Sensor Orientation

Dr. **Jan Skaloud**, M.E.R.
TOPO (Geodetic Engineering Lab), ENAC

Fall semester

Section SSIE, Faculty ENAC
Section SYSCOM, Faculty I&C
Section SEL, Faculty STI

Fr 12:15-17:00 GR-**A331** / GR-**C02 (**or **GCD0383)**

Agenda – details per session

Navigation / Lecture

1. Concepts & applications, LS review
2. Sequential LS, Random proc.
3. Ref. systems 1+2, Sensors (1*)
4. T1, ~~Ref. sys 2,~~ Eq. i-frame
5. DAC:e-frame, Attitude Sol. Sens.(2*)
6. ~~Attitude sol~~., Alignment, Sensors(3*)
~~7. Alignment, Sensors (4*)~~
8. Align errors + Schuler, Sensors (4*)
9. **T2**, KF-intuitive
10. $\Phi=e^{F\Delta t}$, observability, Sensors (5*)
11. EKF, GPS/INS integration
12. Total x vs. Δx, GPS/INS in 2D
13. Direct sensor orientation, demo
14. T3

Estimation/LAB

L1a: Random noise + ran. walk
b: GM1, Auto-Correlations
L2a: collect real IMU data
b: analyze data, AC, PSD
L3 : dR/dt
L4/5 : 2D INS – ideal + realistic
~~L5 : 2D INS – realistic case~~
L6: INS physic – initialization
L7 : KF of GPS – model a=0
L8 : KF of GPS – model a=con.
L9 : KF of GPS – model rdot=0
L10a: GPS/INS – theory
implementation

* = presented by students, practical labs

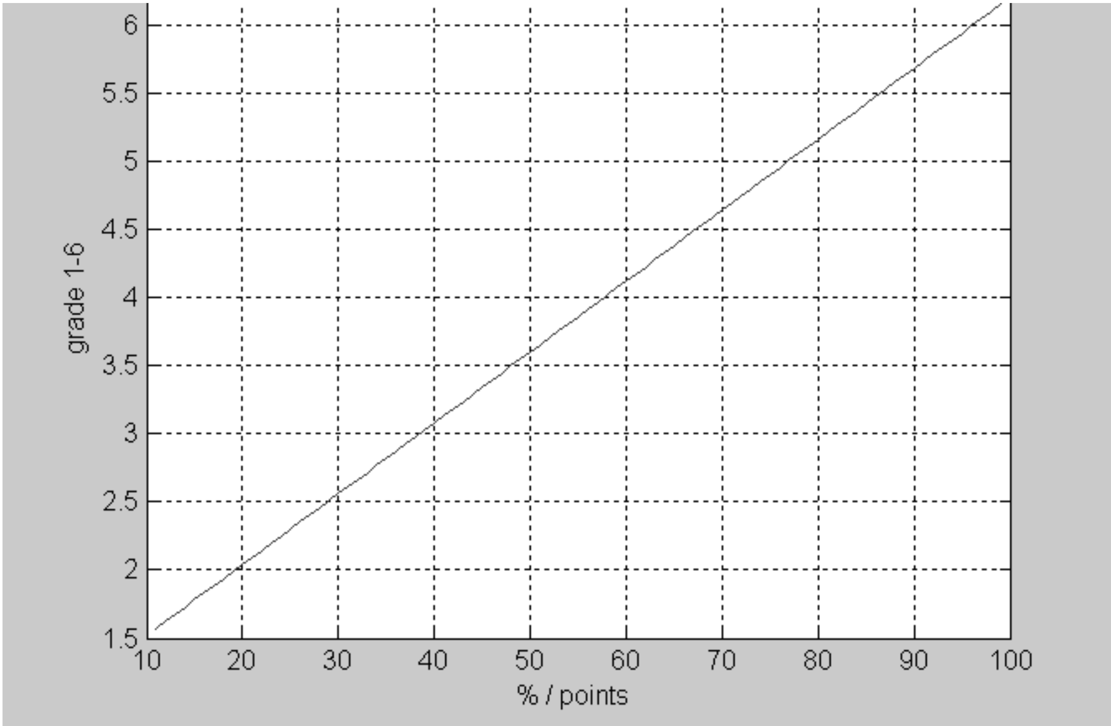
DAC=Davide Cucci

Control

☐	Test 1 (lecture 4, 14.10.)	20%	
☐	Test 2 (lecture 9, 18.11.)	20%	
☐	Test 3 (lecture 14, 23.12.)	20%	60%
☐	Participation/presentation 10%		
☐	Labs	30%	40%
☐	TOTAL	100%	

