

12.010 Computational Methods of Scientific Programming

Matlab Lecture 4
Lecturers
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Review of Last Lecture

- Analysis of some of the functions needed for the GUI development in Matlab
- Look at functions which would be appropriate for the GPS data analysis GUI
- Looked at how to use graphics objects

Today's Lecture

- This is the last lecture on Matlab
- Analyze a complete GPS time series data analysis program
 - Basic idea is to display position estimates as function of time and to work with these data
 - Operations:
 - De-trending (rate of change and breaks)
 - Editing
- Implementation through a Graphical User Interface (GUI)

Aims and Layout of program

- The GUI layout was designed using the Matlab `guide` tool.
- Basic features of GUI:
 - Time series of GPS positions are stored in files which contain 3 header records and then
 - time (in decimal years),
 - position (north measured as distance from equator, east measured as distance from Greenwich meridian, Up as ellipsoidal height). Values in meters
 - Uncertainty given as a standard deviation
 - Since the positions are large numbers, the leading digits greater than 10 meters are removed from the values in the file.

GUI Features

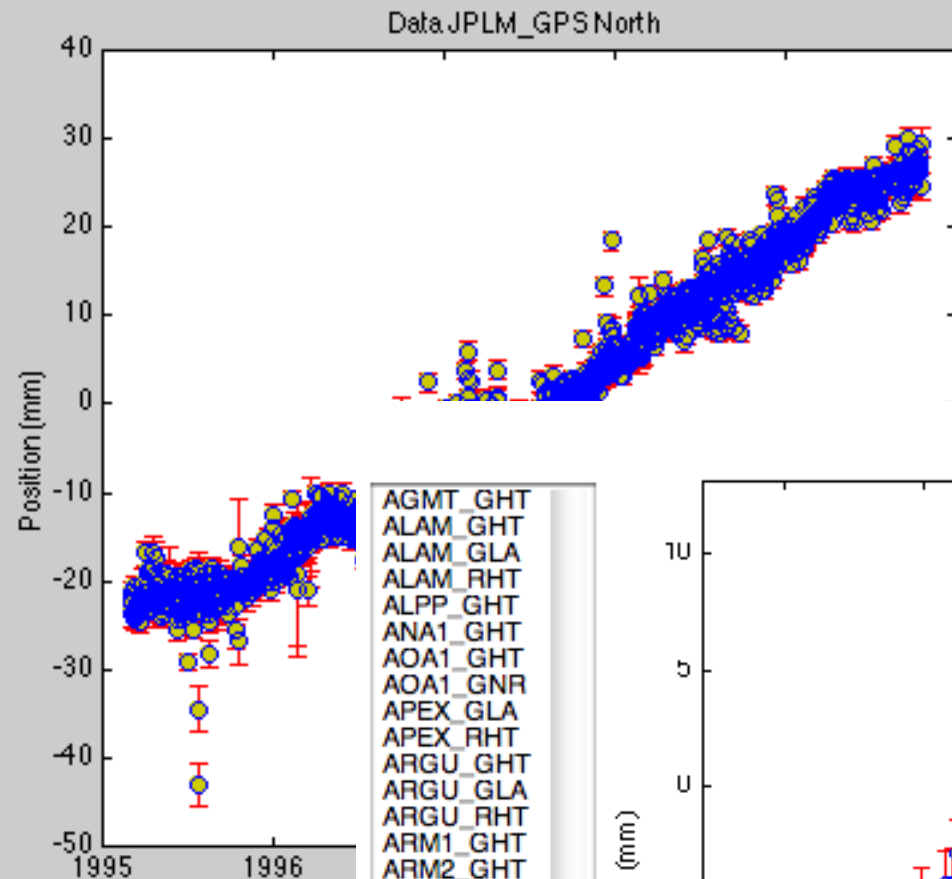
- GUI needs to be able to:
 - Load data file
 - Append another file to the loaded file (needed since the data file are separated into before and after a major earthquake in California: Hector mine Oct 17, 1999)
 - Remove the linear trend from the data and possible jumps in the time series
 - Edit the time series (both as individual points and a selected region of the data)
 - Allows breaks when there appears to be jumps in the time series to be added
 - Allow zoom of the plot so that break times can be set.

