Point and Control with Gestures in a Smart Home

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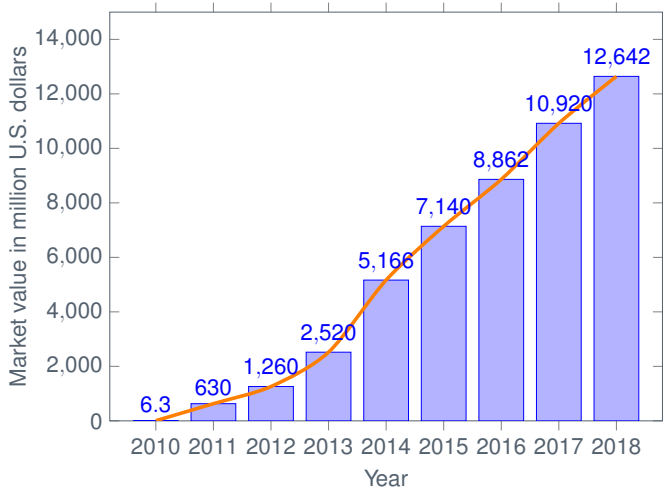
Agenda

- Introduction
- Architecture
- Gesture Recognition
- Orientation
- Indoor Positioning
- Evaluation

Introduction
Initial Problem

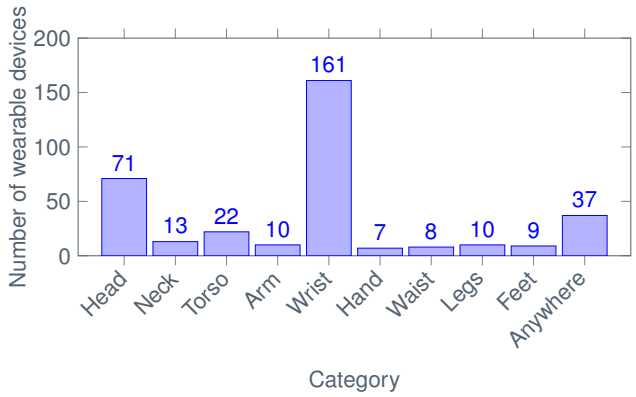
Combining wearables and smart houses

Introduction
Wearables trend



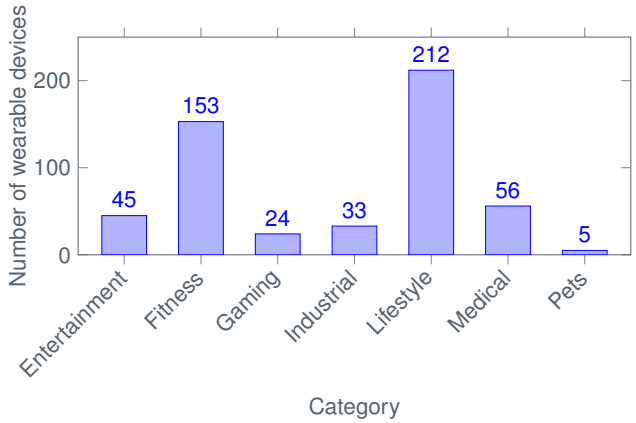
Data from statista.com

Introduction
Placement of wearables



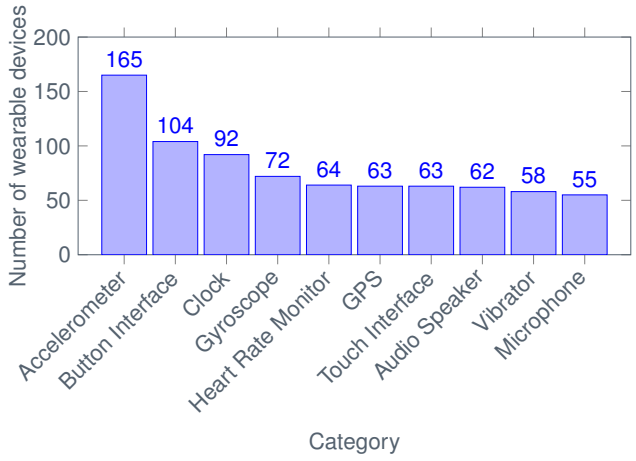
Data from vandrico.com

Introduction
Applications of wearables



Data from vandrico.com

Introduction
Components in wearables



Data from vandrico.com

Introduction
Degrees of home automation

- **Interactive systems**: Lowest degree of automation
- **User defined rule systems**: Medium degree of automation
- **Autonomous systems**: Highest degree of automation