% → grade conversion

- Mark ~= [%] * 5.2/100 + 1



Labs – rules

- Lab weight 3% per lab, 10 labs in total
- Evaluation
  - Completeness ~ 1%
  - Correctness (plots) ~ 1%
  - Answers (questions) ~ 1%
  - Penalty -0.5% per day past deadline
- Content
  - Written ~1 page: **answers** with analysis (poss. synthesis)
  - Plots (relevant)
  - Code (all)
- Hand in
  - Printed version, bring it to the course or give to the assistant

Assistant support

- Merhan Khaghani
  - main assistant (labs & consulting)

- Philipp Clausen
  - present in labs

- Martin Rehak
  - (backup for presence in labs)

Inertial sensors – student distribution

- Gyroscopes
  - Rigid rotors gyros (RRG)
  - Nuclear resonant (NMRG)
  - Ring laser gyro (RLG)
  - Fibro optic gyro (FOG)
  - Hemispherical resonator (HRG)
  - MEMS:
    - Vibrating fork-quartz (QRS)
    - Resonant ring
- Accelerometers
  - Force/mass rebalance
  - MEMS: vibrating (QRS)
- Magnetometers

- Students
  - 1:
  - 2:
  - 3:
  - 4:
  - 5:
  - /
    - 6:
    - 7:
- /
  - 9:
  - 10:
  - 11:

First group in 2 weeks (3rd session)

Sensor presentation

- Prepare
  - 1. Presentation (~10-12 min)
  - 2. Document to be handed to colleagues (16) + PDF (slides or extended abstract with references)

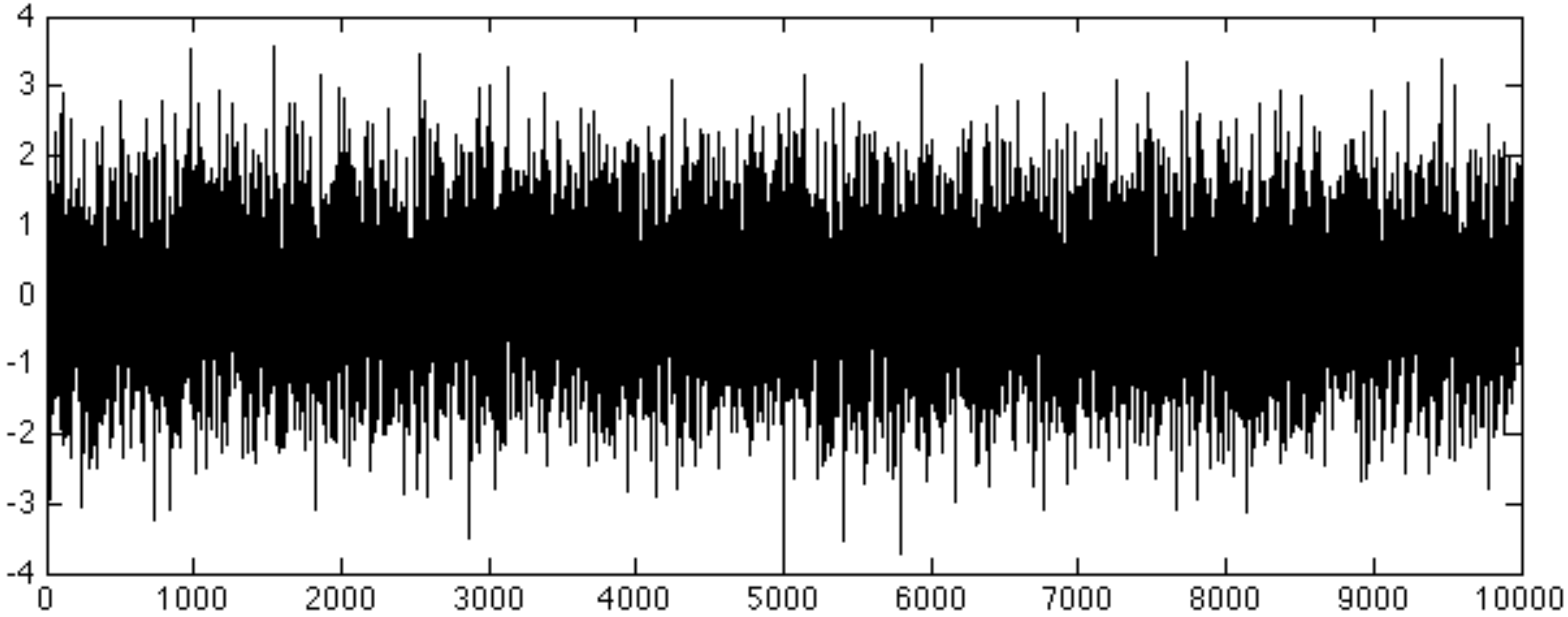
- Content
  - Clear **physical concept**
  - Mathematical relations
  - **Limits** – physical and in realization/fabrication
  - **Advantages** and disadvantages (environment, size, cost, **accuracy ranges**)

