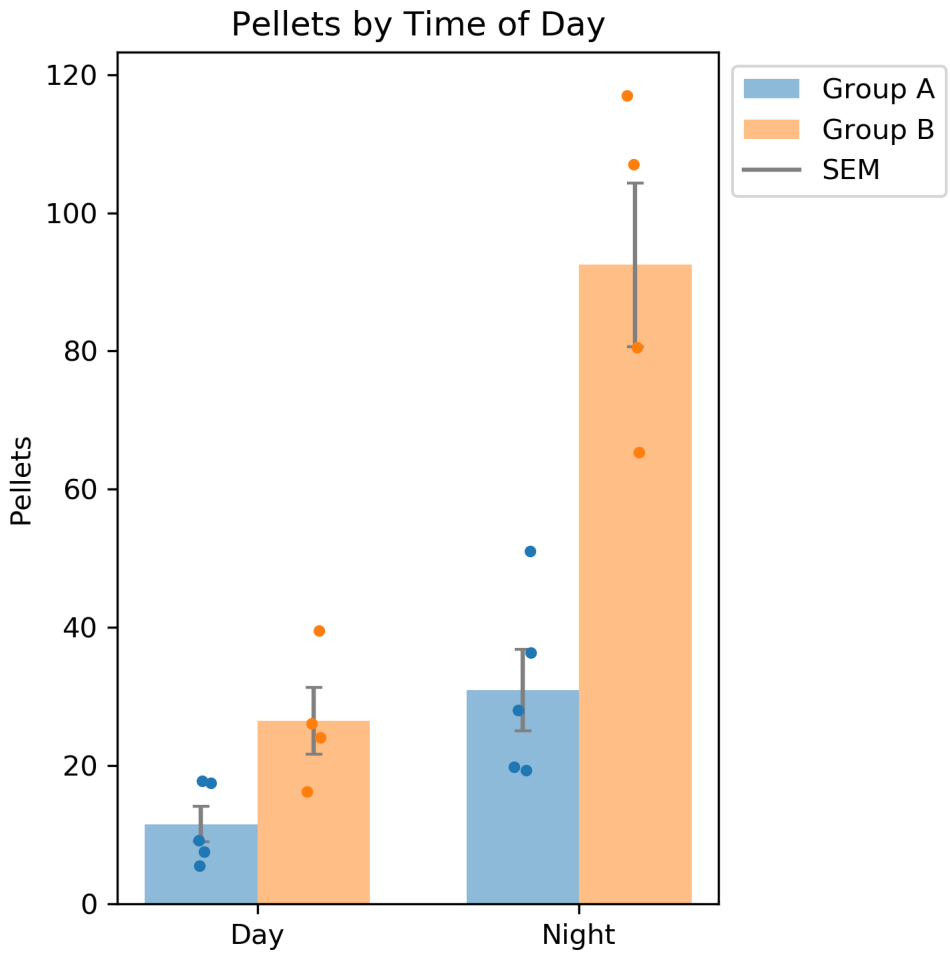
Note that Interpellet Interval Plots use logarithmically spaced x-axes (in minutes).

Day/Night Plot

Dependent Columns are different for each value to plot :

Value	Dependent Columns
pellets	*DD:MM:YY hh:mm:ss, Pellet_Count*
retrieval time	*DD:MM:YY hh:mm:ss, Retrieval_Time*
interpellet intervals	*DD:MM:YY hh:mm:ss, Pellet_Count*
correct pokes/errors	*DD:MM:YY hh:mm:ss, Pellet_Count, Left_Poke_Count, Right_Poke_Count, Active_Poke*

Uses groups 🖇



Day/Night Plots show average values for Groups of data during daytime and nighttime. What is consider day or night is set by the times selected in **Settings > General > Shade dark periods (lights on/off)**. The options to edit this graph are:

- **Values to plot**: What values are being plotted on the y-axis. Options are pellets, interpellet intervals, retrieval time (of pellets), correct pokes, and errors; the latter two can also be expressed as a percent.
- **Error bar value**: What values to use to create error bars; options are SEM (standard error of the mean), STD (standard deviation), or None.
- **Show individual FED data points**: When ticked, values for individual recordings are superimposed over the bars to show the values contributing to the average.