Introduction
Mental picture

http://www.hypable.com/robert-downey-jr-salary-marvel/

http://www.digitaltrends.com/home/mit-engineers-invented-cameraless-motion-tracker-home-automation/

Introduction
Reemo

- Requires a receiver placed near each smart device

http://www.getreemo.com

https://www.youtube.com/watch?v=hSP5vqopgOQ

Introduction
Problem statement

How can wearables be utilized for home automation in a gesture driven solution?

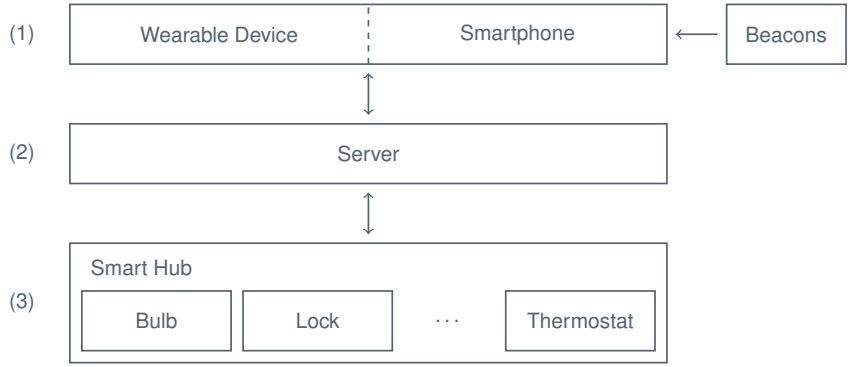
SCENARIO

1. Point at the device
2. Perform a gesture

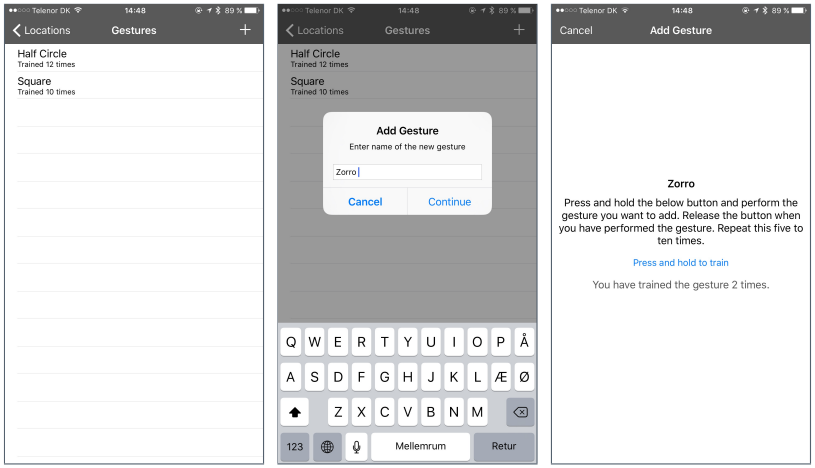
over

1. Take up his smartphone
2. Open up his smart hub application
3. Find and select the device
4. Find and select the action

