Mobile Intelligent Systems 2006

Lecture 4:

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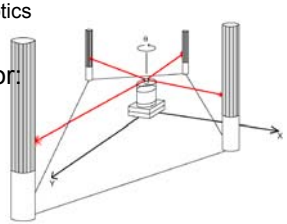
Contents

- Global positioning system (GPS) – chapter 4.1.5.1

Ground-Based Active and Passive Beacons

- Elegant way to solve the localization problem in mobile robotics
- Beacons are signaling guiding devices with a precisely known position
- Beacon base navigation is used since the humans started to travel
  - Natural beacons (landmarks) like stars, mountains or the sun
  - Artificial beacons like lighthouses
- The recently introduced Global Positioning System (GPS) revolutionized modern navigation technology
  - Already one of the key sensors for outdoor mobile robotics
  - For indoor robots GPS is not applicable,
- Major drawback with the use of beacons in indoor:
  - Beacons require changes in the environment -> costly.
  - Limit flexibility and adaptability to changing environments.

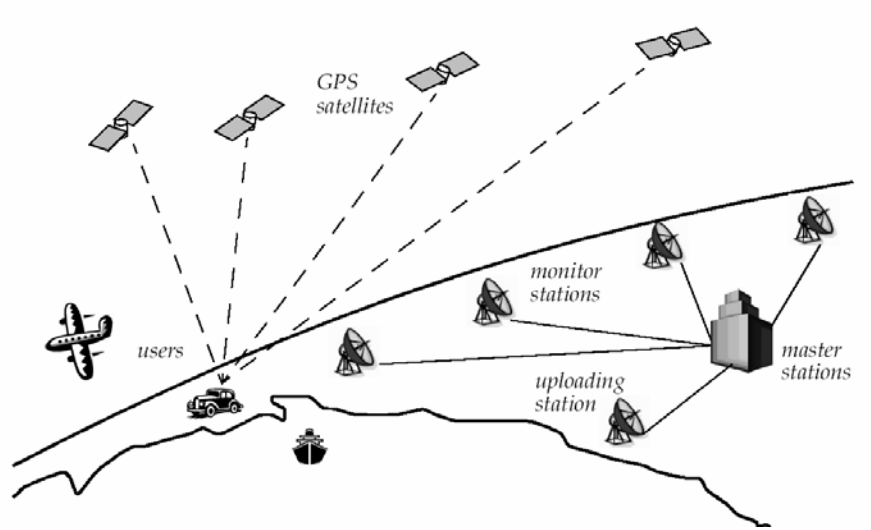


Global Positioning System (GPS) (1)

- Developed for military use
- Recently it became accessible for commercial applications
- 24 satellites (including three spares) orbiting the earth every 12 hours at a height of 20.190 km.
- Four satellites are located in each of six planes inclined 55 degrees with respect to the plane of the earth's equators
- Location of any GPS receiver is determined through a time of flight measurement

- Technical challenges:
  - Time synchronization between the individual satellites and the GPS receiver
  - Real time update of the exact location of the satellites
  - Precise measurement of the time of flight
  - Interferences with other signals

Global Positioning System (GPS) (2)

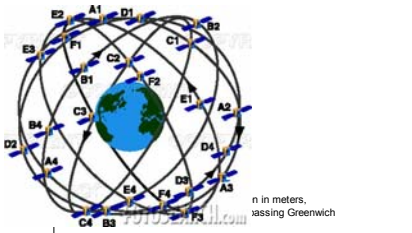


Global Positioning System (GPS) (3)

- Time synchronization:
  - atomic clocks on each satellite
  - monitoring them from different ground stations.
- Ultra-precision time synchronization is extremely important
  - electromagnetic radiation propagates at light speed,
- Roughly 0.3 m per nanosecond.
  - position accuracy proportional to precision of time measurement.
- Real time update of the exact location of the satellites:
  - monitoring the satellites from a number of widely distributed ground stations
  - master station analyses all the measurements and transmits the actual position to each of the satellites
- Exact measurement of the time of flight
  - the receiver correlates a pseudocode with the same code coming from the satellite
  - The delay time for best correlation represents the time of flight.
  - quartz clock on the GPS receivers are not very precise
  - the range measurement with four satellite
  - allows to identify the three values (x, y, z) for the position and the clock correction ΔT
- Recent commercial GPS receiver devices allows position accuracies down to a couple meters.

GPS – (Lon, Lat) <=> (X, Y)

- Assumes flat world, i.e. approximate to calculate position in x and y. All positions lies on the same height above ground, i.e. z is constant in the area.
- Origin = Greenwich and the Equator
- Use conversion tables or calculate exact values for a defined height above ground



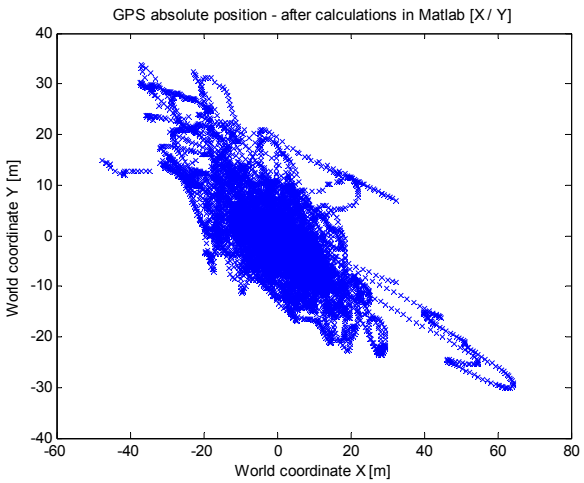
GPS - Applications

- Human navigation – ”treasure hunt”

- Navigation: ship, car, airplanes

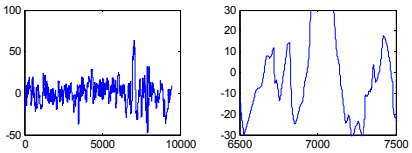
Images from http://www.fotosearch.com

GPS - Errors



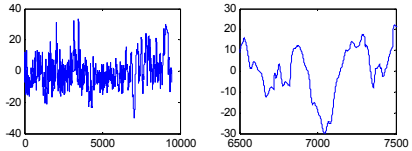
GPS – Errors

- Errors are correlated with time
- How to use this knowledge?
  - Velocity
  - Position



X: Longitude

$$e_x = x - \bar{x}$$



Y: Latitude

$$e_y = y - \bar{y}$$

Exercise #1

DGPS – Differential GPS