Inertial Measurement Units

01.12.2014

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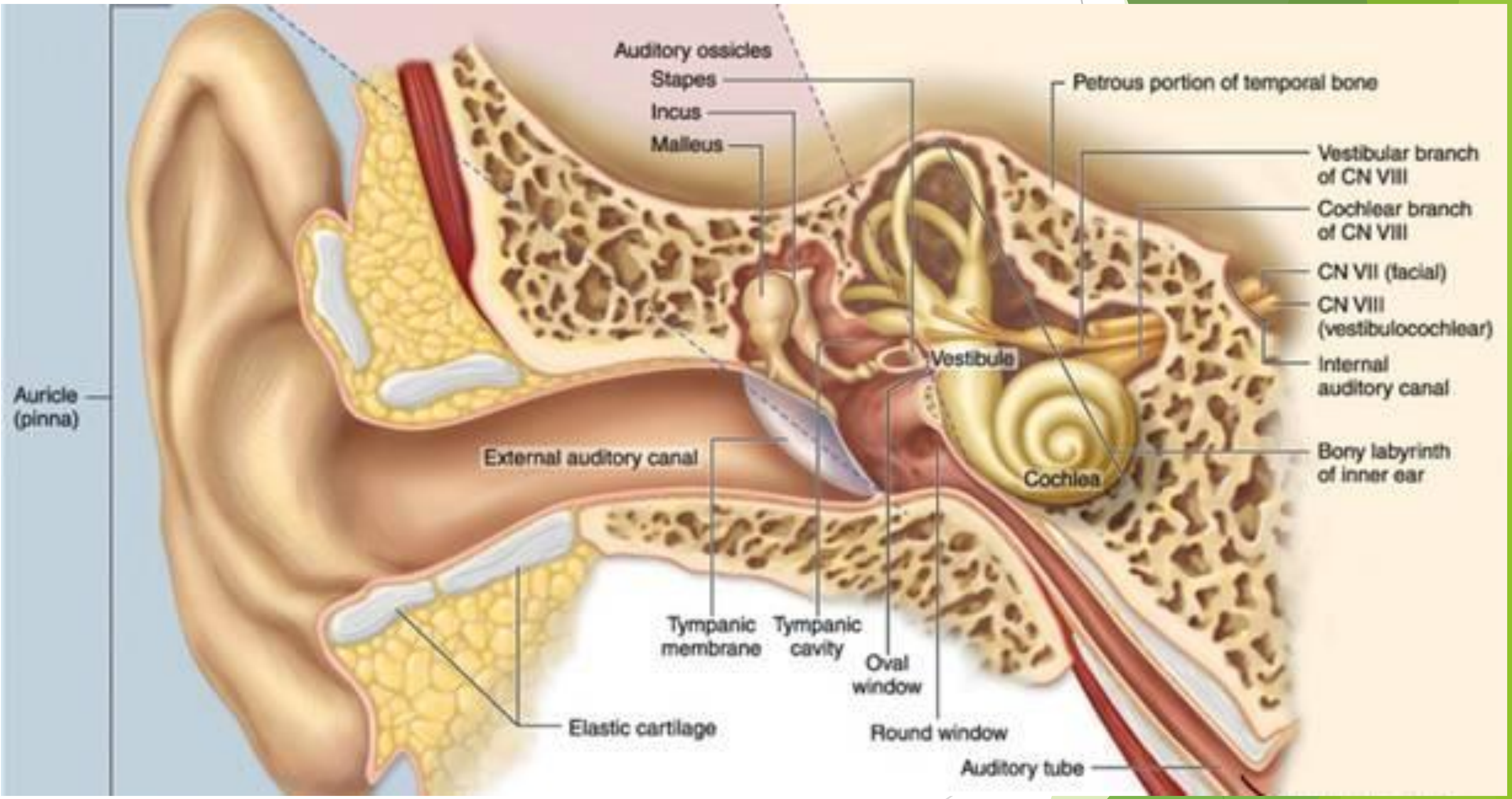
Introduction

