Title: GNSS Lab Report

Lab 1: GNSS Positioning

Course:	AAE4203 — Guidance and Navigation
Group:	Group 8
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Abstract

This template demonstrates how to structure a PolyU lab report using the hkpolyu-labreport class. It includes examples of figures, tables, equations, code listings, and citations, while conforming to page and submission requirements.

Keywords: template, GNSS, SPP, least squares, figures, tables, citations, code

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1 Template Usage (Quick Guide)

- Place hkpolyu-labreport.cls in the same folder as main.tex.
- Use \setlogo{polyu-logo.png} to set the HK PolyU logo (PNG/JPG/PDF).
- Fill metadata fields (title, author, student ID, course info) at the top of this file.
- Compile with XeLaTeX or PDFLaTeX. If you see BoundingBox errors, avoid DVI mode.
- Keep the report within 10 pages; in-report code listings within 2 pages.
- Put complete, well-documented source code and raw data in your GitHub repository.

2 Data Collection

Describe the data collection process conducted near Block X: - Hardware setup (receiver, antenna, mount height). - Software tools (logging, parsing). - Environmental conditions (obstructions, weather, time).`

Hardware Setup: Connect the GNSS Receiver and Antenna to Laptop.

Environmental conditions: Tall buildings, Sunny, 11 a.m.

Software tools: Logging data by U-center. First, select the COM port for the receiver and set the baud rat to 9600. Then, start recording. Finally, stop the recording after collecting enough data.

Example figure (site photo or map):

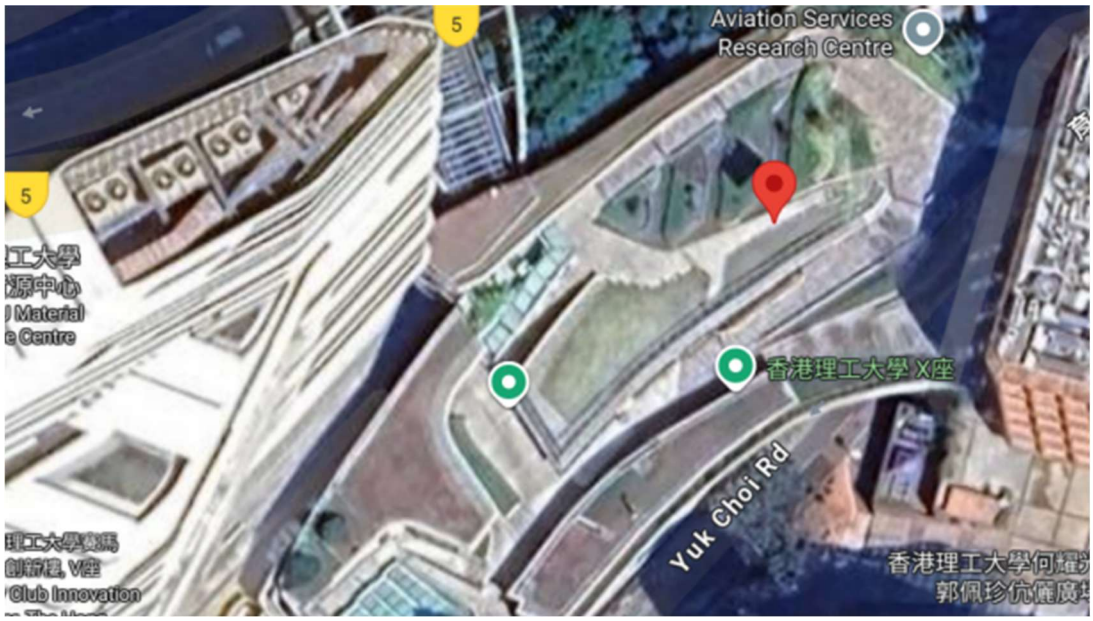

Figure 1: Data collection environment near Block X (placeholder).

Example table (log summary):

Table 1: Data collection summary (example format).

Field	Value
Location	Vicinity of Block X
Duration	30 min @ 1 Hz
Receiver	Multi-constellation GNSS
Conditions	Urban campus, partial obstruction

3 Raw Data Analysis

Summarize raw measurements and quality indicators: - Observed satellites per epoch, C/N0, GDOP, flags.