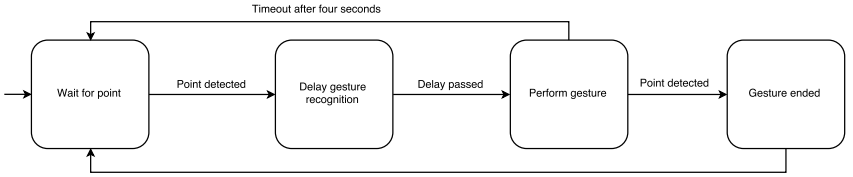
Architecture



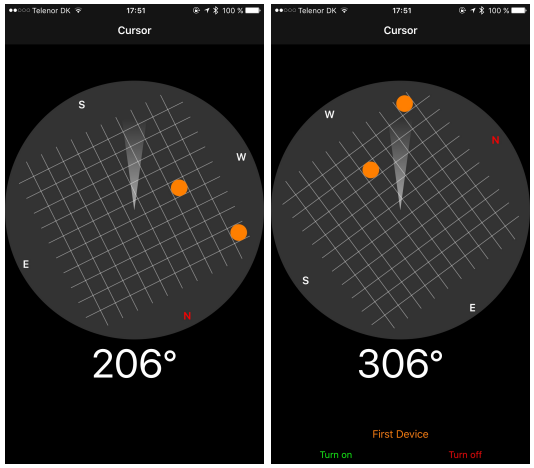
Gesture Recognition



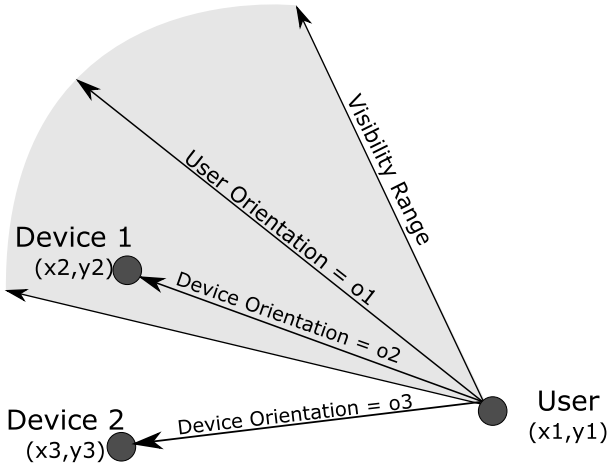
Gesture Recognition
Point Detection



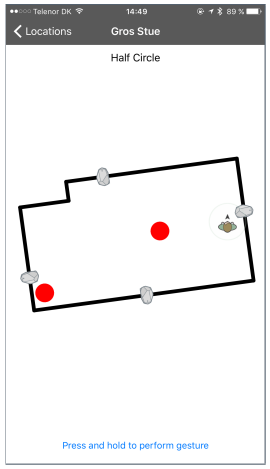
Orientation



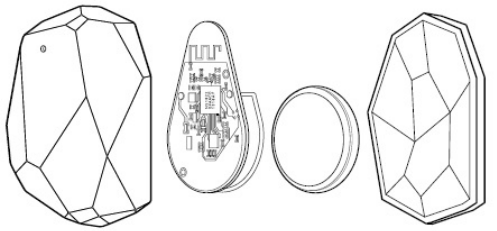
Orientation



Locating the user



Locating the user



http://blog.estimote.com/post/106913675010/how-do-beacons-work-the-physics-of-beacon-tech

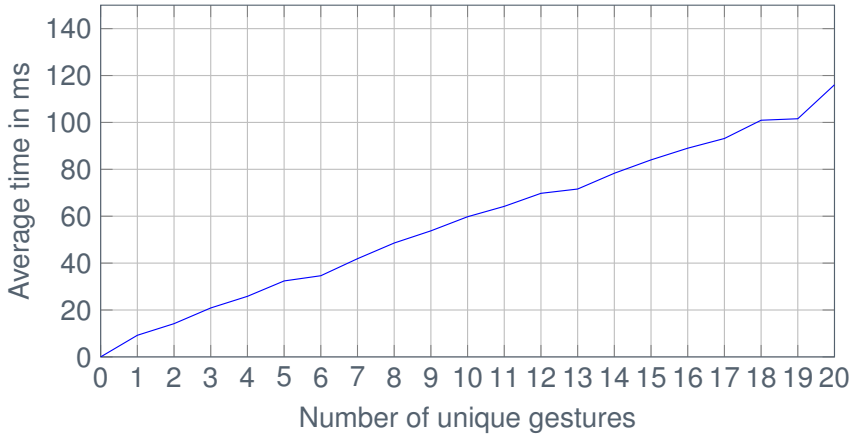
Gesture Recognition Performance

Setup

- Measure recognition time for $5, 10, \ldots, 100$ gesture traces
  - Equal to $1, 2, \ldots, 20$ unique gestures, trained 5 times each
  - Measured mean of 60 measurements per number of gesture traces
- Generate random gesture trace inputs
- Requirement: Faster than 200 ms