Introduction

- vestibular systems knows about:
  - orientation of head
  - current movement
  - changes in movement (accelerations)



Definition of IMU

- An inertial measurement unit (IMU) is a device that utilizes measurement systems such as gyroscopes and accelerometers to estimate the relative position, velocity, and acceleration of a vehicle in motion

  (Springer Handbook of Robotics Springer Berlin Heidelberg 2008-01-01 Dudek, Gregory Jenkin, Michael 477-490)

- *one system without external references*

- *Are used in planes, cars, space vehicles, smartphones, Oculus rift, robots*

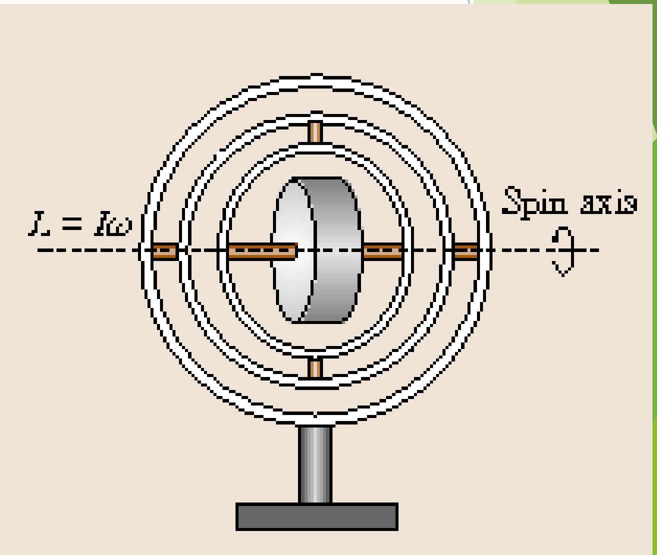
Architecture of IMU

- gimballed system
  - freedom to move in every dimension
  - keeps mass in horizontal position
  - e.g. cameras or ship stoves

- strap down system
  - system connected fixed
  - orientation is calculated
  - state of the art

Architecture of IMU - Gyroscopes

- spinning top in instrumentals (technical use)
- measures changes of position with physical laws (angular momentum)
- first known use as instrumental in 1743 by John Serson
- 1817 Johann Bohnenberger described first gyroscope

