Graphical Analysis with Gnuplot
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Outline

1. Introduction to gnuplot
2. Gnuplot in practice
3. Plot examples
4. Output and terminals
Introduction to Gnuplot
Graphical Analysis

- The art of discovering relationships in data & extracting information from it by visual means
- Gnuplot: the state-of-the-art tool for graphical analysis
About Gnuplot

A command-line open-source program for graphically exploring, plotting and visualizing data.

- Thomas Williams, Colin Kelley 1986
- Gnuplot is not GNU & not released under a GPL license
- Gnuplot solves data analysis problems with graphical methods
- Graphs quality: Polished (publications) or simple (exploratory)

Available in all platforms!

Tip

*Install the wxwidgets variant. It contains the powerful terminal wxt.*

(More about terminals later on)
How it works

• **Iterative process** of graphical analysis **via the command-line**:
  – Issue commands at prompt & gnuplot redraws the plot
  – Output is generated and displayed **immediately**
  – Still can be used in **batch-mode**

• **Do not get scared with the command line!**
  – Very easy to use! Does not require programming skills!
Why Gnuplot

- Stable, mature and actively maintained
- Free and open source - available to all platforms
- Highly customized visualizations - you can control everything
- Supports all common graphics formats
- Reads input text formats and tolerates inconsistent formatting
- Highly scalable - Supports millions of data points
- Requires limited resources

However, gnuplot is neither a statistical program nor a drawing tool!
Gnuplot in Practice
Runtime I

- Starting and exiting gnuplot:
  >gnuplot
  >exit

- Choosing the terminal:
  >set terminal wxt enhanced

- Issue commands:
  1. Directly at the command line or
  2. Load a gnuplot script at the command line:
     >load "script.gp"

- Gnuplot scripts development:
  1. Write at a text file and issue:
     >load "script.gp"
  2. Write at the command line and issue:
     >save "script.gp"
Runtime II

- Accessing and plotting data:
  >plot "data.txt"

- Resetting all options to system defaults:
  >reset

- Clears the current output device:
  >clear
Selecting Data

• Selecting columns:
  > plot "data.txt" using 1
  > plot "data.txt" using 1:3
  > plot "data.txt" using 1, "data.txt" using 3, ...

• You can add comments directly in your data with '‐
  – Gnuplot ignores these lines

• You can choose the field separator:
  > set datafile separator ","

• Multiple data blocks in one file:
  – Separation with two blank lines
  – Accessing specific blocks:
    > plot "data.txt" index 0:1 using 1
Controlling the Appearance

Test plot styles: dots, points, lines, linespoints, impulses

```plaintext
>plot sin(x) with style

>set title "My cool plot"
>set style line 1 lt 2 lw 2 pt 3 ps 0.5
>set xlabel "My X axis"
>set xlabel "My Y axis"
>set xtics 1,20,100
>set xrange [1:100]
>set yrange [1:100]
>set key top right
>set size square
>replot
```
Operators, Constants & Functions

Performing on-the-fly operations on the data:

\[ \text{plot } "\text{data.txt}" \text{ using } (\sqrt{\$1}) \]
\[ \text{plot } "\text{data.txt}" \text{ using } (\sqrt{\$1/100}) \]

Plotting functions and defining variables:

\[ \text{plot } \sin(x) \]
\[ \text{set } \text{xrange } [0:250] \]
\[ \text{plot } \sin(x)*(x**2) \]
\[ a=10 \]
\[ \text{show variables} \]
\[ \text{plot } \sin(a*x)*(x**2) \]
Plot Examples
Demos

Demos in gnuplot homepage:
http://gnuplot.sourceforge.net/demo_cvs/

- Simple plots: http://gnuplot.sourceforge.net/demo_cvs/simple.html
- Error bars: http://gnuplot.sourceforge.net/demo_cvs/mgr.html
- 3-D palette-mapped: http://gnuplot.sourceforge.net/demo_cvs/pm3d.html
- Cool "bars": http://gnuplot.sourceforge.net/demo_cvs/barchart_art.html
- Gantt charts: http://gnuplot.sourceforge.net/demo_cvs/gantt.html
Output and Terminals
Output and Terminals

Gnuplot supports more than 70 terminals!

>set terminal

Terminals are classified into 3 categories based on their output:

1. Standard graphics file format, e.g. GIF, JPG, PNG, SVG
2. Output for print, e.g. PostScript and PDF
3. Terminals for interactive use
Saving to PNG

A script "export.gp" to export a plot to a PNG file:

```
save "myplot.gp"
set terminal push
set terminal png
set output "output.png"
replot

Calling the script:

>call "export.gp"
```
Saving to Standard Graphics

A more generic script:

>save ARG1.".gp"
>set terminal push
>set terminal ARG2
>set output ARG1.".".ARG3
>replot
>set output
>set terminal pop

Calling the script:

>call "export.gp" "myplot" "pdfcairo" "pdf"
You can output plots in \LaTeX in at least four different ways:

- Output EPS files and use in a \LaTeX document

  > set terminal postscript eps enhanced
  > set output "output.eps"
  > replot
Gnuplot and Latex II

- Output PDF files and use in a \LaTeX\ document
  
  >set terminal pdfcairo enhanced
  >set output "output.pdf"
  >replot
Gnuplot and Latex III

- Use of the epslatex terminal and the \input{output.tex} \LaTeX command:

```plaintext
>set ylabel '$\sigma$'
>set terminal epslatex
>set output "output.tex"
>replot
```
Gnuplot and Latex IV

• Use of the gnuplottex package
  \usepackage{gnuplottex}
  ...
  \begin{figure}[htbp]
  \begin{centering}
  \begin{gnuplot}[terminal=pdf]
  load "myscript.gp"
  \end{gnuplot}
  \end{centering}
  \end{figure}
Interactive Terminals

- **wxt**
  - In wxWidgets. Uses Cairo & Pango libs for graphics & text
  - Cross-platform
  - High-quality graphics (anti-aliasing)
  - Interactive menus

- **x11 Unix terminal**
- **Aqua MacOS terminal**
- **windows Microsoft Windows terminal**
- **Many other, e.g. check dumb terminal :)**
Comparing Terminal Appearance

Use the test command:

```
$ xterm -test
```

Enhanced text: \textit{Bold} \textbf{Italic}

- linewidth
- left justified
- centre-d text
- right justified
- test of character width:
- filled polygons:
- pattern fill:

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Things to Remember

• Plot size vs canvas size
• Terminals handle the fonts, not gnuplot! e.g.:
  >set terminal wxt font 'Verdana, 20'
• Enhanced option:
  >set terminal wxt enhanced
  – Provides more appearance options
  – E.g. use of Greek letters, subscripts and superscripts
Proposed Literature

P. K. Janert.  
*Gnuplot in Action: Understanding Data with Graphs.*  
Manning Publications Co., Greenwich, CT, USA, 2009.

But also check the latest documentation:  
http://www.gnuplot.info/docs_5.0/gnuplot.pdf
What is next?

- Machine learning and data mining