First, run RTKCONV from RTKLIB launcher and convert the raw data to u-box UBX format. Then, open the ubx format data on u-center and plot the graphs.

Graph:

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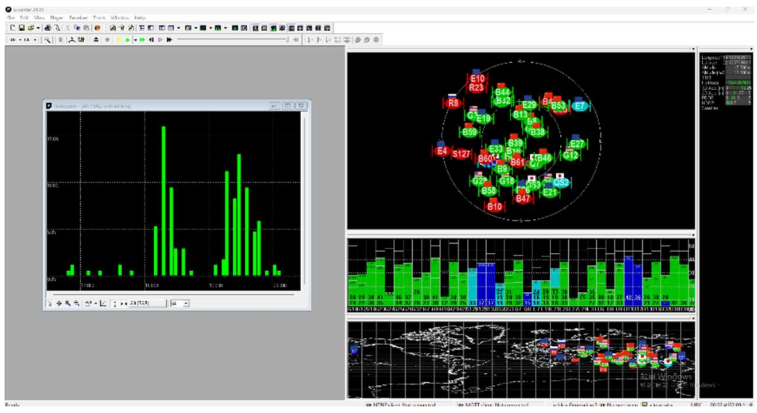

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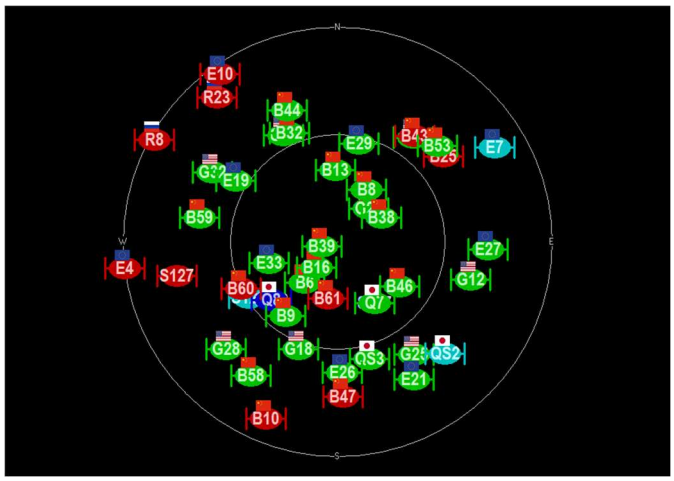