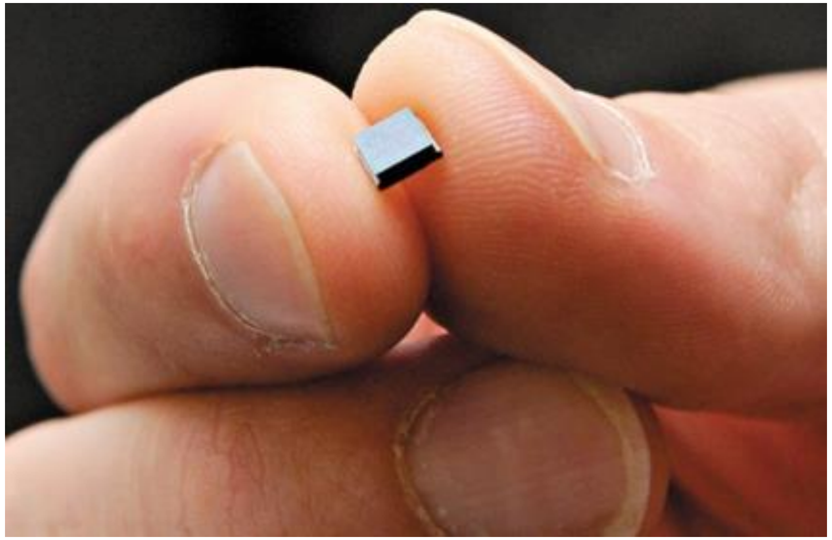


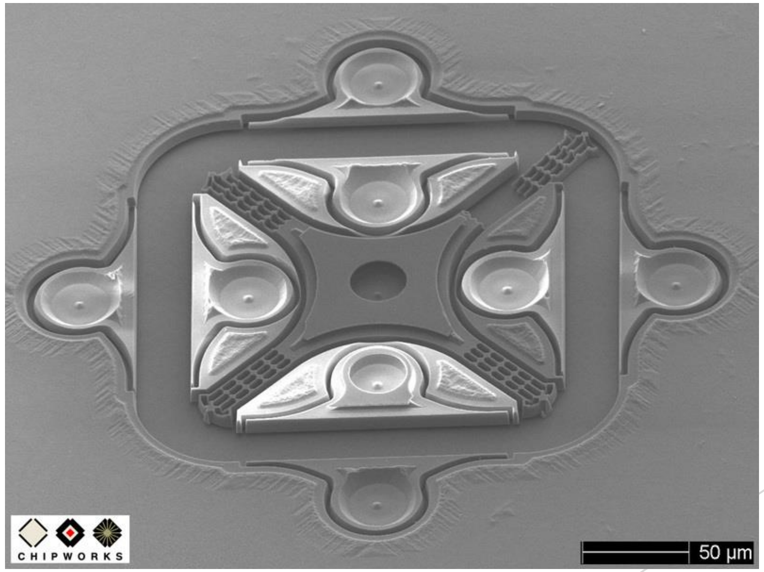
Architecture of IMU - Gyroscopes

- various technologies
  - Fibre optic gyroscopes (light)
  - Ring laser gyroscopes (light)
  - Hemispherical resonator gyroscope (electrostatic)
  - London Moment (magnetic field)
  - MEMS - gyroscope (vibrating elements)

Architecture of IMU – Gyroscopes - MEMS

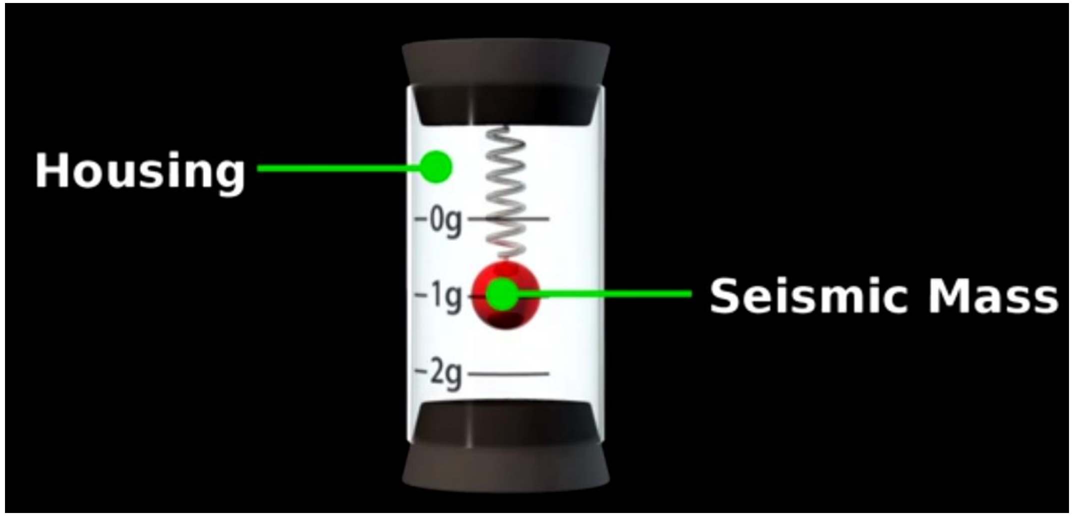
- Micro Electromechanical Systems
- using silicon based vibrating structures underlying external forces

