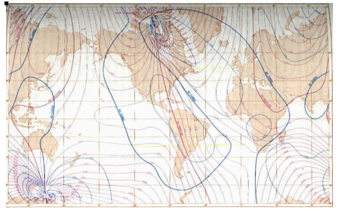
Ubiquitous Tracking

martin.bauer@in.tum.de

What we have

- GPS, but only outside
- ART DTrack, but only in the Lab
- AR Toolkit, but only with Line-of-Sight
- Gyroscope, but only with some drift
- Compass, but only with distortions



What we want

- Know the position (and orientation)
  - anytime
  - anywhere
  - as accurate as possible
- Don‘t care about Coordinate Systems

Scenario 1999

- A Firefighter comes to an emergency site
- He uses his wearable computer and Head-Mounted-Display for Navigation inside the building
- He rescues the injured person

Scenario 2003

- A Firefighter comes to an emergency site
- He uses his wearable computer and Head-Mounted-Display for Navigation inside the building
- He rescues the injured person

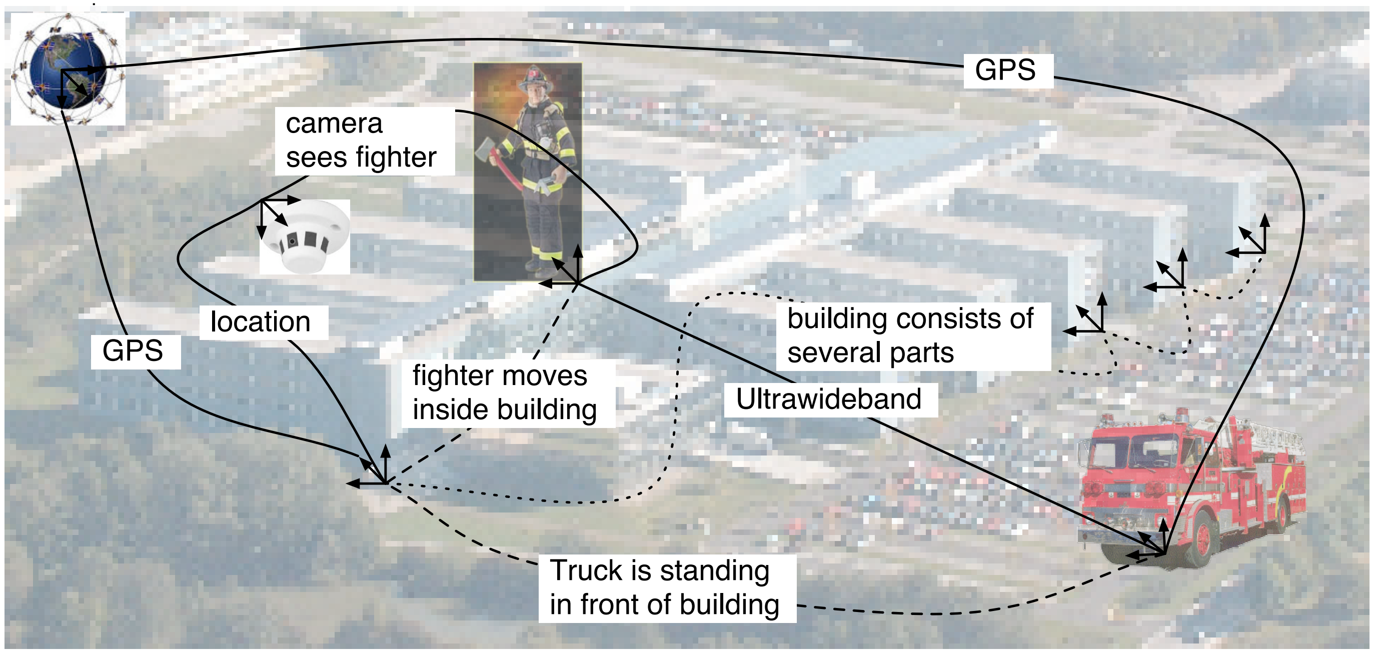
Scenario 2003

- Truck is tracked by GPS
- Firefighters are tracked from the truck using ultrawideband technique
- Building has a centralized fire alarm system — smoke detectors are networked and location in the building is known

…but all use different coordinate systems

- GPS is relative to some earth-centric reference ellipsoid
- Ultrawideband is relative to emitter
- Pedometer, gyroscope relative to “nothing”
- smoke detector locations relative to some building coordinate system
- building coordinates relative to somewhere