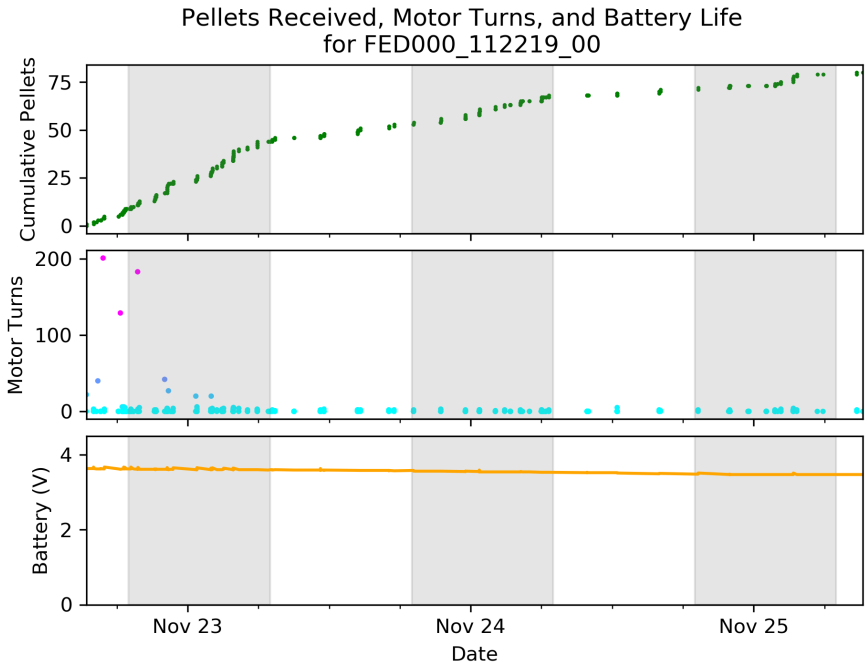
Regardless of the value plotted, the bars represent the *Group average of the daily or nightly average values of each file*. That is, for each file, the program averages the selected value for all its day or night periods; those values represent the individual FED data points, and they are averaged to create the value for the bar.

Diagnostic Plot

Dependent Columns = MM:DD:YYYY hh:mm:ss, Pellet_Count, Battery_Voltage, Motor_Turns

Can use night shading 🌚

Creates one plot for each highlighted file 📊📊📊



The Diagnostic Plot is used to help identify problems with the FED over the course of its recording. It is a 3 panel plot, which shows the pellets retrieved, motor turns, and battery life over time.

The motor should only need to turn a few times (under 10) for each pellet dispensed. Slightly higher values than this (10-50) may represent the FED's mechanism to try and unjam, while much higher values (>100) may represent a longer pellet jam.

Managing Plots

When a plot is created using a button on the Home Tab, the Plots Tab will be raised and the newest plot will be shown in the Display Pane. All active plots will be shown in the Plot List, and clicking the name of the plot will render it in the Display Pane.

The Plots Tab has additional buttons which allow you to manage and save your plots; there are also some additional features which allow for editing of the plot after creation.

Renaming Plots:

To rename a plot, select a **single** plot from the Plot List, and click the **Rename Button**. In the text entry box that pops up, enter a new name for the plot and click OK. Plot names must be unique.

New Window:

To show plots in a new window, select one or more graphs from the Plot List and click the **New Window Button**. This feature allows for viewing of multiple graphs simultaneously.

Navigation Toolbar:

FED3 Viz includes a `matplotlib` interactive toolbar for editing rendered plots. This can be used to limit the axes, zoom in on a certain region of the graph, or alter the aspect ratio. Specific guidance on how to use this tool can be found here, but note that the keyboard shortcuts will not work.

