NeuroGlyphics Manual (Incomplete)

Current release version might not support all features

(Draft Ver. 1.0.0.0 – October 2, 2016)

Content:

1.

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October 2, 2016

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2. What is NeuroGlyphics?

Neuroglyphics (NG) is a software package that implements a) a user interface, b) a task engine that controls the presentation of unique tasks and controls the data collection and c) a series of analysis routines intended to provide quantitative metrics of fine motor dexterity and pen kinematics. The first step in the process is the collection of pen tip position with a high degree of spatial and temporal fidelity. The newer "off-the-shelve" digitizing tablets, TabletPC and other graphic user interfaces using touch sensitivity are capable of delivering those basic requirements.

For over a century, neurologists, psychologists, forensic experts, education professionals and other practitioners have had interest in capturing features of fine motor control during writing and the degradation of these processes in the context of various diseases or conditions by asking patients to draw Archimedes spirals or by collecting sequential writing samples with the purpose of documenting characteristic features, evidence of disease progression or response to treatment.

For example, a distinct reduction in the size of handwriting (micrographia) is typical for Parkinsonism, while tremor in Essential Tremor (ET) can be easily elicited by drawing the Archimedes spiral. Other fine motor control abnormalities can be brought up during drawing or writing tasks. This is the case, for example, of patients with cerebellar dysfunction, Writer's Cramp (WC), developmental dysgraphia or patients with action myoclonus.

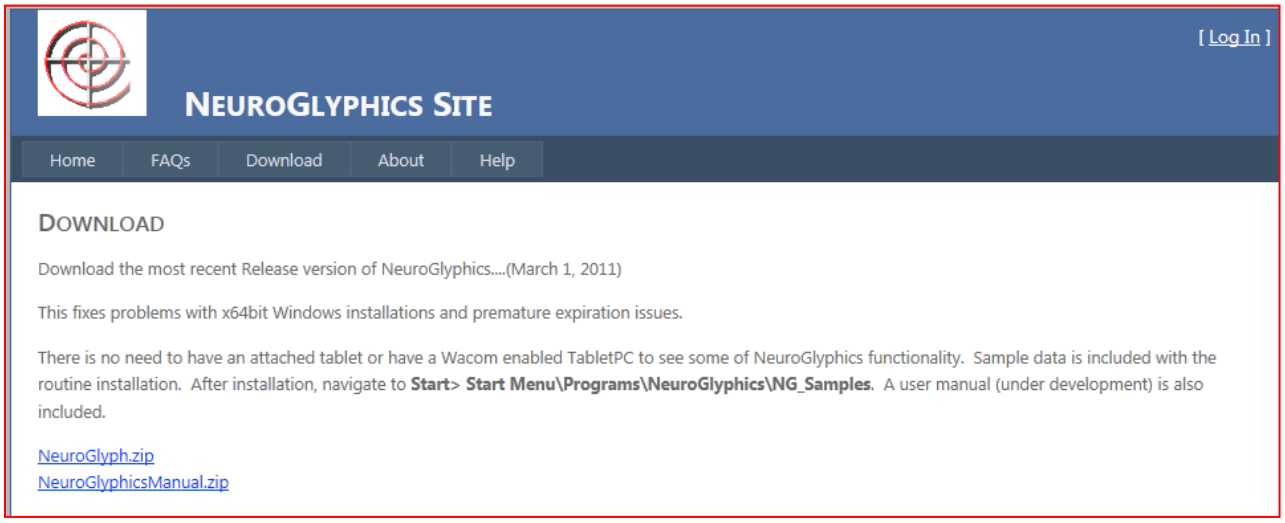
While qualitative side to side morphological comparison of the samples is valuable, NG's main goal is to add extra dimensions to the analysis by providing metrics reflecting pen-tip kinematic and other spatial features adding a truly quantitative dimension to the performance. The derived features are a more objective reflection of hand motor control providing a more robust and unambiguous estimation of performance and could serve as foundations to qualitatively explore longitudinal changes or response to interventions.

One key aspect that distinguishes paper based (or simple morphological analysis) from the analysis offered by NG, is the fact that NG treat the writing output generated by the tablet as a high temporal and spatial resolution collection of data points on which further numerical analysis can be undertaken. As a result, estimations of accuracy, pen tip velocity and acceleration magnitude in the time and frequency, among many other metrics, becomes possible.

The functionality of NG can be divided into five main features:

1. Data collection
2. Data display
3. Data analysis
4. Data file input/output and storage
5. Report generation

3. Installing and Configuring NeuroGlyphics



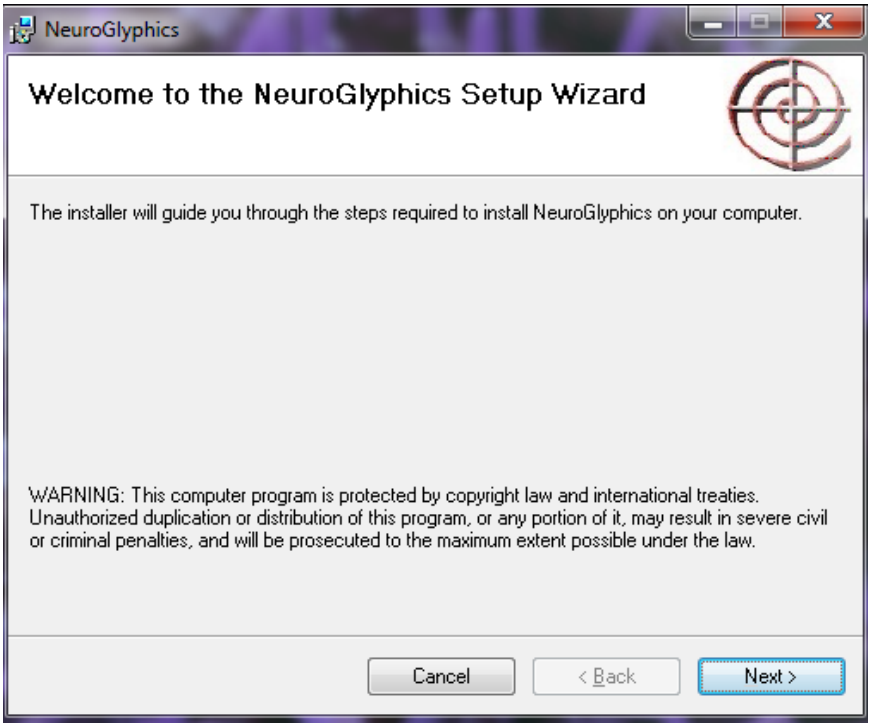


Figure 1. Neuroglyphics installer's first screen. Admin privileges are needed to proceed.