GUI Features 02

- Figures below shows the lay out the GUI from different versions of Matlab

FYPK_GHT
FYPK_GPS
FXHS_GPS
FZHS_GPS
GMRC_GHT
GOL2_GHT
GOL2_GPS
GOLD_GPS
HARV_GPS
HCMN_GHT
HOLC_GHT
HOLC_GPS
HOLP_GHT
HOLP_GPS
ISLK_GPS
JOHN_GPS
JPLM_GHT
JPLM_GPS

North

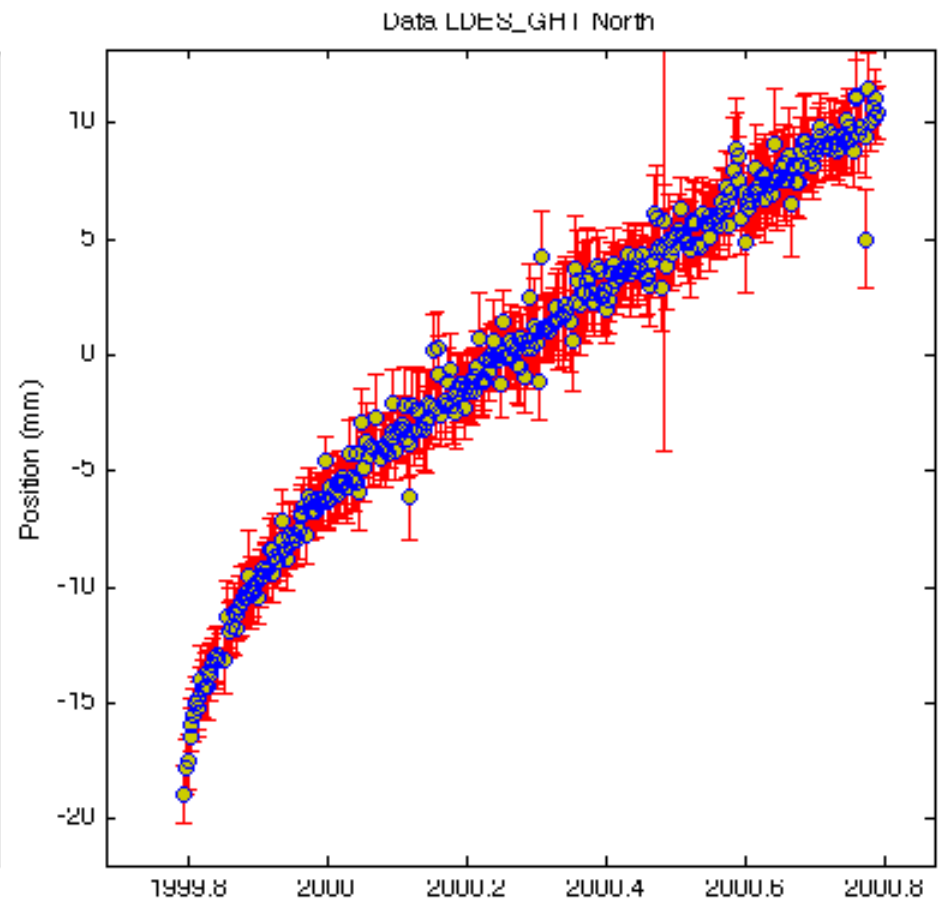


Load

Append

Detrend

AGMT_GHT
ALAM_GHT
ALAM_GLA
ALAM_RHT
ALPP_GHT
ANA1_GHT
AOA1_GHT
AOA1_GNR
APEX_GLA
APEX_RHT
ARGU_GHT
ARGU_GLA
ARGU_RHT
ARM1_GHT
ARM2_GHT
AVRY_CHT
AVRY_CNR
AVRY_GNR
AZRY_GHT
AZRY_GLA
AZU1_GHT
AZU1_GNR
LDES_CHT
LDES_GHT
LDES_GLA
LONG_GHT



Load

Append

Detrend

Edit

Block Edit

Break

Zoom

GUI Features 03

- In MatLab code that implements the GUI is contained in the M-files, GPSanal.m and gpsgui.m. (These files are in the Matlab section of the web page). GPSanal.mat is also needed to initialize some variables (can be avoided)
- In the lecture, these M-files will be examined in detail.
- The features of the GUI are:
 - Rather than listing file names, the names of the sites are extracted from file names and user selects a site and a component (North, East, Up)
 - The file name is regenerated by re-concatenating the parts of the file name back together.