Lecture summary

- Each student presents (at least ones) brief summary of the previous lecture

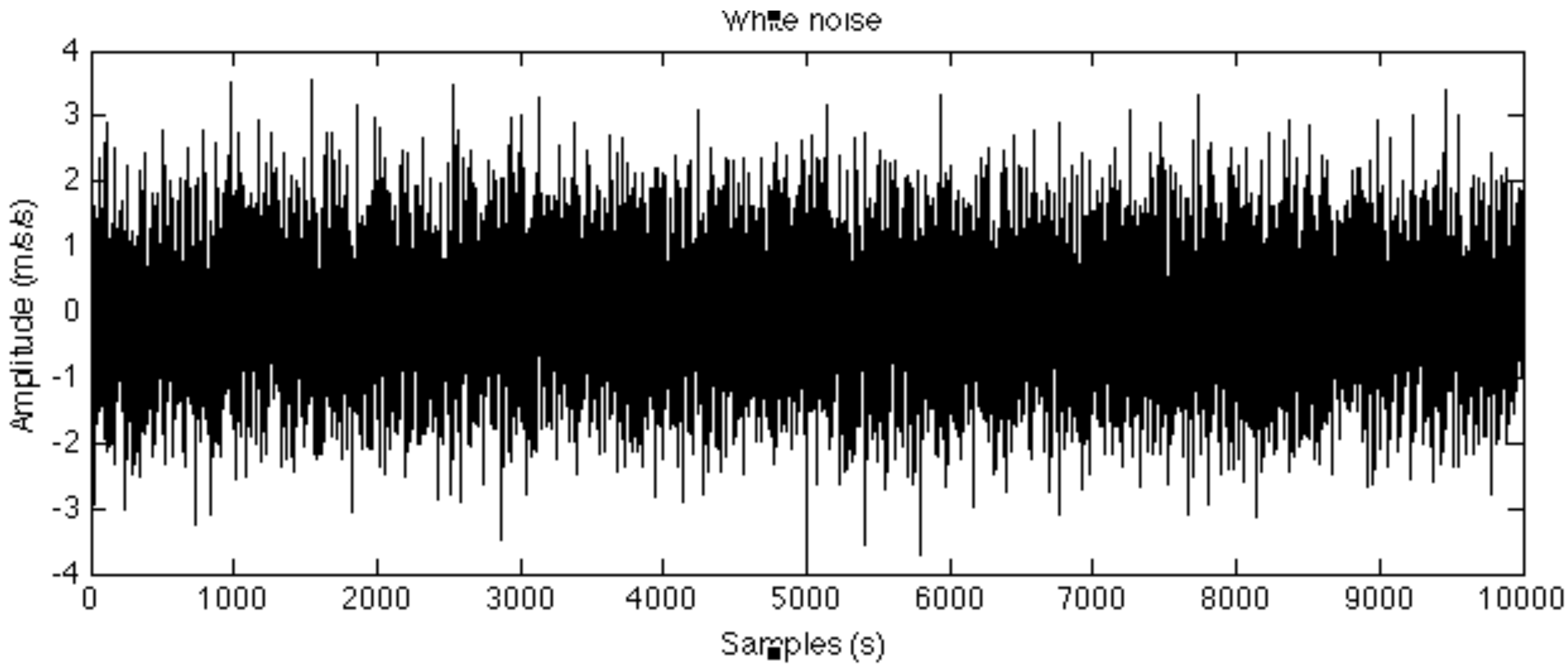
- Summary:
  - Slides 1-2 max
  - Or on blackboard (prepare before lecture starts)
  - 3-4 minutes max

Plots



4
3
2
1
0
-1
-2
-3
-4
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

Plots


White noise
Amplitude (m/s/s)
Samples (s)
4
3
2
1
0
-1
-2
-3
-4
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

Lab - evaluation

- **C**ompleteness – 1/3
- **C**orrectness – 1/3
- **A**nswers – 1/3

- Later delivery – 50% (of the lab weight)

- Reports:
  - Description (plots) – n pages
  - Answers – max 1 page
  - Code (with all functions)