Saving Plots

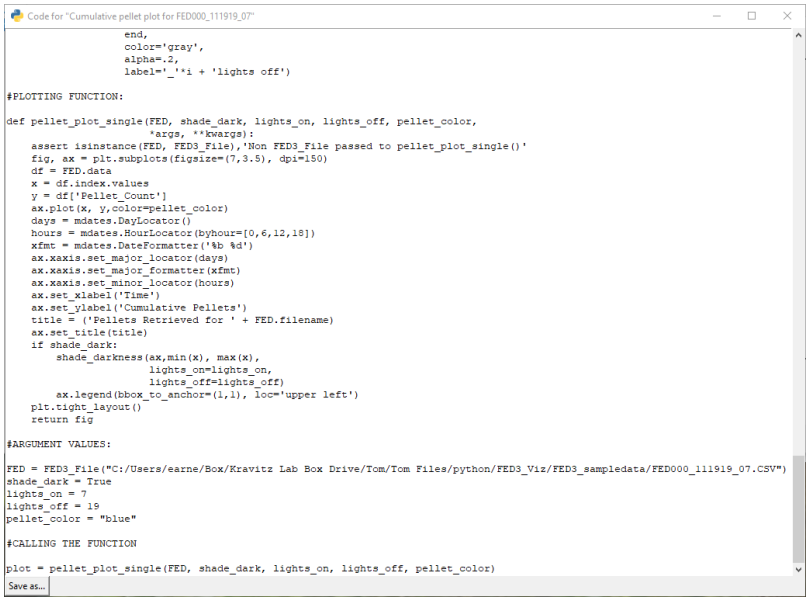
There are three main aspects of plots which can be saved in FED3 Viz: images, data, and code.

Note that by default, FED3 Viz will not overwrite images or data saved with conflicting names. This can be changed by checking **Settings > General > Overwrite plots & data with the same name when saving**.

Saving Images

To save plots, highlight one or more plots from the Plot List and click the **Save Plots Button**. This will bring up a file dialogue, and prompt the user to select a folder to save the images in. Plots are saved in `.png` format at 300 DPI. The name of the file will be the same as the plot's name in the Plot List. Note that the Navigation Toolbar also has a button that can save plots, but using it (in this case) will limit the DPI to 150.

Saving Code



FED3 Viz can return the code used to create each plot through the **Plot Code Button**. The aim of this feature is to allow users to be able to tweak graphs (with Python) in ways not possible from FED3 Viz.

Each plot button in FED3 Viz is associated with one or more plotting functions defined in Python; settings from the Settings Tab translate into arguments passed to these functions. The Plot Code Button uses Python's `inspect` library to return the source code of these plotting functions. The program formats this code with additional lines that are specific to each plot, like the data source and the settings used.

The Plot Code output should be a functional script; that is, running the script in a separate Python session should recreate the plot (given the appropriate packages and package versions in that environment). To achieve this, the output script has to include the following:

- a list of packages to import
- the definition of a class used to load FED3 data and do some preprocessing
- definitions of helper functions used by the plotting function
- definition of the plotting function
- assignment of the specific arguments used by the function for the plot
- a line calling the function

All this makes the code somewhat verbose, but it aims to make the script run-able without modification.

Plot Code is displayed in a new window, and can be saved as a `.py` or `.txt` file using the Save As... button at the bottom of the window.

Saving Data

Clicking the **Save Plot Data Button** will export one or more `.csv` files which contain the values plotted; the format depends on the type of graph. These files can be used to recreate graphs or run statistics in separate software. Clicking the Save Plot Data Button will bring up a file dialogue, and will ask the user to select a location for saving the output.

Deleting Plots

To delete plots, highlight one or more plots from the Plot List and hit the **Delete Button**.

Settings

Most of the settings available on the Settings Tab pertain to plots and were described above. There are a couple additional aspects of the Settings menu which will be described here.

Saving Settings

FED3 Viz can save settings and load settings in case of specific user preferences. Settings files are saved in `.csv` format, and they preserve the state of all settings in the Settings Tab. There is a default **Settings Folder** for saving settings, which depends on the installation method:

- **Windows or Mac Executable:** `fed3viz/settings/`
- **Python Script** (i.e. GitHub source code): `FED3_Viz/FED3_Viz/settings/`

To save the current settings, click the **Save Button** under **Settings > Save/Load Settings.** This will prompt you to provide a name for the settings file.

Settings can later be loaded by using the **Load Button** under **Settings > Save/Load Settings**. This will default to looking in the Settings Folder.