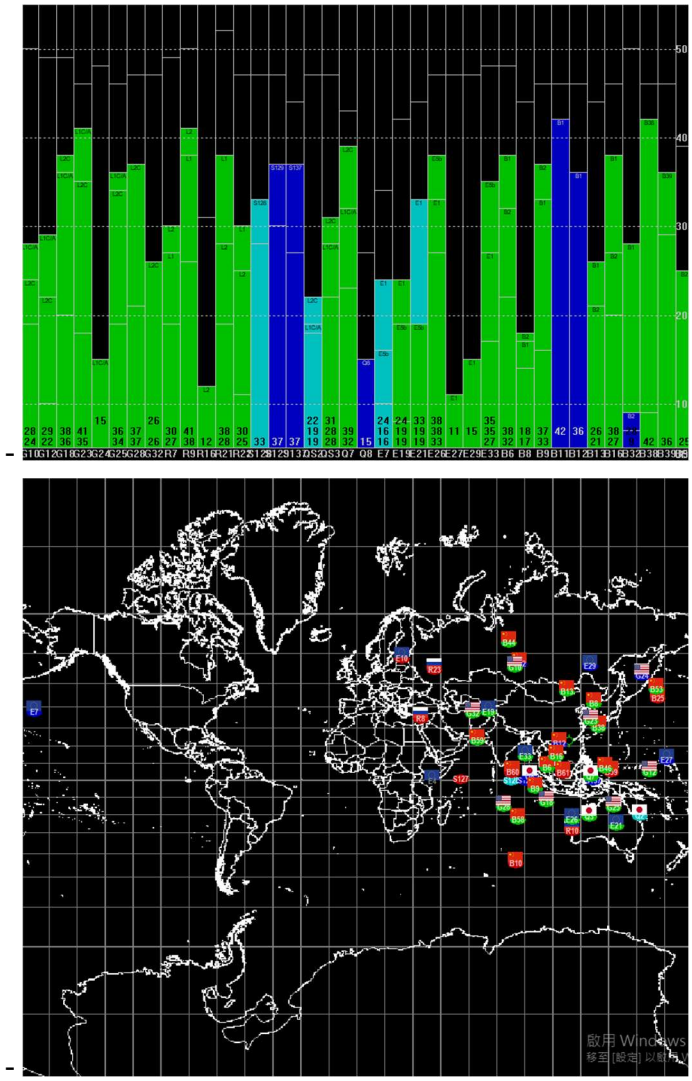


Figure 2: C/N0 time series (placeholder).

4 SPP Algorithm (Least Squares)

Briefly introduce the SPP model and provide a reference:

$$\rho_i = \|\mathbf{x} - \mathbf{s}_i\| + c\Delta t + \varepsilon_i \tag{1}$$

Linearization yields the normal equation

$$\delta = \mathbf{H}^{\top}\mathbf{W}\mathbf{H}^{-1}\mathbf{H}^{\top}\mathbf{W}\mathbf{v}, \tag{2}$$

where $\mathbf{W}$ can be identity (unweighted) or designed from elevation/C/N0 [1, 2].

Least Squares method is the method to find the best trend line for a data set on a graph. When there are many data points on the graph, set up a distance formula between the data sets and seeking linear equations.
Single Point Positioning model is used for calculating the observation equation including the bias, delay, noise and error.

5 Code Listing

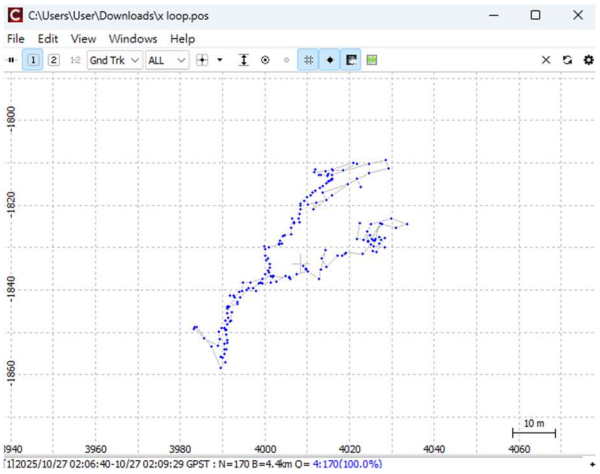
Keep code excerpts within 2 pages in the report; place full, documented code in GitHub.

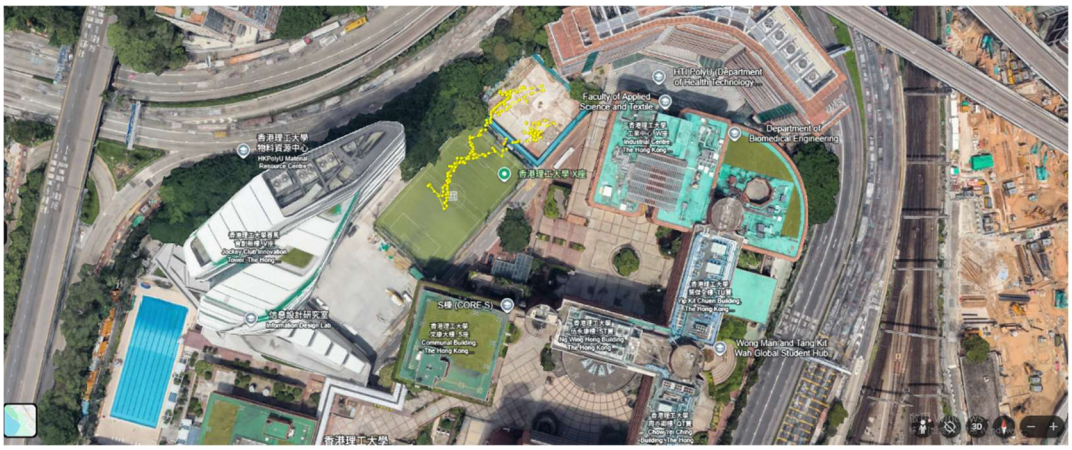
```python
import numpy as np

def spp_ls(sat_ecef, pseudorange, x0, weights=None, max_iter=8, tol=1e-4):
    """
    sat_ecef: (N, 3) satellite ECEF positions [m]
    pseudorange: (N,) measured pseudoranges [m]
    x0: (4,) initial [x, y, z, c*dt] in meters
    weights: (N,) optional weights (e.g., elevation/CN0-based)
    """
    x = np.array(x0, dtype=float)
    for _ in range(max_iter):
        H, v = [], []
        for s, rho in zip(sat_ecef, pseudorange):
            r = np.linalg.norm(x[:3] - s)
            los = (x[:3] - s) / r
            rho_hat = r + x[3]
            v.append(rho - rho_hat)
            H.append(np.r_[los, 1.0])
        H = np.array(H); v = np.array(v)
        W = np.diag(weights) if weights is not None else np.eye(len(v))
        dx = np.linalg.solve(H.T @ W @ H, H.T @ W @ v)
        x += dx
        if np.linalg.norm(dx) < tol: break
    return x  # [x, y, z, c*dt]
```

