
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, MT, Robotics, Faculty STI

Fr 13:15-17:00 GR-**A331** / GR-**C002** (~~or GCD0383~~)

Agenda – details per session

Navigation / Lecture

1. Intro, LS review, Random proc. 1
2. Seq. LS, Random proc. 2
3. Ref. systems 1+2, Sensors (1*)
4. **T1**, R, dR, Eq. i-frame
5. **DC**: e-frame, Attitude Sol. Sens.(2*)
6. l-frame, num. integ., Sensors(3*)
7. Alignment princip, Sensors(3*)
8. Align. limits, Schuler, Sensors (4*)
9. **T2**, KF-intuitive
10. $\Phi = e^{F\Delta t}$, obs., Sensors (5*)
11. EKF, INS/GNSS integration
12. Total x vs. Δx , GPS/INS in 2D
13. Direct sensor orientation, demo
14. **T3**

* = presented by students,

practical labs

Estimation/LAB

- L1a: noise gener.: WN, RW, GM1
- b: noise characteristics
- L2a: collect real IMU data
- b: analyze & characterize
- 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 $a=\text{con.}$
- L9 : KF of GPS – model $\text{rdot}=0$
- L10a: GPS/INS – implement
- b: debug

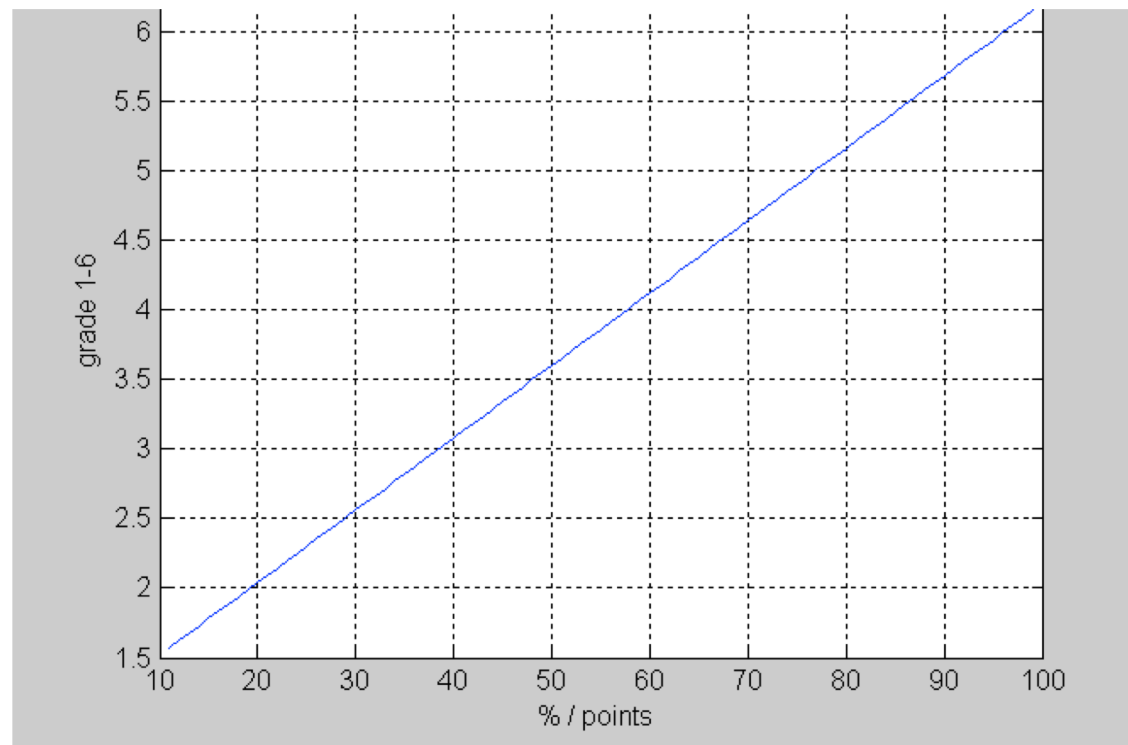


Control

☐ Test 1 (lecture 4, 11.10.)	20%	
☐ Test 2 (lecture 9, 15.11.)	20%	
☐ Test 3 (lecture 14, 20.12.)	20%	60%
☐ Participation/presentation	10%	
☐ Labs	30%	40%
☐ TOTAL	100%	

% → grade conversion

□ $\text{Mark} \approx [\%] * 5.2/100 + 1$



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

- Pasquale Longobardi
 - main assistant (labs & consulting)



- Gabriel Laupre
 - Present in lab (& consulting back-up)



- Kenneth Joseph-Paul
 - present in labs



Sensor presentation (group of 2)

□ Prepare

- 1. Presentation (~7-8 min)
- 2. PDF version sent to teacher (slides or extended abstract with references)

□ Content

- 1. Physical concept** , mathematical relations
- 2. Limits** – physical and in realization/fabrication
- 3. Advantages** and disadvantages (environment, size, ~cost, **accuracy ranges**)

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)
- MEMS: Resonant ring

☐ Accelerometers

- Force/mass rebalance
- MEMS: vibrating (QRS)
- Compact cold-atomic
- MEMS gravimeter

☐ Magnetometers

☐ Students

- 1:
- 2:
- 3:
- 4:
- 5:
- 6:
- 7:
- 8:
- 9:
- 10:
- 11:
- 12:

First group in 2 weeks (3rd session)

Lecture summary (group of 2)

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

- Roles:
 - Presenter
 - Questioner

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

Lab - evaluation

- ☐ **Completeness** – 1/3
- ☐ **Correctness** – 1/3
- ☐ **Answers** – 1/3

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

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