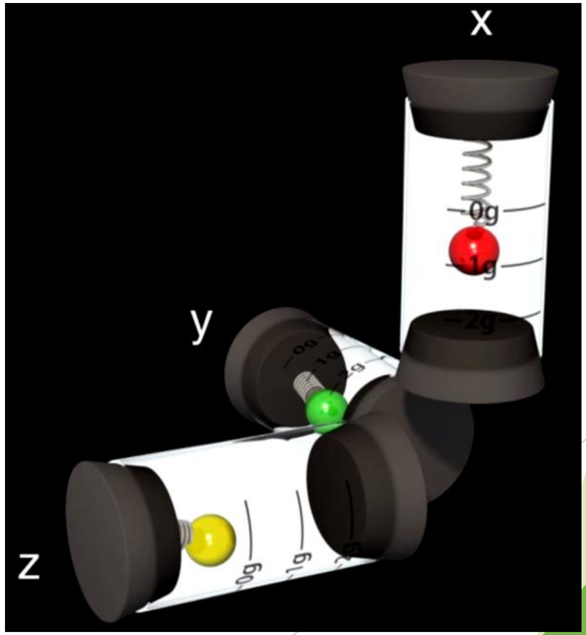




Architecture of IMU – accelerometer

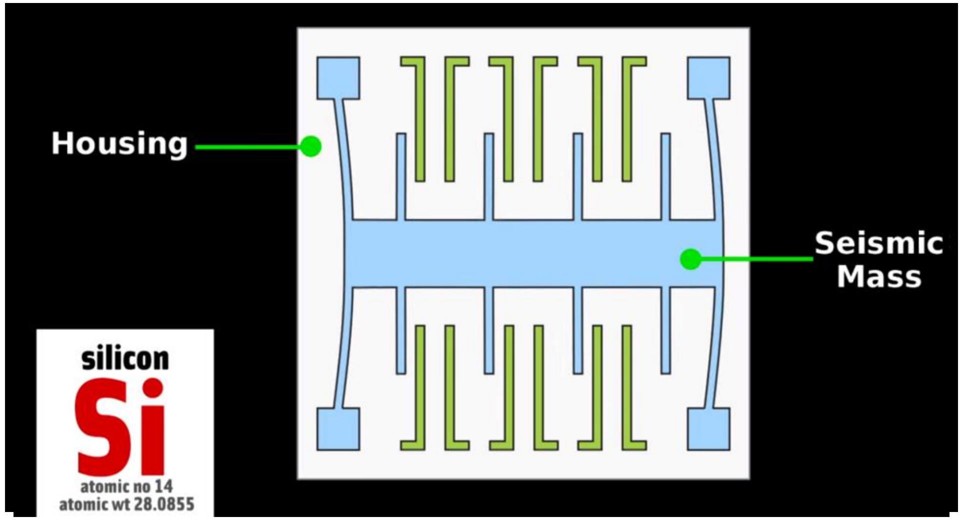
- measures external forces (including gravity)
- calculated by deflection of mass