GUI Features 04

- Nearly all of the callbacks for the GUI use the `gpsgui.m` function M-file and a series of cases in a `switch` function. (This approach has the advantage on not requiring large number of M-files to implement the GUI.)
- Because functions “forget” their values between calls (unless `global` or `persistence` is used specifically save values), the `gpsgui.m` function saves the values needed in the `UserData` structure for each of the objects.
- Some of the handles are known when the GUI is called because the handles of the call back objects (`gcbo`) are available, but in other cases we need to find the object using the `findobj` function and a unique Tag added to each object.

Algorithms needed

- The main algorithms needed by this GUI are:
 - Least square fitting: We want to fit a function of the form
$$\text{pos}(t) = \text{pos}(t_0) + \text{vel} * (t - t_0) + \text{Sum}(\text{dpos}_i)$$
where $\text{pos}(t)$ is position at time t ,
 t_0 is a reference time (we use the mean time)
 vel is velocity
 dpos_i are jumps in the time series at time given by the break times.
 - We can write the above equation in matrix form by making $\text{pos}(t)$ a vector and the quantities to be estimated another vector

Algorithms 02

- Defining another vector soln with entries
 $\text{soln} = [\text{pos}(t_0) \text{ vel } \text{dpos}_1 \text{ dpos}_2 \dots \text{dpos}_n]$
where n is the number of breaks
- Matrix form of equation is written as
 $\text{pos} = A^* \text{soln}$
where A is made up of rows that look like:
 $A = [1 (t-t_0) 0 0 \dots 1]$
where the last group $[0 0 \dots 1]$ depend on when the time of the measurement is with respect to the times of the breaks. The column value is 1 for all data times after the time of a break

Solution to Least squares problem

- Solution to the above problem is given by
$$\text{soln} = \text{inv}(A' * A) * A' * \text{pos}$$

(see Detrend case in gpsgui.m)
- We also compute the root-mean-square (RMS) of the fit to the model using
$$\text{rms} = \text{sqrt}(\text{res}' * \text{res} / \text{numdata})$$

where res is the residual vector computed as the difference between the observed positions and the model estimate of the position, and numdata is the number of data.
- The rms of the residuals is used to estimate the standard deviation of the model parameter estimates.

Analysis of GUI

- Run through the `gpsgui` function, examining the way that the call backs and the objects in the GUI interact.
- The main features to examine are:
 - Use of `UserData` to save values
 - Use of tags to name and find objects
 - Use of button tool tips
- The sequence of using the GUI is to select a site and component (left hand sided options), Load the data, possibly select a continuation of the data and append it. Detrend and the edit, block edit, break, and zoom features allow detailed analysis of the data.

Data access in GUI' s

- Basic approaches are:
 - Use persistent variables. Easiest but there are problems if multiple instances of the GUI are used
 - Store the data (often as a structure) in the User Data part of the handle for a particular object. (This is method used examples)
 - Use the `getappdata`, `setappdata`, `rmapppdata` and `isappdata` to get data, set data (done first), remove data. Generally tag is used to find correct handle.
 - Use `guidata` to save data in figure handle and retrieve data using `data = guidata(gcbo);` [graphic call back object). With this approach switchyard programming is not needed.

Final GPS Analysis tool

- On the web page, under Matlab is also the final version of GPS analysis tool called tsview.m
- This tool has the GUI interface re-arranged and enhanced with new button and features.
- This version also explicitly accounts for screen size and has a ResizeFcn to correctly change the GUI when the window is re-sized.
- EasyGUI is a toolkit for making GUI' s and is available from:
<http://www.mathworks.com/matlabcentral/fileexchange/22936>

Conclusions

- In general in using Matlab: Use the helpdesk and helpwin to find functions that could be useful
- Remember the basic features of the language in the way that arrays, structures and cells are defined
- Remember the range selection devices
- Remember the control structures
- Remember that functions forget their values (and handles can forget the UserData and Tags as well).
- Matlab is very powerful for quick and easily set up problems for analyses involving matrices.
- **Homework #5 has been set and is due December 1, 2011**

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