Default Settings

The Settings Folder comes with a `DEFAULT.CSV` file, and the program attempts to load this every time it starts up. You can overwrite this file, or save any other settings as `DEFAULT.CSV` in order to load them automatically at startup. If this file cannot be found or is improperly formatted in anyway, it will not be loaded and the application will fall back to some built-in default settings.

Last Used Settings

There is also an option to remember the settings used the last time the application was closed. Every time the program closes, it writes a `LAST_USED.CSV` file into the Settings Folder, containing the state of settings at that time. If you have checked **Settings > Save/Load Settings > Load last used settings when opening**, these settings will be loaded.

FAQ

This section will mainly cover troubleshooting and issues; please also check the manual for discussion of specific functions and features.

- **I downloaded the executable but it won't run.** Unfortunately, I am fairly unaware of the exact system requirements for FED3 Viz (it was built with `PyInstaller`, which is largely a black box to me). If on Windows, one thing you can try is running the `.exe` from the command line (`cd` into the directory and then enter `fed3viz.exe`). This will leave the console open and may provide an error message which can be shared. On Mac, the Terminal can similarly be inspected.

  If the error persists, I would instead recommend trying to run FED3 Viz from the Python script (Method 2 of the Installation instructions). This is more likely to be troubleshooted successfully.

- **I can't load some of my FED data, or I can load but some plots don't work**. The most likely cause is that you have a previous version of FED output data, or that there have been edits to raw data. FED3 Viz tries to handle old formats of the data, but there may be cases which cannot be caught. Some examples of current data are included on GitHub in the `example_data` folder. You can compare your data to these to see if there might be any obvious differences; you can also test that the example data load correctly. Please share any specific issues on GitHub.

- **I'm seeing errors & warning when starting up or running the program.** Some of these are to be expected, and you shouldn't worry about them if the program continues to work as expected. If there are functional issues, please report these errors.

- **On Mac, I don't get the option to select some files when loading.** This is a bug right now; try to change the file types searched for from "All" to another option, and then back to "All".

- **I'm encountering issues when using files with the same name**. Please report these; there could be some errors with duplicate files or files with exactly matching names which need to be resolved. The easiest workaround before a fix is to rename files (outside of FED3 Viz) to be unique.

- **Will there be more plots/features added?** Yes! FED3 Viz will likely be worked on through Summer 2020. There are more features in the works, particularly in regards to the operant functions of FED3 Viz. Please share any suggestions for development on GitHub or the FED3 Google Group.

- **I saved the Python code for a plot and it doesn't run.** This could be due to many issues, but some possible causes are:

  - You are not using Python 3
  - You do not have the necessary packages installed, or their versions are incompatible with FED3 Viz. The packages used by FED3 Viz are documented in the `requirements.txt` file on GitHub
  - Your IDE is not showing the plot (sometimes an issue with how inline plotting is handled; sometimes this causes plots not to show on the first run)
  - There is an error in the output plot script, which is certainly possible! The most likely issues are that some of the necessary helper functions were not included or the arguments are improperly formatted. Please report these errors on GitHub with the specific context, both to help solve your specific case and to improve the application.

- **I have suggestions for improving the plot code I saved.** Please note that FED3 Viz's plotting functions are designed to handle different settings on the fly, and the code to make one specific plot may be writable in a much less verbose way. Some pieces of the code may be helpful for the application, but irrelevant to your specific plot.

  That being said, I would enjoy discussing (on GitHub) and possibly including any proposed changes which significantly contribute to the readable or speed of the code. Aside from that, sharing code may be useful for other users.
- **I can't load some settings, or my settings look weird.** This could be an issue with altered setting files, or settings files with which have entries that don't match the application. Please redownload the `DEFAULT.CSV` and `LAST_USED.CSV` files from GitHub and replace them in your FED3 Viz folder. Alternatively, try to save new settings from the application to overwrite the `DEFAULT.CSV` file.
- **I have an issue that I have shared and I haven't heard back from anyone.** Please be aware that FED3 Viz and FEDs are developed and maintained by a small group of researchers as a means to meet our research goals. We will do our best to respond prudently to questions shared online, but bear with us!