Gesture Recognition Performance

Results



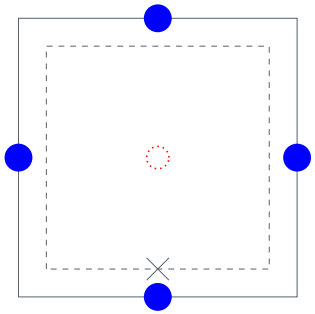
Gesture Recognition
Correctness

- Requirement: At least 80 %
- The authors report a correctness rate of 80 %
  - Based on a study of 12 people
  - Best score: 98 %
  - Worst score: 58 %

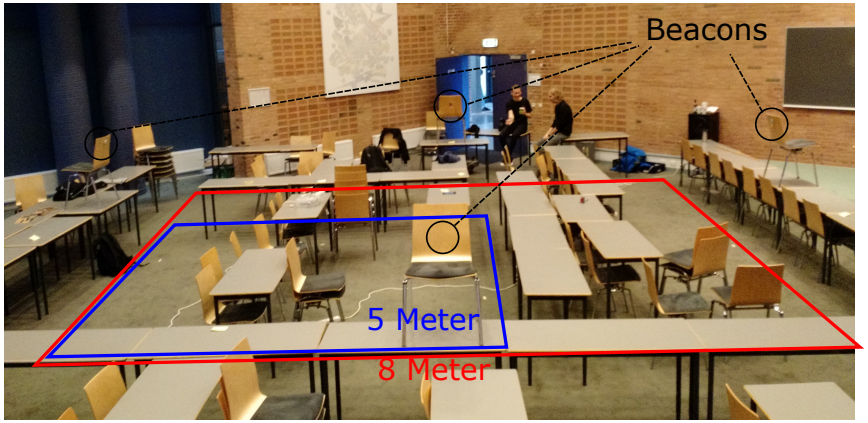
Precision of Indoor Positioning
Setup

Tested in 4 settings:

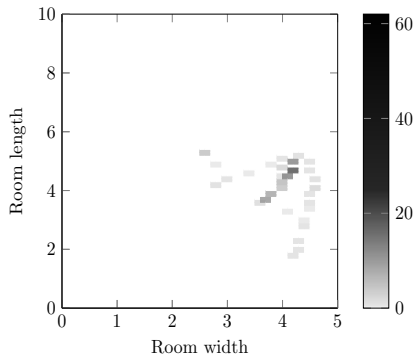
Name	Size in meters	# of Beacons	# of Tests	# of WiFi Access Points
Room 1	5×5	4	8	19
Room 2	8×8	4	7	19
Room 3	17.9×17.9	4	3	3
Room 4	4.90×9.95	4/8	33	20

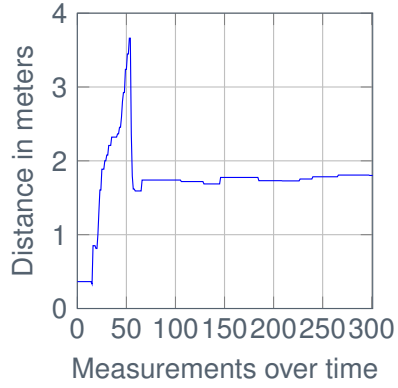


Precision of Indoor Positioning
Auditorium Setup



Precision of Indoor Positioning
Heatmap and Distance Graph (Room 4)