Configuration:

Note: Tablet PC users, NeuroGlyphics currently operate properly **ONLY** in a "landscape" aspect ratio. I'll work on getting it to work the "Slate" or "Portrait" aspect ratio in the near future.

[Subject to change]. In some circumstances, especially in TabletPCs, it is required to further configure NeuroGlyphics to achieve the desire features. Configuration changes can be made on the file ***NeuroGlyphConfig.xml*** file which now resides on the directory **C:\Users\[User Name]\Documents\NeuroGlyphics\Configuration**. Note that this is a change from prior versions. Each user can change hers/his preferred parameters by editing this file. This file can be edited in any text or xml editor.

Set default environment [TablePC or Detached tablet].
This is accomplished by changing in the ***NeuroGlyphConfig.xml*** the parameter
<HardwareConfig>
<Integrated> between the values **False** or **True**.

```
<Configurations>
  <Config>
    <HardwareConfig>
      <Integrated>False</Integrated>
      <Metrics>
```

True is the appropriate value for a Tablet PC and **False** the value for a detached tablet.

[No longer an issue with the Oct 2, 2016 version*] Forced correction of Sample Rate for some TabletPCs. Some Tablet PCs report a sample rate of 100 Hz when in reality; they are collecting at 166 Hz. This can be changed to the correct value in the ***NeuroGlyphConfig.xml*** as shown in the figure below. Users of detached tablets do not need to change this value.

(*) From the Oct 2, 2016 version on, Neuroglyphics uses the time stamp generated by the software driver to internally convert the sample rate to a standard sample rate of 100Hz while removing duplicate and out of order points.

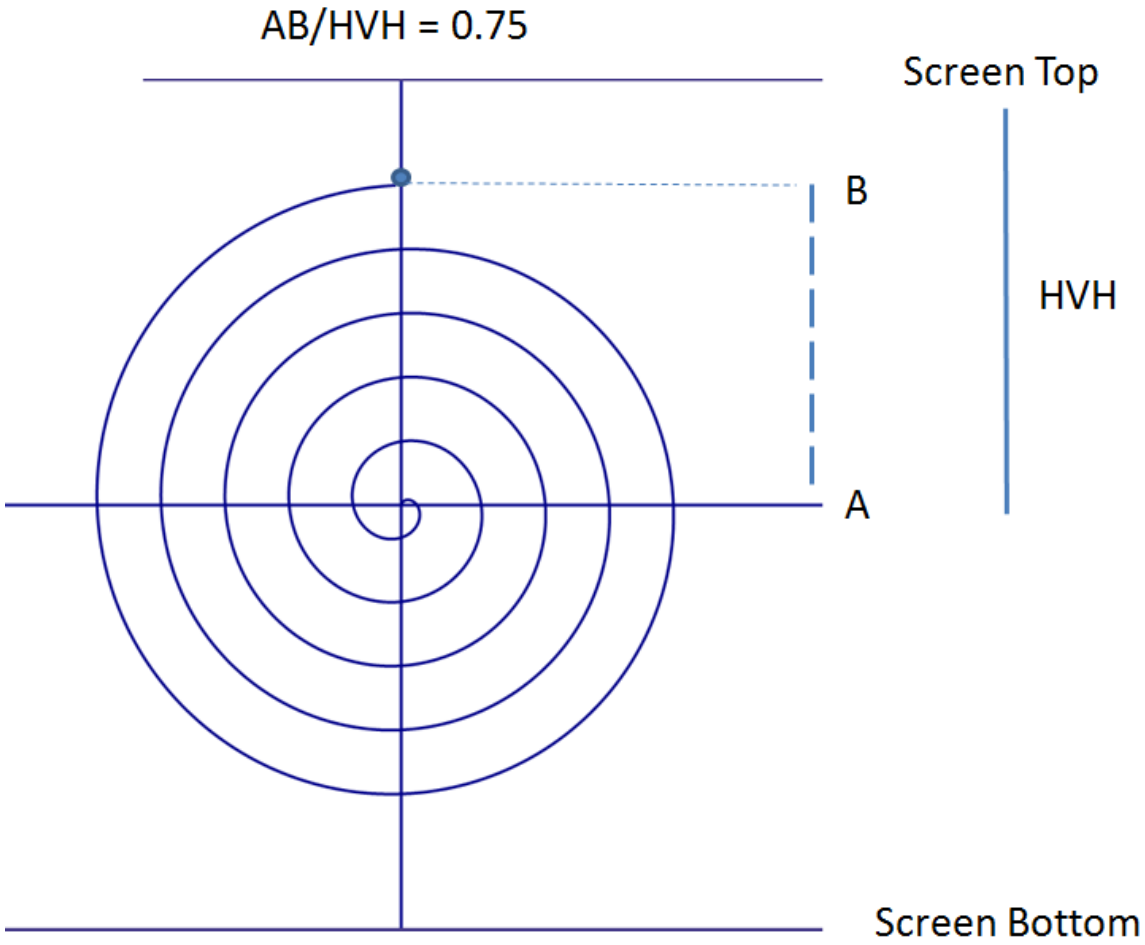
Set size of spiral with respect to screen size.

Users of Tablet PCs might want to adjust the size of the spiral stencil as a proportion of the fixed tablet physical size. This is accomplished by setting the configuration parameter MaxLoopRadius as shown below. The size is references as the ratio between

the segment from the center of the spiral to the outer most point of the spiral (AB) and half (1/2) the vertical height (HVH).