Example

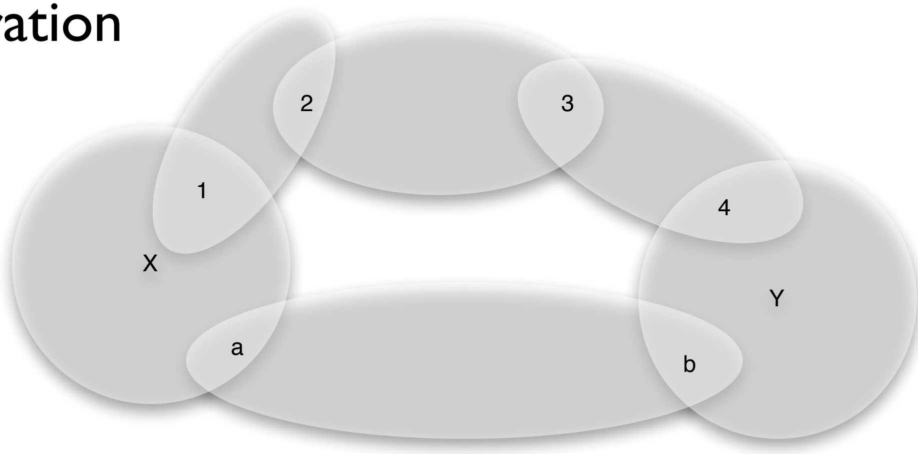

GPS
camera
sees fighter
location
GPS
fighter moves
inside building
building consists of
several parts
Ultrawideband
Truck is standing
in front of building

Problems

- There is no time (no resources) for manual adjustment
- manual adjustment is tedious and error-prone
- centralized systems tend to be outdated — and therefore useless
- multiple users want different coordinate systems

Lab Setup

- (1,2,3,4) leads from X to Y, so does (a,b)
- Overlapping areas can be used for calibration



Some Definitions

- *Pose estimation* is the determination of the relative position and orientation of an object at a given time, relative to a reference coordinate system. In general, this is a repeating process, since it can be assumed that the object is moving.

- *Tracking* is the continuous pose estimation of one (or more) objects.

- *Calibration* is the estimation of fixed (but unknown) properties of the tracking system, including coordinate transformations, external and internal camera parameters

Goals

- easy setup of new tracking hardware in lab environments
- easy integration of all kinds of "world models" in such setups
- dynamic integration of infrastructure in an intelligent building
- use of cheap mobile sensors *(M.Wagner)*

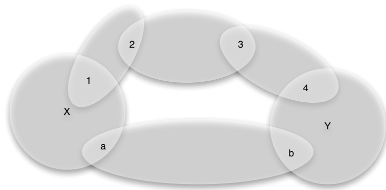
Software Architecture

The Dwarf-Framework makes it easy to:

- integrate new tracking hardware
- communicate between components
- plug hardware in & out
- use mobile setups
  (even on handheld computers)

Proposed Solution

- in overlapping areas, gather information from multiple sensors
- compute best fit for coordinate transformation
- use global optimization techniques when circles are encountered
- use cheap wearable sensores to bridge between tracked areas



Calibration

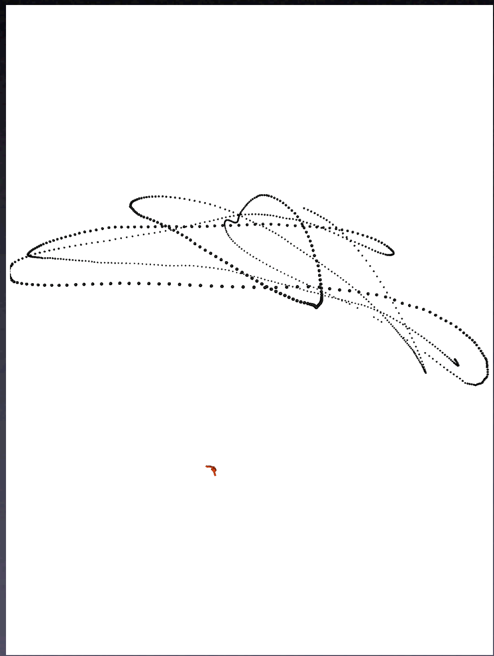
- Calibration is solved:
  - For display calibration, use SPAAM
  - For object calibration, see
    Calibration requirements and procedures for a monitor-based augmented reality system. [Tuceryan, et.al., 1995]
- Really?

Calibration Techniques

- Objects can be calibrated using a (small) set of corresponding points on the real object as well as the virtual model
- a pointing device is needed to identify the points
- how do we calibrate the calibration device…?

