Stanford GPS/GNSS Matlab Platform

Integrated Research Platform with Unbounded Positioning Database

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Stanford GPS/GNSS Matlab Platform

- Stanford GPS Matlab Platform (SGMP) is a platform that enables you to use GPS/GNSS measurements in various formats for your GPS research activity.
Key Aspects of SGMP

- **Everything Matlab**
  Matlab has been most popular for GPS/GNSS research. So let’s move everything to the world of Matlab for seamless and uninterrupted research.

- **Access to Unbounded Database**
  Convert positioning database in various formats (NSTB, NMEA, RINEX…) to a single format in Matlab.

- **Integrated Platform**
  SGMP is a platform intended for GPS simulation as well as measurement interface. Any simulation based on SGMP format can operate under SGMP platform.
Components in SGMP

- **Measurement Interface**
  Convert various formats to SGMP format.

- **GPS Simulator**
  Position estimation, RAIM research…

- **User Interface**
  Provides user control.
Measurement Interface

- An interface to various formats of GPS intermediate measurements (psuedorange). All supported formats of measurements are converted to a Matlab format.

- Extension to other sensors (TV, WiFi, INS…)?
Input Formats: NSTB, …

- **National Satellite Test Bed (NSTB)**
  A data format for Test Bed Reference Station (TRS) and WAAS Reference Stations (WRS) data. The recorded data includes GPS measurements; ephemeris and almanac data; GEO measurement and WAAS broadcast data; as provided by the GPS receivers at the Reference sites.

- **Receiver Independent Exchange Format (RINEX)**
  A data interchange format for raw satellite navigation system data. This allows the user to post-process the received data (usually with other data unknown to the original receiver, such as better models of the atmospheric conditions at time of measurement) to produce a more accurate solution.

- **National Marine Electronics Association (NMEA)**
  NMEA 0183 (or NMEA for short) is a combined electrical and data specification for communication between marine electronic devices such as echo sounder, sonars, anemometer (wind speed and direction), gyrocompass, autopilot, GPS receivers and many other types of instruments. It has been defined by, and is controlled by, the U.S.-based National Marine Electronics Association.
Output Format: SGMP

- Structured data tree
- \textit{rx} contains information and measurements by a receiver during a specific time frame.
- \textit{rx.info}, \textit{rx.meas}, and \textit{rx.aiding}.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>info</td>
<td>receiver and data file information</td>
</tr>
<tr>
<td>meas</td>
<td>measurements by receiver</td>
</tr>
<tr>
<td>aiding</td>
<td>aiding information from external sources</td>
</tr>
</tbody>
</table>
- `rx.info` contains receiver specific static information such as receiver type and the start and end time of overall data file.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>User defined receiver identification number</td>
</tr>
<tr>
<td>sitename</td>
<td>receiver site name</td>
</tr>
<tr>
<td>type</td>
<td>receiver type</td>
</tr>
<tr>
<td>initpos</td>
<td>initial position of receiver in XYZ (meter) and equivalent to true position for stationary receiver</td>
</tr>
<tr>
<td>gpswk</td>
<td>reference time in gps week number</td>
</tr>
<tr>
<td>starttow</td>
<td>start time of reception in time of week (second)</td>
</tr>
<tr>
<td>endtow</td>
<td>end time of reception in time of week (second)</td>
</tr>
</tbody>
</table>
**rx.meas.tx** contains transmitter specific measurements for given reference measurement time.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>prn</td>
<td>transmitter identification number. prn for GPS satellites</td>
</tr>
<tr>
<td>numch</td>
<td>number of channels for this transmitter</td>
</tr>
<tr>
<td>pr</td>
<td>pseudo-range (meter)</td>
</tr>
<tr>
<td>cr</td>
<td>carrier-range (meter)</td>
</tr>
<tr>
<td>dp</td>
<td>Doppler (meter/second)</td>
</tr>
<tr>
<td>snr</td>
<td>signal-to-noise ratio (dBHz)</td>
</tr>
<tr>
<td>slip</td>
<td>cyclic slip counter (0-7)</td>
</tr>
</tbody>
</table>
**rx.aiding**