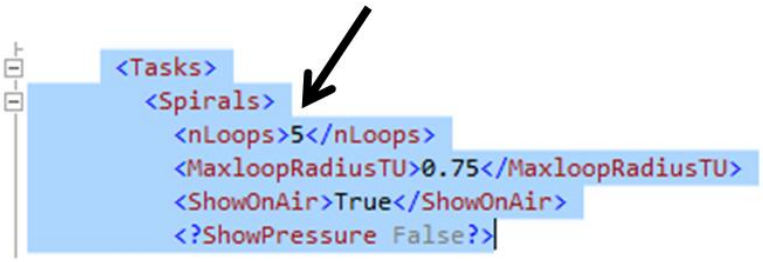
```
<Tasks>
  <Spirals>
    <nLoops>5</nLoops>
    <MaxloopRadiusTU>0.75</MaxloopRadiusTU>
    <ShowOnAir>True</ShowOnAir>
    <?ShowPressure False?>
```

In the example above, this value is 0.75 or [0.75 = AB/HVH]. Re-stating it, the segment AB is 75% of the vertical distance from the top to the center of the screen. These values generate a spiral similar the one shown below. If using a TabletPC, keep in mind that this value would be different if using the TabletPC in landscape mode or using it on portrait mode.



Set the number of loops in the spiral traces.

In this version of Neuroglyphics, users can specify the number of loops in a the CW and CCW spirals by adjusting the parameters <nLoops>5</nLoops> as illustrated below. Currently it defaults to five (5) in the configuration file.



4. Using Neuroglyphics

a. Configuring NeuroGlyphics for data collection

After installation of the appropriate hardware drivers and the latest release of the Neuroglyphics package, the collection of data points from an input device can proceed. The proper operation can be verified using the **Tablet Dx** tab in the GUI (**Figure 1**.) The properties of the input device (stylus, pointing device or other pointing instrument), sample rate, XY position resolution and other facilities supplied by the input device can be viewed.

A snapshot of the current hardware configuration, software configuration, preferences and task in use are persisted along with the captured stream of data (position, pressure, inclination, etc) in such a way that that the recording conditions can be recreated when the serialized data is restored for analysis.

b. Collection Tasks

A variety of tasks are offered for data collection. Each task explores a different aspect of hand control. Together, they provide metrics on various aspects of the kinematic performance of human hand fine motor control (**Figure 2**.)

i. **Archimedes spiral**: For over a century, neurologist and other health care professionals have examined samples of Archimedes spirals in patients with movement disorders (tremor, Parkinson's disease, ataxia, etc) with the aim of extracting categorical information on subject's pen control. Neuroglyphics provides the facilities to present subjects with spirals in the clockwise (CW) and counterclockwise (CCW) directions and to adjust the size and number of loops. Subjects are asked to trace in between lines (or over the spirals) with the pointing device providing the capacity to display on real time feedback on their performance.

ii. **Caligraphy Pad**: A standard calligraphy paper pad with adjustable line separation (adjustments are not operational at present) can be used as a platform to evaluation penmanship performance.

iii. **Static Pointing ("Bull's eye pointing")**: Postural hand control can be evaluated in the task of static pointing in which a subject is asked to point to the center of a bull's eye target with the tip of a stylus or other pointing device. Feedback on proximity, accuracy and applied pressure can optionally be provided in real time. **Blue** circle: out of range, **Green**: in proximity range but not touching, **Red**: Touching.

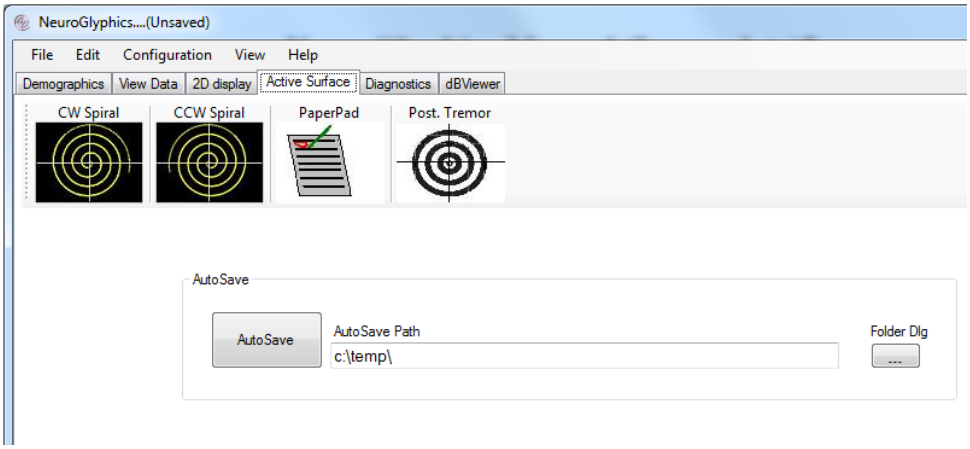


Figure 2. The active surface tab presents an assortment of tasks.

c. Saving collected data

A recording session and all the pertinent information can be persisted digitally via a data header contains information on subjects demographics, date and recording conditions and followed by the output data stream from the input device.

d. Viewing data

A collection of all points relating to a recording session is viewable for review as part of the real-time feedback or by the **View Data** Tab in the main menu (**Figure 3**.).