Calibration Techniques

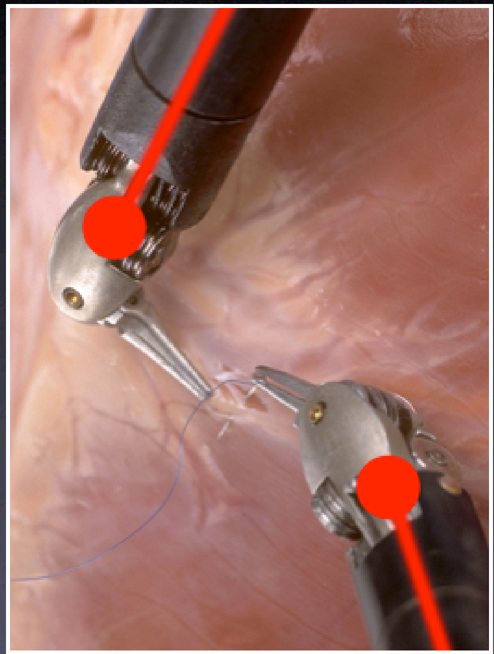
- Pointing devices are calibrated by rotating the pointer around its tip
- the tip is at a fixed position (e.g on a table)
- the measurements give a system of equation that can be solved in a least squares manner



Calibration Techniques

But:

- how do we get the orientation?
- what about objects that cannot be rotated around its tip?
- what if we cannot rotate the device due to mechanical constraints?



Diplomarbeiten

- Calibration of virtual cameras for Dwarf
- Intra-operational augmented reality enhanced port placement in minimal invasive heart surgery.
- Navigation for the endoscopic placement of a stent for the treatment of thoracic aortic aneurisma.

Diplomarbeiten

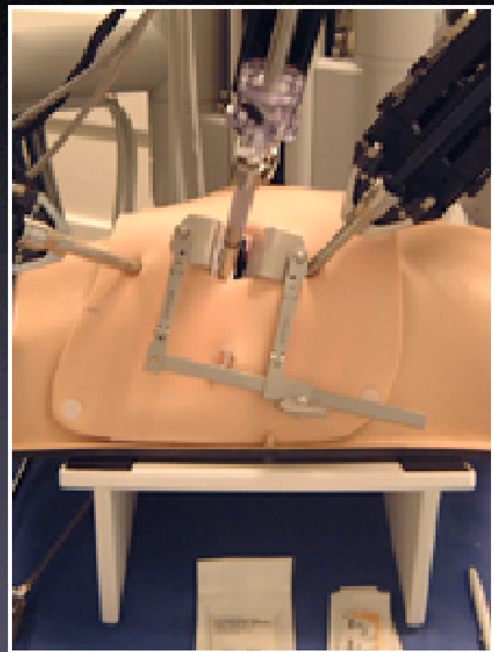
Calibration of virtual cameras for Dwarf

- Implementation of the SPAAM algorithms with minor extensions
- Ideas for the calibration of video-see-through laptops and other display devices

Diplomarbeiten

Intra-operational augmented reality enhanced port placement in minimal invasive heart surgery.

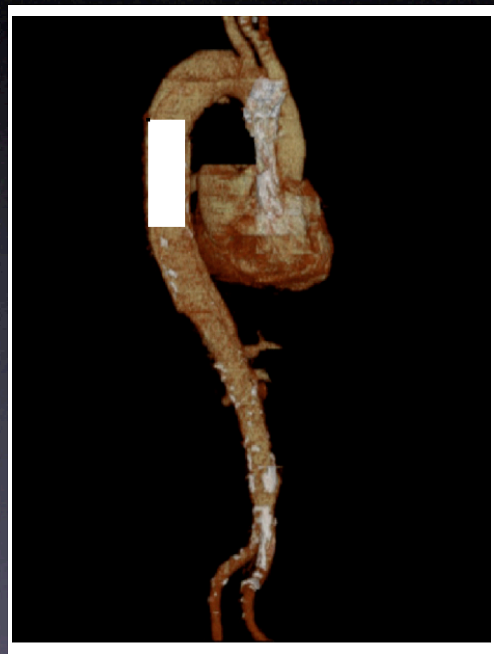
- Augmentation of live video with preoperative CT scans and tracked robot arms.
- Calibration of the teleoperator, CT scans, body, etc.



Diplomarbeiten

Navigation for the endoscopic placement of a stent for the treatment of thoracic aortic aneurisma.

- Augmentation of preoperative MRI scans with intraoperative X-Ray images
- 2D/3D registration of X-Ray and CT data



Next Steps

- build Dwarf components for calibration
  - Display calibration
  - Object calibration
  - Coordinate system calibration
- build Dwarf components for tracking
- build Dwarf components for the combination of different trackers