- **rx.aiding** contains aiding information provided by external sources such as GPS satellites and WAAS satellites. Includes *eph, waas, almanac, iono, utc, tms, tus, sqm, sqminfo, and waassstatus*.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>eph</em></td>
<td>ephemeris and clock parameters from GPS navigation message</td>
</tr>
<tr>
<td><em>waas</em></td>
<td>WAAS broadcast message</td>
</tr>
<tr>
<td><em>almanac</em></td>
<td>almanac message</td>
</tr>
<tr>
<td><em>iono</em></td>
<td>ionosphere (Klobuchar) message</td>
</tr>
<tr>
<td><em>utc</em></td>
<td>UTC message</td>
</tr>
<tr>
<td><em>tms</em></td>
<td>TMS to TUS message</td>
</tr>
<tr>
<td><em>tus</em></td>
<td>TUS to TMS message</td>
</tr>
<tr>
<td><em>sqm</em></td>
<td>SQM message</td>
</tr>
<tr>
<td><em>sqminfo</em></td>
<td>SQM information message</td>
</tr>
<tr>
<td><em>waassstatus</em></td>
<td>WAAS subsystem status message</td>
</tr>
</tbody>
</table>
Now We’re Ready to Rock!

*GPS Simulator* is a block allocated for signal processing functionalities based on data from *Measurement Interface*. A sample program is provided which can be modified according to user’s needs.
Example: Position Fixes

- Position Estimation

"Acv EPak 1330 1514 00 0.mat" at (41.0, -124.1, 56.2m)

100.0% success with 1.0m (2drms)
Example: Position Fixes (cont’d)

"Acv EPak 1330 1514 00 0.mat" at (41.0, -124.1, 58.7m)

Position error \((\mu, \sigma)\) = -0.0 0.5

\((\mu, \sigma) = 0.0 0.6\)

\((\mu, \sigma) = -0.0 1.5\)
How it works: Setting Up

- Go to waas.stanford.edu

- Download and unzip SGMP.zip

- You’ll see following directories created under /SGMPrelease:
  - /SGMPrelease/document
  - /SGMPrelease/measurement interface
  - /SGMPrelease/simulator
  - /SGMPrelease/user interface
How it works: Parsing

- **Getting NSTB Data**
  - Go to [http://www.nstb.tc.faa.gov/DisplayNSTBDataDownload.htm](http://www.nstb.tc.faa.gov/DisplayNSTBDataDownload.htm)
  - Download and unzip NSTB files
  - Move the unzipped NSTB files to /SGMPrelease/measurement interface/data/nstb

- **Parsing**
  - To parse all NSTB files, use /SGMPrelease/measurement interface/batchparseNSTB.m
  - To parse a NSTB file, use /SGMPrelease/measurement interface/parseNSTB(filename, starthour, endhour, crccheck)
    
    ```
    ex) rx = parseNSTB('Acv_EPak_1330_1514_00', 1, 5, 0);
    %parse NSTB file from 1 hour to 5 hour without CRC checking
    ```
How it works: Positioning

- **Positioning**
  - After parsing NSTB files to SGMP files (located under `/SGMPrelease/measurement interface/data/parsed`), we are ready to rock!
  - Start Matlab and go to `/SGMPrelease/simulator/`
  - Execute `batchPosfixSGMP.m`
  - Alternatively, use `posfixNSTB(filename)`

- **Results**
  - Go to `/SGMPrelease/simulator/result/posfix/`
  - Check out `*.mat`, `*.fig`, or `*.eps` files for results
SGMP (Stanfor GPS/GNSS Matlab Platform) is a Matlab based platform providing access to multi-format positioning database.

SGMP enables you to tap into existing and ever-growing database regardless of formats.

Standardized format (SGMP) opens door to research collaboration and connection b.t. generations of students.
What’s next…

- **Measurement Interface**
  - Support for NMEA, RINEX, …
  - Extension to other sensors such as TV, WiFi,…

- **GPS simulator**
  - Add more blocks (RAIM simulation, differential positioning, …)
  - For example, NSTB provides dual frequency code and carrier measurements. Lots of possibilities.

- **User Interface**
  - Implement a “Per”-friendly GUI?
Reference

1. NstbDataFormat1103.doc Description of NSTB format

2. www.nstb.tc.faa.gov/DisplayNSTBDataDownload.htm NSTB data files are provided.


4. SGMP.zip
Thanks!

Thanks to Euiho and Grace for their earlier works for NSTB data.

Thanks to Todd, Juan and Per for their inputs to SGMP.

Thank you, everyone!