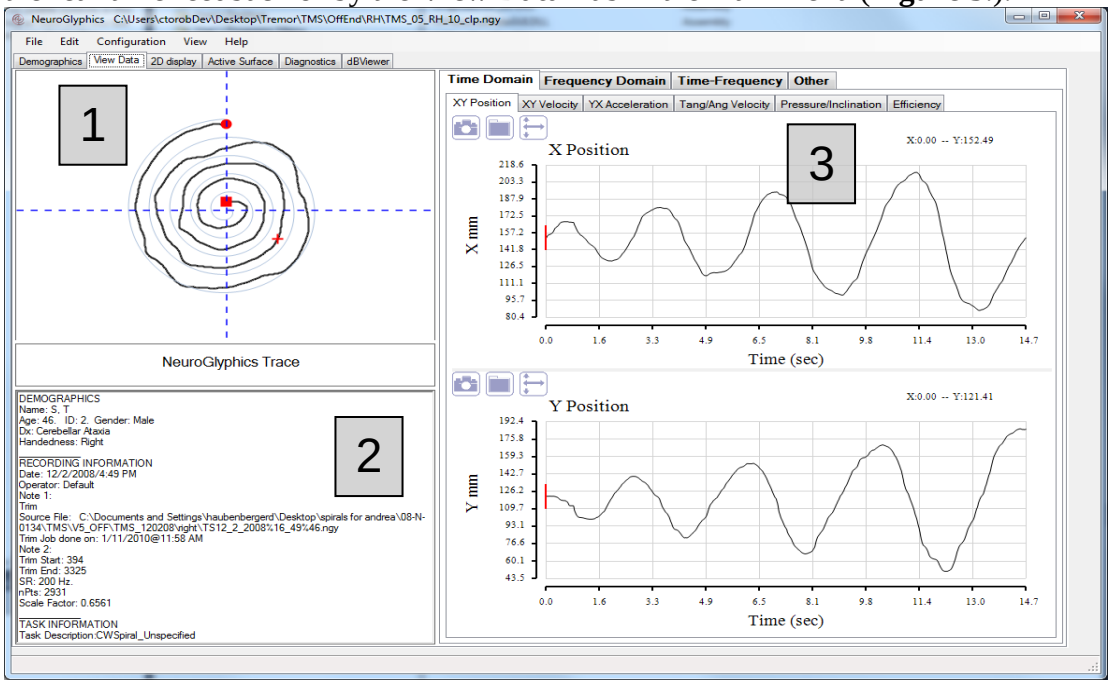


Figure 3. Viewing the Data (View Data Tab). Panel 1 represents the 2D recordings. Panel 2 has a compilation of recordings specs including demographics, recordings history, tasks and prior editing. Panel 3 offers many instantaneous analysis routines.

The View Data tab is intended as a relatively easy way of reviewing your data and extracting some of its fundamental information. It is designed into three main panels.

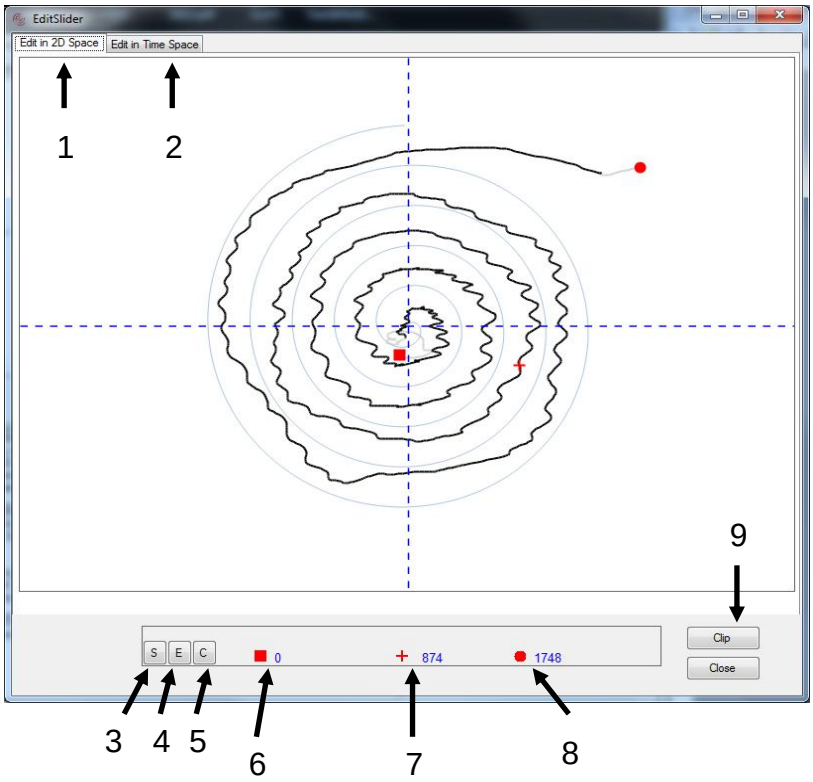
Panel 1 presents an XY display of the data
Panel 2 presents a text compilation of the recording parameters and editinghistory
Panel 3 is a multifunction display panel that divides the analysis display into Time, Frequency, Time/Frequency and other domains. Each one of these selections, lead to additional structured options.

e. Editing data

Currently, NeuroGlyphics file can be edited, or "trimmed" by selecting "**star**t" and "**end**" points or by defining segments of data **centered** at a particular location or time in the recordings.

The task of trimming could be accomplished by selecting in the main menu bar the **Edit** menu and selecting the **Slide**r option. A new window appears for editing. This window has two tabs "**Edit in 2D Space**" or "**Edit in Time/Space**"

The example in **Figure 4a.** illustrates the basic components used in the typical task of editing an Archimedes spiral.



1 & 2. *Toggles edit mode between* **2D-Space** *and* **Time-Space**
3. *Forces "Start" marker to default position (first pt.)*
4. *Forces "End" marker to default position (last pt)*
5. *Forces all markers to default (fist, middle & last pts)*
6. *Current "Start" location*
7. *Current "Middle" location*
8. *Current "End" location*
9. *Proceed with Clipping or cancel by closing*

Figure 4a. Editing a NeuroGlyphics data file

When editing under the 2D Space mode (**Figure 4b**) tab, simply point with the mouse to the desired location for the new start point and click the **left** mouse button. For the end point, do likewise, but perform a **right** mouse button click. The markers should automatically reposition. When a trace overlaps or appears crowded at multiple points in proximity to the desired selection, this method of selection might not give the desired results. In those cases, switching back and forth between 2D and Time/Space (**Figure 4c**) facilitates the proper point selection. The marker values are automatically updated between the two modes.

