Sensing Location in the Pocket

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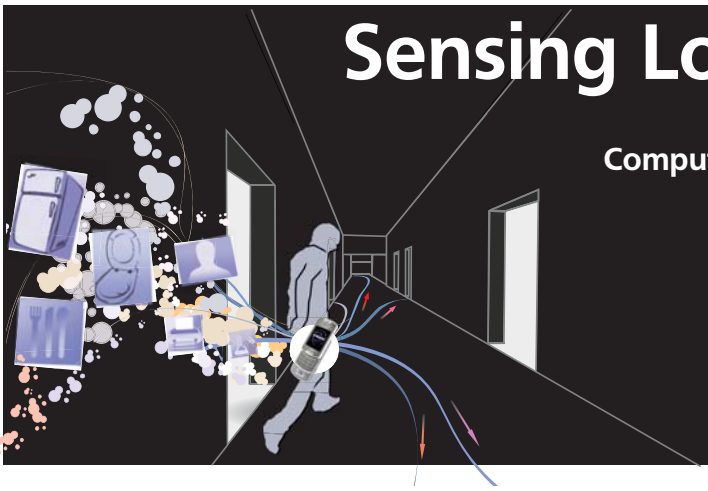

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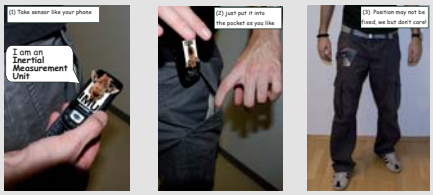
Goal

Recognition of location transitions in buildings by **inertial motion sensing** and **relaxed requirements**

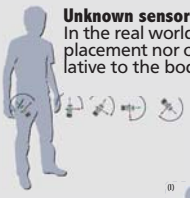


Flexible placement
Just put it into the pocket regardless of the sensor's orientation and fixation

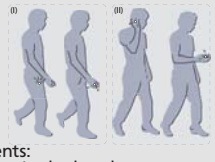
Location transition
...is a sequence of locations visited by a user, starting at location A and ending at location B, with possible intermediate locations C, D.

Problem

How do we tell the sensor the user's heading?
What if the orientation of the sensor drifts?



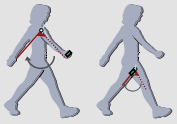
Unknown sensor positions/orientations
In the real world we cannot assume a fixed placement nor orientation of the sensor relative to the body.



Modes of carrying.
Different placements:
(I) In the pocket or In the hand,
(II) Talking or Typing a message.

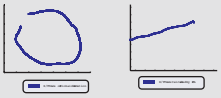
Solution

Exploit the body motion determining the orientation of the sensor to the body and **to get the heading of the user**



Body motion
While walking we have a strong rotational component at the pocket and in the hand

Without preprocessing **With our preprocessing**



Change during operation
Walking a straight line while rotating vertically the sensor in the pocket.

Algorithm

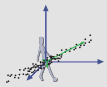
(1) Preprocessing

Goal:
- Find relative orientation of the sensor to the body
- use it as heading of the user

Given:
Global orientation vector and gyroscope values

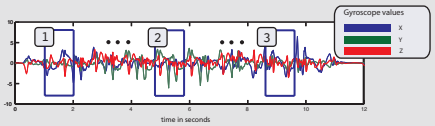
Method:
For each timestamp t:

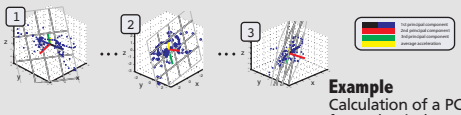
Step 1
PCA* of 3D-gyroscope values on a *1s*-sliding window



PCA
...reveals the axis of the main rotation perpendicular to the heading

* Principal Component Analysis



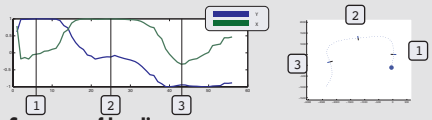


Example
Calculation of a PCA for each window

Step 2
- Select first Eigenvector as axis $\omega(t)$
- Project $\omega(t)$ onto ground plane

Step 2.1
calculate angle α between $\omega(t)$ and $\omega(t-1)$

Step 2.2
create normalized heading vector



Sequence of headings
Orientation of main principal component assuming constant speed

As for the hip, this works analogous for the hand.

(2) Classification

Goal:
Classified location transition

Given:
- Set of labeled location transition as trainingsdata
- Unknown location transition

Method:
K-Nearest Neighbor classifier on a rotation invariant correlation distance measure

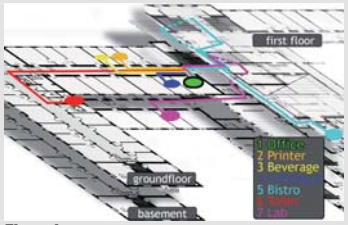
Evaluation

Hardware

Sensor Platform
XSens Intertial Measurement Unit

Xsens Inertial Motion Tracker delivers
- 3D Orientation vector
- rotational acceleration
- linear acceleration
- magnetic field

Data

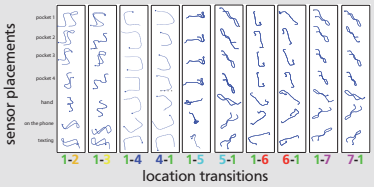


Floorplan
Defined Locations for Data Recording

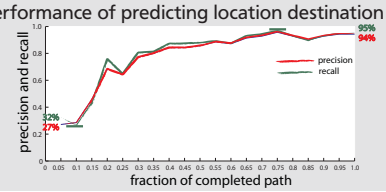
- Single user
- 10 typical location transitions during office day
- 4 different orientations in the pocket
- 1 in the hand
- 2 while on the phone or texting
  = 70 sets in total

Results

Accumulated sequence of headings (trajectory)



Performance of predicting location destination



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