GNSS Education at the University of Melbourne

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Outline of Presentation

• Introduction
• What we teach
• How we teach
• When we are not teaching…
• Questions
Danger! Danger!

• This is not a normal presentation

• You will be asked to ACTIVELY participate!

• It’s an important part of how we teach
Instructional Objectives

- By the end of this presentation you will be able to:
  - Describe the GNSS course at Melbourne University
  - List the advantages of Active Learning
  - Explain how GNSS signals work using a drinking straw
What we teach
GNSS Education

• GNSS is an important part of a larger Geomatics degree

• Subjects with GNSS include
  - Mapping Environments
    • First look at GNSS
    • Segments (Space, Control, User)
    • Applications

• Satellite Positioning and Geodesy (SPAG)
  - Theory of satellite positioning
    • Reference frames, datums, projections
    • Orbits, signals, errors, observation equations
    • Processing strategies (SPP, DD, NRTK)
    • GNSS heighting (geoid modelling)
Course Structure

Background (Chapters 1-2)
• Geodesy, Coordinates, Systems, Geodetic Datums

The Global Positioning System (Chapters 3-8)
• Chapter 3 – System Structure
  - Space, Control and User segments
• Chapter 4 – Code based positioning
  - Absolute and relative positioning
• Chapter 5 – GPS error sources
  - Satellite, receiver and transmission errors
• Chapter 6 – GPS orbit description
  - Keplerian orbits, broadcast ephemeris (currently not taught)
• Chapter 7 – Carrier phase positioning
  - Carrier phase observable, measurement differencing
• Chapter 8 – Practical issues in GPS surveying
  - Ambiguity resolution, cycle slips, data processing options

Heights from GPS (Chapter 9)
• Geoid Modelling

The Future of Satellite Positioning (Chapter 10)
• GNSS developments
Activity 1 - Reinforcement

• It’s your turn...

• Look at our course structure again...

• Write down (or type in your laptop)
  - 1 similarity with a course you attended/taught
  - 1 difference with a course you have attended/taught
Single Point Position Computation

- Theoretical knowledge
  - Orbits (precise ephemerides)
  - GNSS observation types
  - SPP observation equation
    \[ p_r^s(t) = p_r^s(t, t - \tau_r^s) + c[dt_r(t) - dt_r(t - \tau_r^s)] + e_r^s \]

- Least squares estimation
  \[ \hat{x} = (A^T V_m^{-1} A)^{-1} A^T V_m^{-1} y \]

- Reference frames and rotation matrices
  \[
  \begin{bmatrix}
  \delta e \\
  \delta n \\
  \delta h
  \end{bmatrix} =
  \begin{bmatrix}
  -\sin \lambda & \cos \lambda & 0 \\
  -\sin \phi \cos \lambda & -\sin \phi \sin \lambda & \cos \phi \\
  \cos \phi \cos \lambda & \cos \phi \sin \lambda & \sin \phi
  \end{bmatrix}
  \begin{bmatrix}
  \delta x \\
  \delta y \\
  \delta z
  \end{bmatrix}
  \]
SPP - Position Computation Process

\[ \rho = |X^S - X_R| - c_0T + cdt \]

Compute Single Point Position

50-100m

(Satellite XYZ)

My answer is different?!?

Ah, But I know why!
• GNSS Control Network
  
  - Observe, reduce and adjust a control network
  
  - Theoretical knowledge
    • GNSS carrier phase positioning
      \[ \phi_r^s = \rho_r^s + c(dt_r - dt_r^s) - dI_r^s + dT_r^s + \lambda N_r^s + dM_r^s + \varepsilon_r^s \]
    • GNSS carrier phase processing
    • Network adjustment
    • Network testing
GNSS Control Network

Network Adjustment and Testing

Process Baselines

Student Data

CORS Data (RINEX)

XYZ
How we teach
Approach to Teaching

• Organised
  - Majority of course material available immediately
  - Clearly defined course structure (you’ve seen it)

• Open and Accountable
  - Instructional Objectives
    • Clear and measurable objectives for students
    • Our expectations of the students

• Marking Guides
  - Remove subjectivity in assessment (for us and students)
  - Set out our expectations for students
### Example Marking Guide

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<th>451-337 - Assignment 3</th>
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<th>Mark given</th>
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<tr>
<td>Set-up of problem</td>
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<td>Observation equations</td>
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<td>Linearisation</td>
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<td>Variance matrix</td>
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<td>Least squares algorithm</td>
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<td>Solution</td>
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<tr>
<td>Receiver clock offset</td>
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<tr>
<td>Calculated PDOP and GDOP</td>
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<tr>
<td>Coordinate comparison</td>
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<td>Discussion of solution</td>
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<tr>
<td>Discussion of PDOP and GDOP values</td>
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<td>Satellite locations</td>
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<td>Azimuth of each satellite</td>
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<tr>
<td>Zenith angle of each satellite</td>
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<tr>
<td>Skyplot</td>
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<tr>
<td>Discussion</td>
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<tr>
<td>Quality of report</td>
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Approach to Teaching

- **Active Learning**
  - Small exercises or activities undertaken in a lesson
  - Group (2-3 people) or individual based
  - Why?
  - Involves students in their learning
  - Helps to reinforce presented material
  - Breaks up the lesson, energizes class
- At varied times (5-20 minute intervals)
- Varied length (1-5 minutes)
Activity 2 – Drinking Straws are Cool!

- Activity – explain how GNSS signal works using a straw
When we are not teaching
Research

• Melbourne University and CRC-SI
• Quality Control for CORS Networks and Mobile Users
  - Real Time Quality Control (RTQC) Software
  - NRTK Evaluation
• Stochastic Modelling
• GNSS Heighting
ThinkSpatial

• Spatial Information Professionals
  • GNSS Surveying
    • CORS & Survey Networks, Heighting, Engineering
  • Intelligent Mapping
    • Mobile (iOS, Android) & Web
  • Education & Training
    • GNSS, Networks, & Spatial Mathematics
    • 2 – 12 week courses tailored to student needs