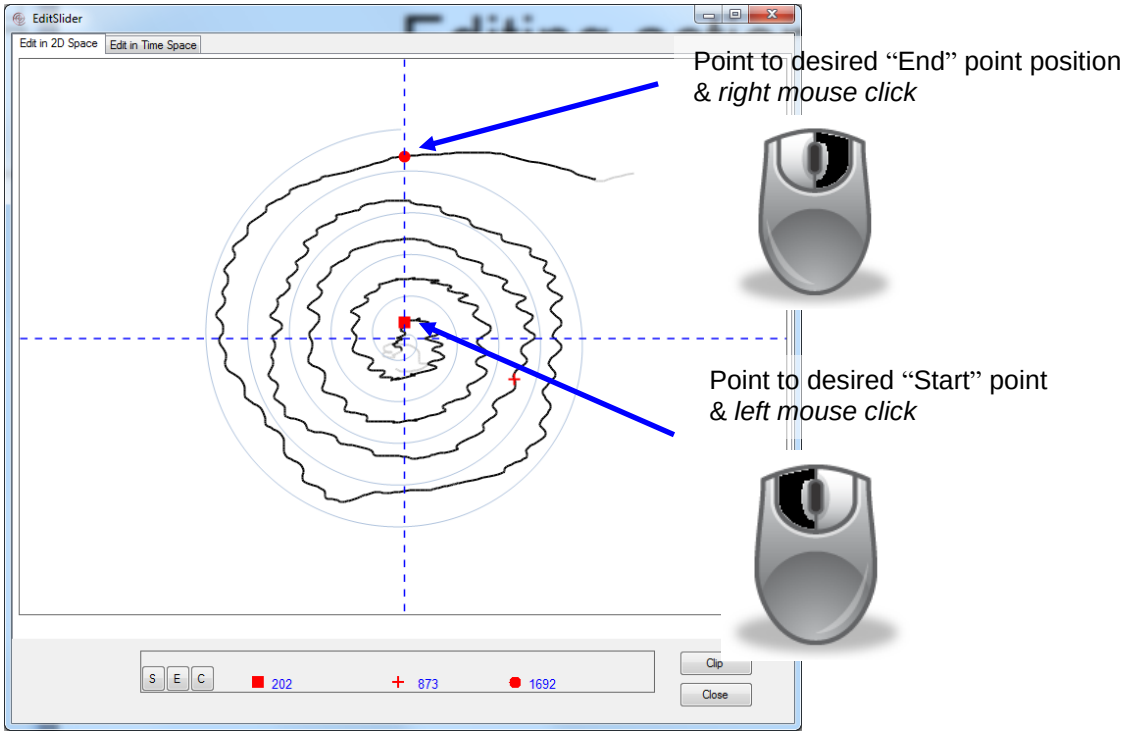


Figure 4b. Editing a NeuroGlyphics data file in 2D-space using the integrated "point and click" editing facilities in 2D space.

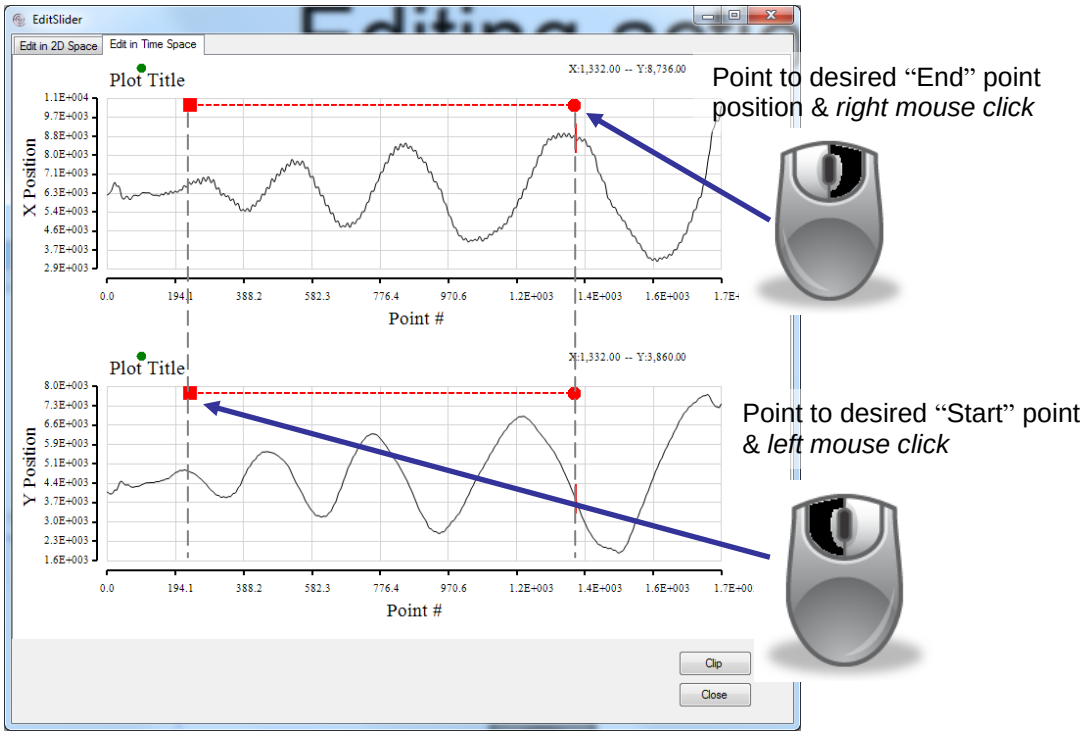


Figure 4c. Editing a NeuroGlyphics data file in Time/Space mode using the integrated "point and click" editing facilities.

After you have selected your start and end points, by clicking the "Clip" button activates and additional dialog (**Figure 4d**) which provides additional option on the clipping mode or gives the user total control on the clip options.

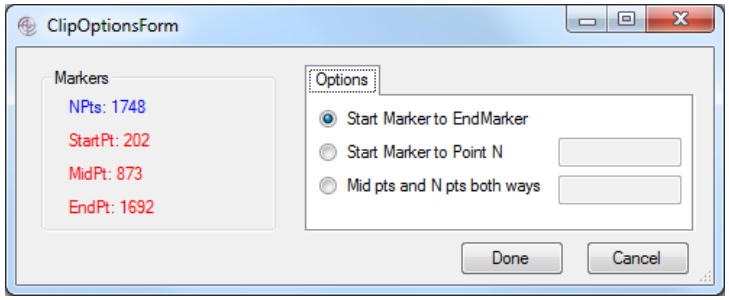


Figure 4d. Editing a NeuroGlyphics by specifying "start", "end", "mid" or "number of points"

After selecting the "Done" button, the newly created data set replaces the "pre" clip dataset. Keep in mind that if your original dataset was not saved, the new one will replace the original and you will lose the capacity to recreate the original unsaved data.

Under the Demographics tab, a note is written indicating the date/time and the specification of the trim job as well as the originating filename. This generates a tracking history of edited files.

f. Data analysis

A NeuroGlyphics dataset is constituted the aggregate of features representing the unique physical properties of the recording device, the conditions of a task presented to the subject via a feedback system including but not limited to visual feedback such as "real-time" feedback on performance (in turn, is controlled by the task engine) and the aggregate of data points collected during the performance of such task. The capacity to control and program the tasks properties of the task and the various analyses for the resulting data points represents the essence and functionality of this work.