Listing 1: Minimal SPP least-squares solver (example).

6 Results and Discussion

Present positioning outputs, concise error analysis, and urban-environment interpretation. Example figure (position scatter):





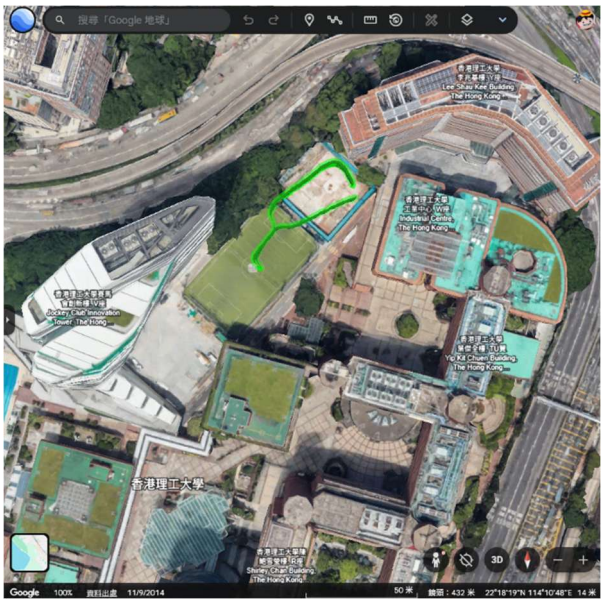


Figure 3: Position scatter (placeholder).

Example table (error metrics):

Table 2: Error metrics (example format).

Metric	Unweighted	Weighted
Mean HPE (m)	–	–
Std HPE (m)	–	–
Mean VPE (m)	–	–
Std VPE (m)	–	–

7 Page Limits and Submission

- Report: max 10 pages; code listings in the report: max 2 pages (include only key parts).
- GitHub repository must include: raw data, PDF report, Python scripts (documented), and README.md.
- Submit the repository link to the lecturer and TAs.
- Deadline: Nov. 10, 2025 24:00 (HKT).

Objectives

- Summarize data collection near Block X. - Provide raw data indicators (satellites, C/N0, GDOP).
- Implement SPP; optionally design weights. - Present results and concise discussion.

Materials and Apparatus

- GNSS receiver with suitable antenna and mount. - Laptop with logging software; Python 3 for processing.

Methods

- Log observations, convert to analysis-ready format, compute indicators. - Run SPP (least squares), optionally apply weights; generate plots/tables.

References

[1] P. Misra and P. Enge, GPS: Signals, Measurements, and Performance, 2nd ed., Ganga-Jamuna Press, 2011.

[2] P. J. G. Teunissen and O. Montenbruck, Springer Handbook of GNSS, Springer, 2017.

A Figure and Table Examples

Use meaningful captions and labels; reference figures/tables in text (e.g., Fig. 1, Table 1).

B Citation and Cross-Reference

Cite background and algorithms using \cite{...} to build a bibliography. Cross-reference labels with `\ref{...}`.

C Compilation Notes

- If you encounter graphics errors (BoundingBox), compile with XeLaTeX or PDFLaTeX and use PNG/JPG/PDF images. - Ensure hkpolyu-labreport.cls and logo file are present.