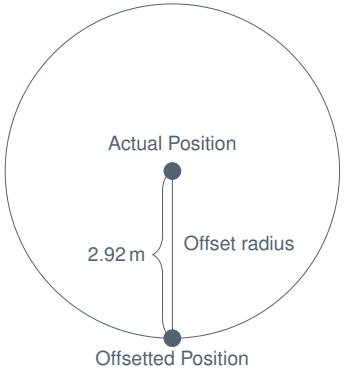


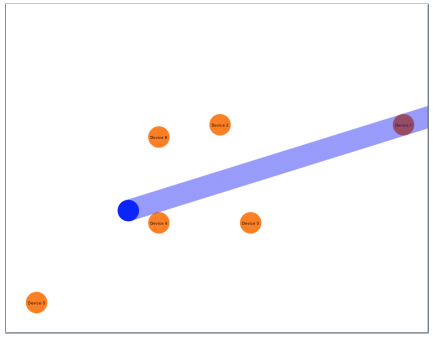
Precision of Indoor Positioning
Stationary Results

Room	Position	# of beacons	# of tests	Mean error
Room 1	Centered	4	5	1.78 m
Room 2	Centered	4	4	2.96 m
Room 3	Centered	4	3	7.31 m
Room 4	Centered	4	3	1.94 m
Room 4	At (2, 8)	4	3	1.22 m
Room 4	Centered	8	3	3.02 m
Total			21	2.92 m

Impact of Simulated Accuracy
Setup

- Given the result of the precision test, how does the system work?
- Simulate a inaccurate position on the circle with radius 2.92 m

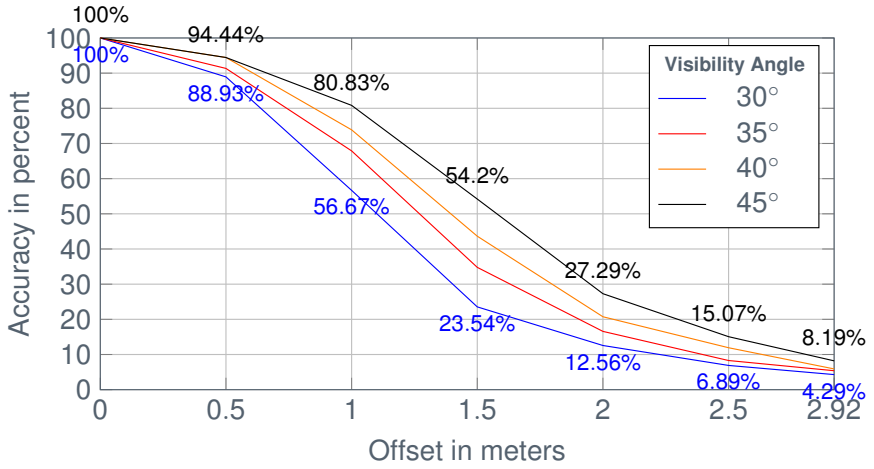




Impact of Simulated Accuracy
Setup

- 18 tests with different *actual* positions
- 6 devices in room of size 6.9 × 5.37 meters
  - 3 test for each focused device
- 100 randomly generated *inaccurate* positions for each test
- Measured mean of 10 iterations
- Requirement: At least 80 % accuracy

Impact of Simulated Accuracy
Results with different visibility angles



Conclusion
Problem Statement

How can wearables be utilized for home automation in a gesture driven solution?

- Developed a system that can control a smart home using a wearable
- Utilizes Bluetooth Low Energy beacons for indoor positioning
- Points at the correct devices 4.29 % of the time
- However, if we exclude the numbers from Room 3, we get
  - An average position accuracy of 2.1 m
  - Corresponds to ∼12.5 % correctness rate
  - ∼27 % correctness rate with visibility angle = 45°
- We need a position accuracy of ∼0.6 m to meet our requirement

Conclusion
Future Work

1. Use a wearable
2. **Investigate Alternatives for Indoor Positioning**
3. **Include Information About the User's Context**
4. Configuration of Locations
5. Improve Detection of Pointing
6. **Continuous Recognition of Gestures**
7. **3-Dimensional Positions**
8. **Support for more than binary gestures**