The following diagram (figure 5) provides a schematic representation of the building blocks of a dataset [not all implemented yet].

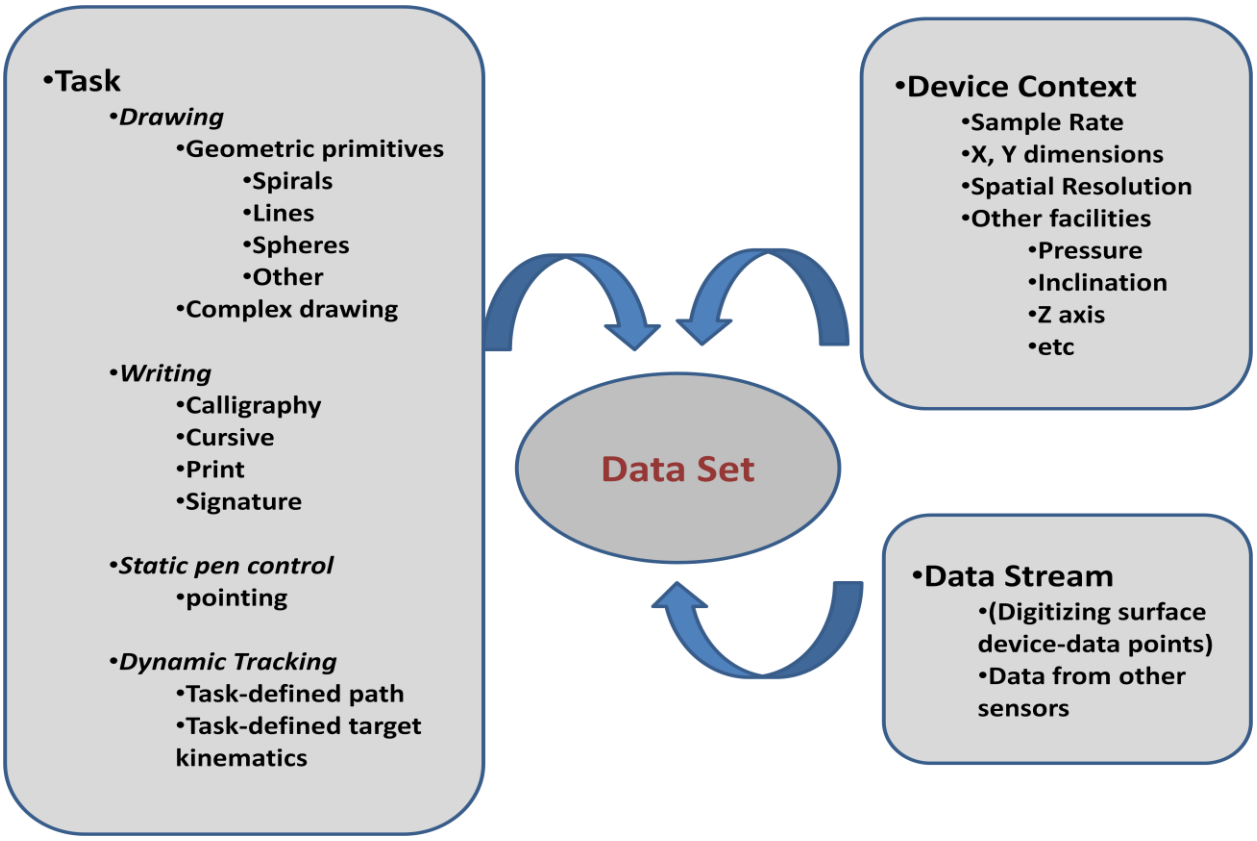


Figure 5

Data analyses are performed of datasets to extract features of the task performance reflective of various aspects of the task execution that reflect aspects of upper extremity motor control. This kinematic information, in turn, can provide insights into relevant psychophysical and neurophysiological phenomena and translates into qualitative and quantitative metrics.

What can be measure with this approach?

1. Actual pen trajectories and pen tip kinematics, pen tip pressure and pen barrel inclination during
    a. Static pointing
    b. Self driven pen excursions with or without visual template (stencil)
    c. Hand writing with patterned surfaces (calligraphy pad)
    d. Dynamic tracking of moving targets over a variety of paths and a variety of target kinematic properties.

Combined with an accurate capture of the physical properties of the tablet and task features, data analysis in a variety of ways leads to a robust estimation of kinematic features.

Data analysis modalities include:

Frequency domain analysis.
A data stream (position, pressure, etc) at high sampling rate generates time series that can be easily analyzed using frequency domain spectral methods such as FFT to explore inherent frequency components of these data. A straight forward application of this approach, for example, is the investigation of hand tremor properties (amplitude, frequency and phase) in subjects with involuntary movement disorders such as Essential Tremor (ET) or Parkinson's disease (PD) (Figure 6).