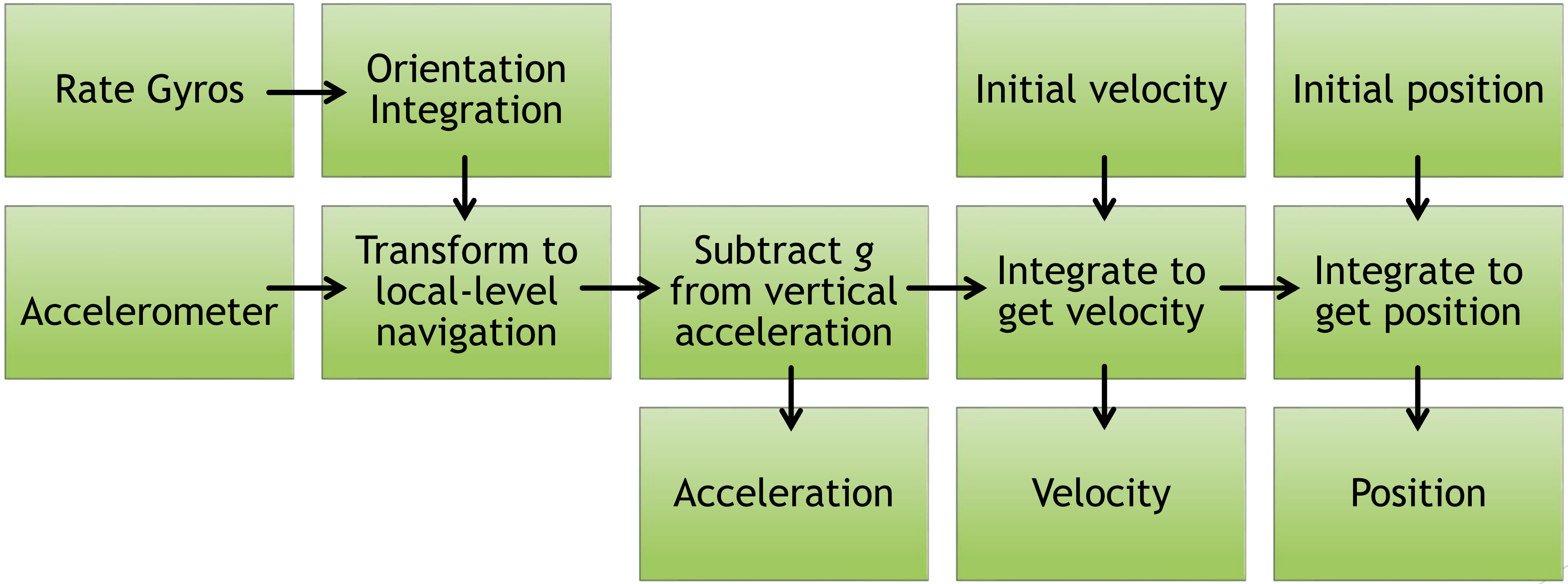


Architecture of IMU – accelerometer

- external forces move seismic mass



Integration of different data



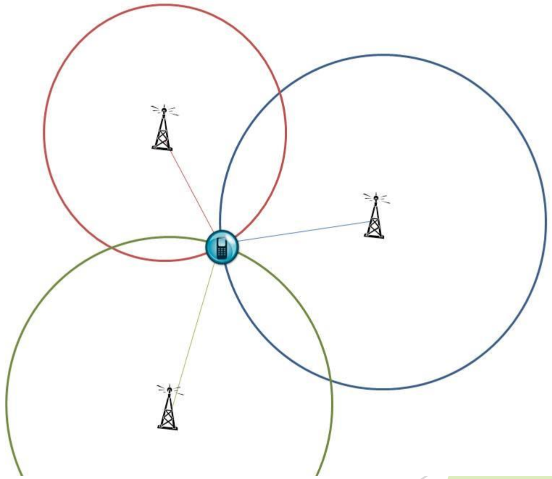
Problems of IMU - drifts

- environment has influence on MEMS
  - different gravity
  - changing temperature
- random drift caused by measuring errors

- leads to short term and long term drift

Solutions to avoid drift

- Integration of other data
  - Usage of GPS for outside Navigation
  - Triangulation of mobile phone masts
- Use of Kalmanfilter



Solutions to avoid drift – in buildings

- Robust 6-DOF Immersive Navigation Using Commodity Hardware
  - by L. Carozza, F. Bosché and M. Abdel-Wahab
  - School of the Built Environment Heriot-Watt University (Edinburgh)
  - at VRST 2014
- used Oculus Rift
- aim to limit drift and jitter with low cost devices

Solutions to avoid drift – in buildings - Oculus rift

- Addition of a camera onto Oculus rift
- Integration of visual data to minimize errors
- Usage of device in environment with different structures
- more visual input if motion is slow
- more IMU input if motion is fast

Solutions to avoid drift – in buildings - Oculus rift

- observed and analysed negative factors on user experience
  - e.g. drift and jitter
- moving slowly or moving fast
- tested two different models to integrate visual data (one fast, one robust)

Result:

- in general, adding visual information is better
- fast relocalization is crucial to avoid negative effects

Discussion – other solutions

- What else could be used to improve IMU data in case of Oculus rift?
- Think about the living room again.
  What other „input“ data could have been helpful to find the path with closed eyes. How would you transfer it to instrumental use?
- Integration of
  - muscles sensors
  - radar / echolocation
  - sensors in floors / shoes
  - magnetic sensors

Thank you for your attention – Any questions?