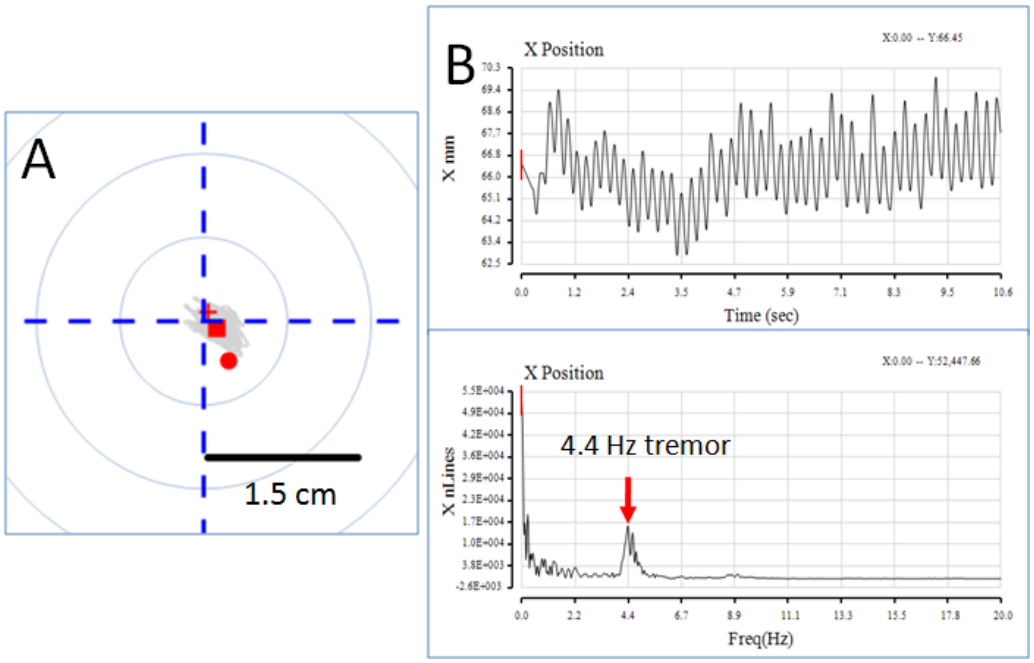


Figure 6. In a static pointing task, a tremor subject pointed to the "bull's eye" target for a period of 10 seconds (A). A low amplitude tremor of about 0.7 cm was recorded (B) with a peak frequency of about 4.4 Hz (C).

A collection of this type of information (i.e.: tremor peak amplitude) over time during and after a therapeutic intervention could serve as an outcome measure to determine the efficacy of such intervention.

Time domain analysis:
Position derivates: Velocity, acceleration and snap are the first, second and third derivatives of position respectively. A dataset of sequentially collected pen tip position points at a high degree of temporal and spatial resolution provide the substrate from which pen tip velocity and acceleration can be achieved by numerical differentiation (Figure 7).

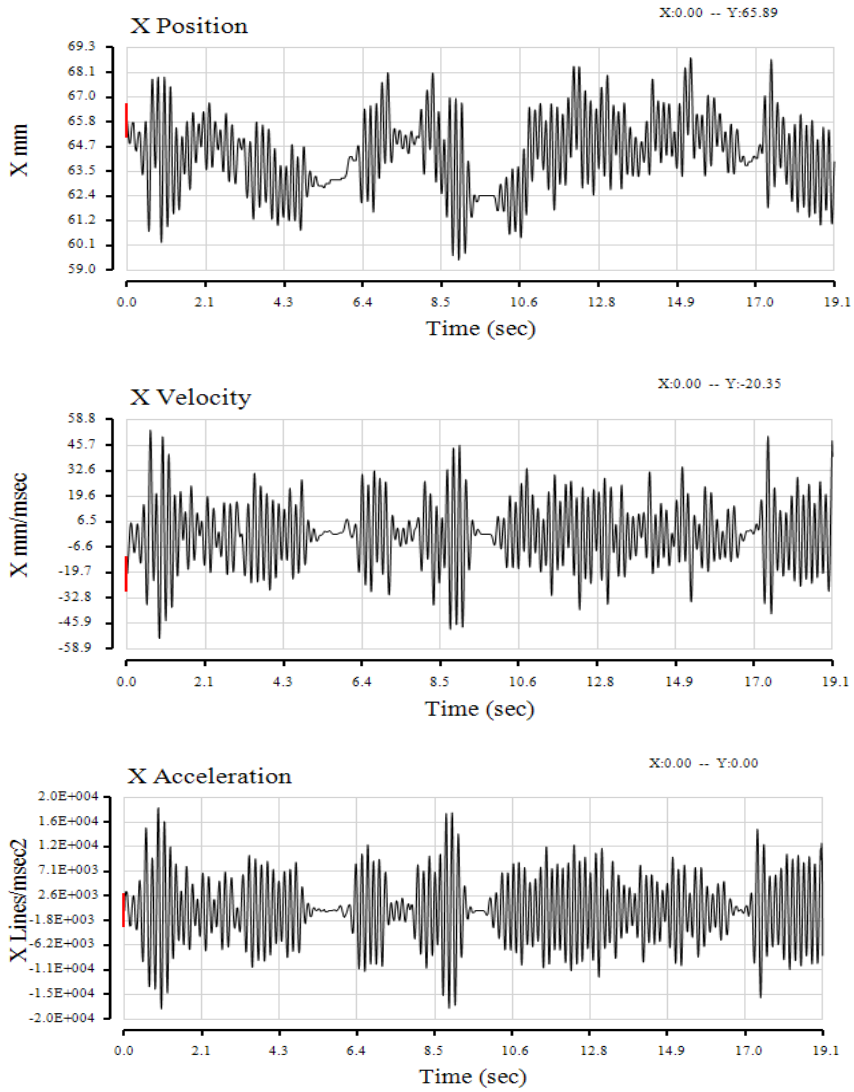


Figure 7. Pen tip position (X axis) recording in a subject with tremor and the corresponding first and second derivatives (velocity and acceleration) **.**

Pen Inclination Analysis

Inclination analysis as a tool to investigate and characterize disorders of pen grip control such as hand dystonia (writer's cramp) (Figure 12).

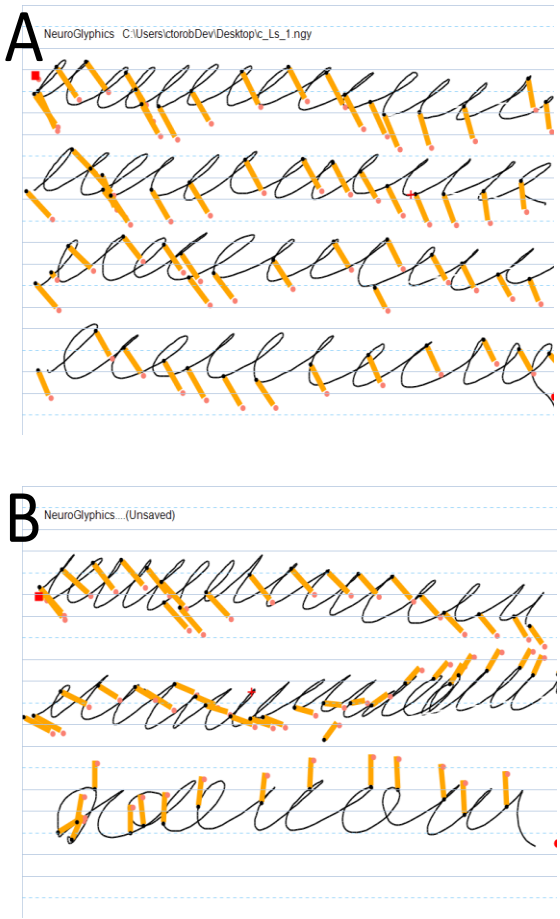


Figure 12. Pen elevation and inclination are here represented as the 2D projection of the pen onto the paper surface. Normal writers exert a good grip control and persist thru writing with a fairly invariant inclination/angle pattern (A) while a subject with writer's cramp changes its grip as writing progresses.

Time/Frequency analysis

Time-frequency analysis provides a combination of the two previously mentioned approaches to analysis of pen tip kinematics. (Figure 13)

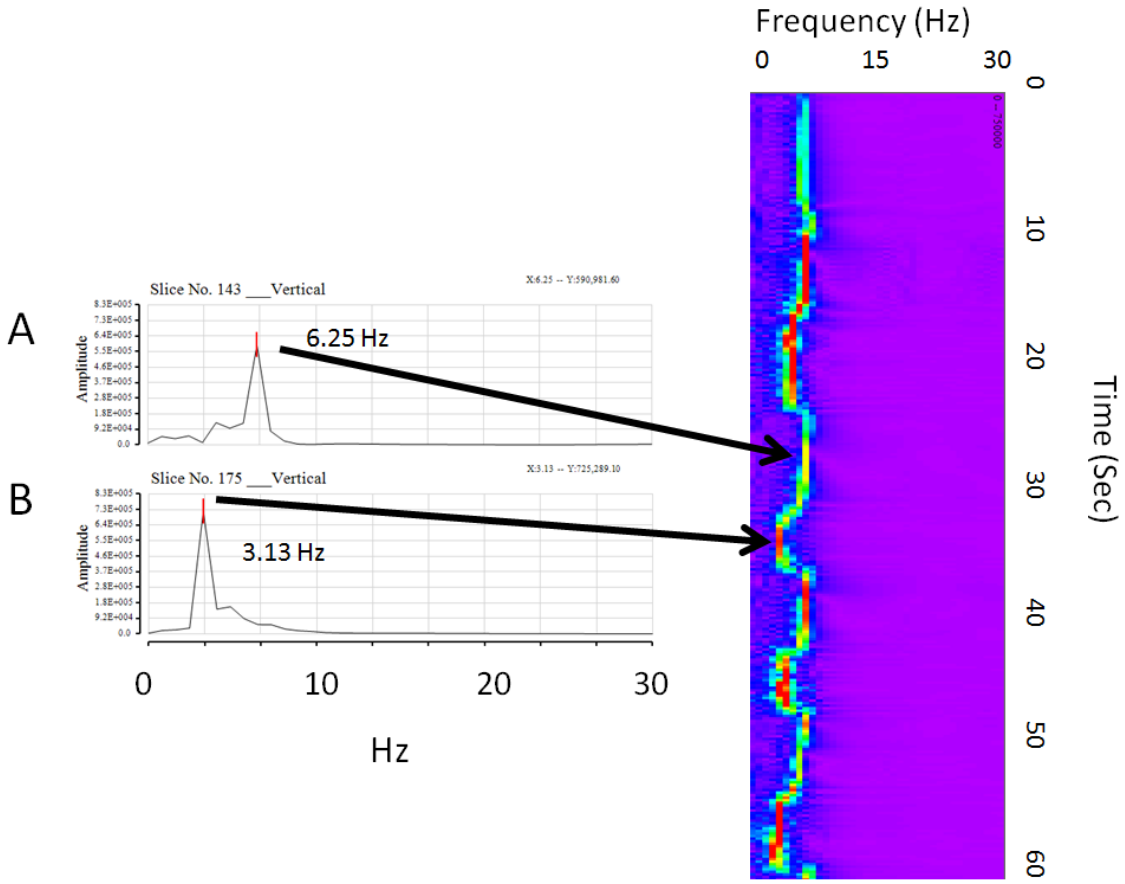


Figure 13. representation of a tremor with highly variant peak frequency. This pattern is highly suggestive of voluntary control of movement oscillatory behavior as seen in people with feigned tremor.

g. Export and Import of data

Exporting data in and out of NeuroGlyphics is not fully implemented but it is functiona.

Export/Import Data function is accessible for the File menu selecting the corresponding item in the menu. You are presented with the Export/Import dialog that is self explanatory.

At present, the program **export** only export a time stamp, X, Y, and pressure and the user can select comma or tab delimitation.

Import allows users to bring into Neuroglyphics data collected under different platforms. The expected format is (with option of tab or comma delimitation)

a) Time stamp,
b) X,
c) Y
d) Pressure

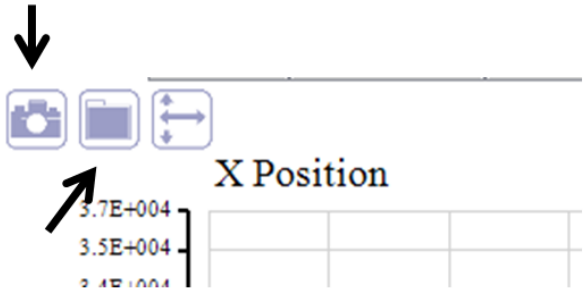
Since Neuroglyphics treats points as a time series, a time stamp is required. In the import function, there is also the possibility to define a "device context" which in essence is a description of the features of the instrument used to collect the points including its time resolution (Hz.), its special resolutions (#lines/cm) and the surface dimensions (in mm). See the default ImportContex.xml file in the directory **C:\Users\[User Name]\Documents\NeuroGlyphics\Configuration**.

This file can be edited to fit your specifications, thus, with no need to re-enter the custom context with each import. The fields are self explanatory.

h. Export Plots and Plot data:

The icons in many of the displays provide a simple way of capturing results or preparing traces to be exported to other publication quality packages or for further analysis.

Places a pixel based image in the clipboard.



Fills the clipboard with

a) Y values of the plot (R. mouse button click)

b) XY values of the plot (L. mouse button click)

- Pre release features

Please contact me about other features not included in this manual:

1. Macro functionality
2. Spiral Error reporting
3. Dynamic tasks
4. Curvature analysis

Camtorbri -at- gmail -dot- com