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Device Positioning Using Smart Zigbee Beacons

Context awareness

Pervasive applications react to sensed data

- Context-aware: react to the environment, understood symbolically

Environmental data

- Light, temperature, humidity, …

Personal data

- Calendar entries, to-do lists, address books, social networks, …

Location data

- Where am I?

The location problem is tricky, and doesn't have a clean, single-technology solution

Locating users

GPS

- Global scale, few meters accuracy, line-of-sight to satellite, doesn't work indoors

Mobile phone observation and triangulation

- Cell scale (needs signal to work), hundreds of meters accuracy

Ubisense, Crickets, Bats

- Room scale, costly, complex to install and maintain

WiFi access points

- Room (or larger) scale, takes advantage of existing infrastructure

PlaceLab

With all these technologies, we still need a way of translating raw sensor observations into meaningful locations

PlaceLab

- Originated as an Intel project
- Open source, community-driven, Java-based

Position devices using visible WiFi access points

- Triangulate based on observed received signal strength (RSS)
- Account for the vagaries of architecture

Requires *war driving* set up phase, and subsequent maintenance

- Go around and measure the signal strengths of the access points in sight to create a map
- Upload and share maps at wigle.net to share across the community

Architecture uses *spotters* to observe the APs

- WiFi, Bluetooth, cell towers
- … but no Zigbee, which is now starting to become prominent

Zigbee spotter

Our project wass to build Zigbee spotters PlaceLab-style systems

- For location tracking in the home, office, or any Zigbee enabled environment

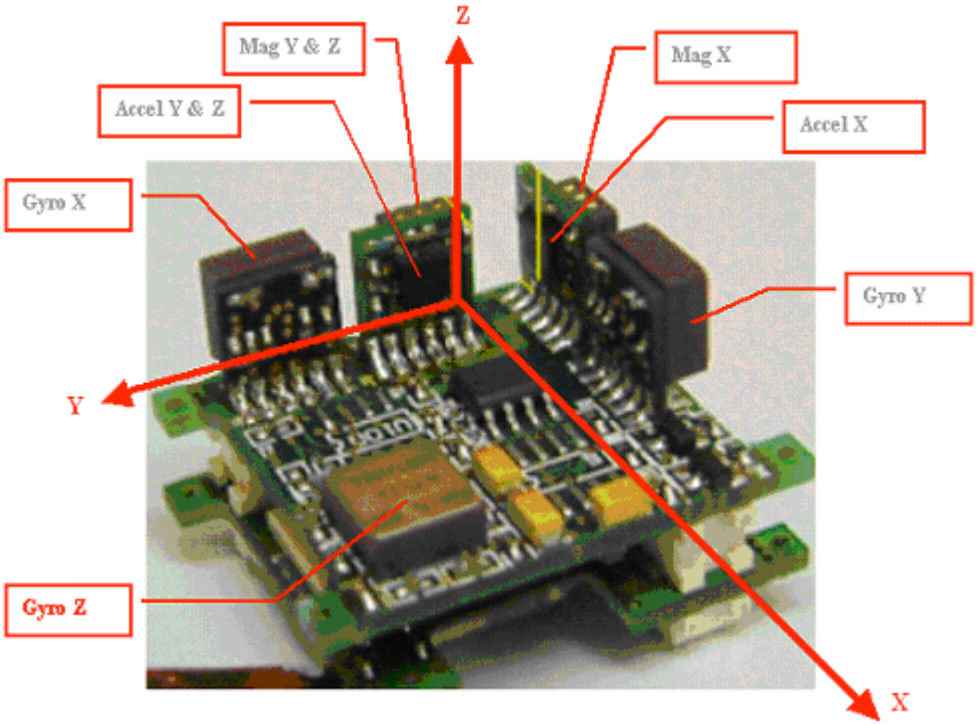
Tyndal motes platform for this

- Zigbee radios plus other goodies

Two possible architectures

- Mote as sensor: let a mote track its position using Zigbee triangulation fused with its other sensors
- Mote as beacon: place a mote as a dedicated location beacon, that can track its own position because of its extra sensors

Hardware



A smarter spotter

From previous work we know that PlaceLab-style spotting on its own is quite flaky

- Low resolution triangulation, APs move, maps “drift”

Tyndal motes also have additional sensor modalities

- Inertial measurement unit
- Accelerometer
- Gyroscope

Take advantage of these facilities to build a better mousetrap

- Beacon could facilitate location of devices whilst emitting a description of its environment
- Combined with our *Construct* contextual systems platform the mote acts as the core of a *Context co-processor*

Address the war drive problem

Am immediate win is to address the war drive problem

- APs move after they've been observed to build the map
- When a beacon moves, spotter accuracy faLls

But motes know when they move

- Fuse additional sensor information

Use this knowledge to repair the maps

- Ask for a new war drive
- Or self-heal, if we can tell how far the beacon moved

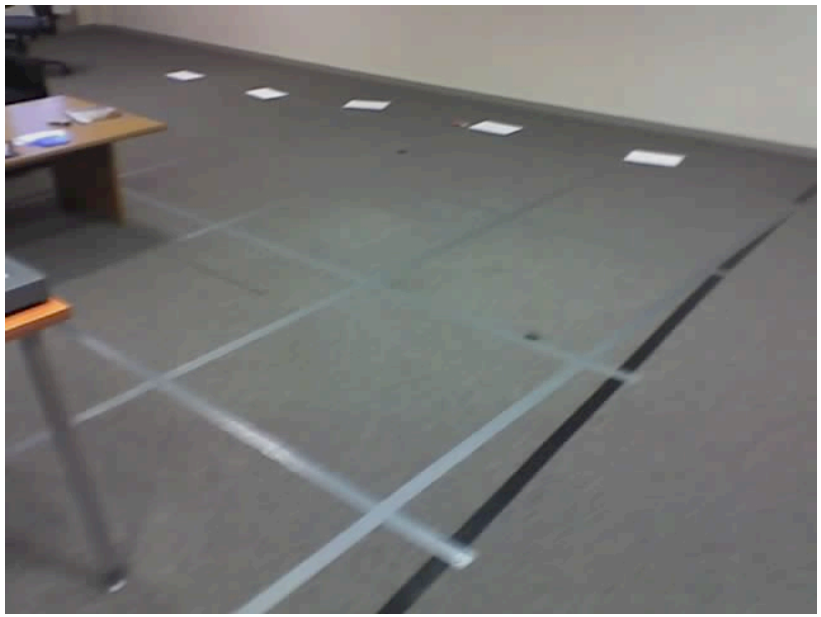
Experiments

We've developed the software spotter, and are now characterising it

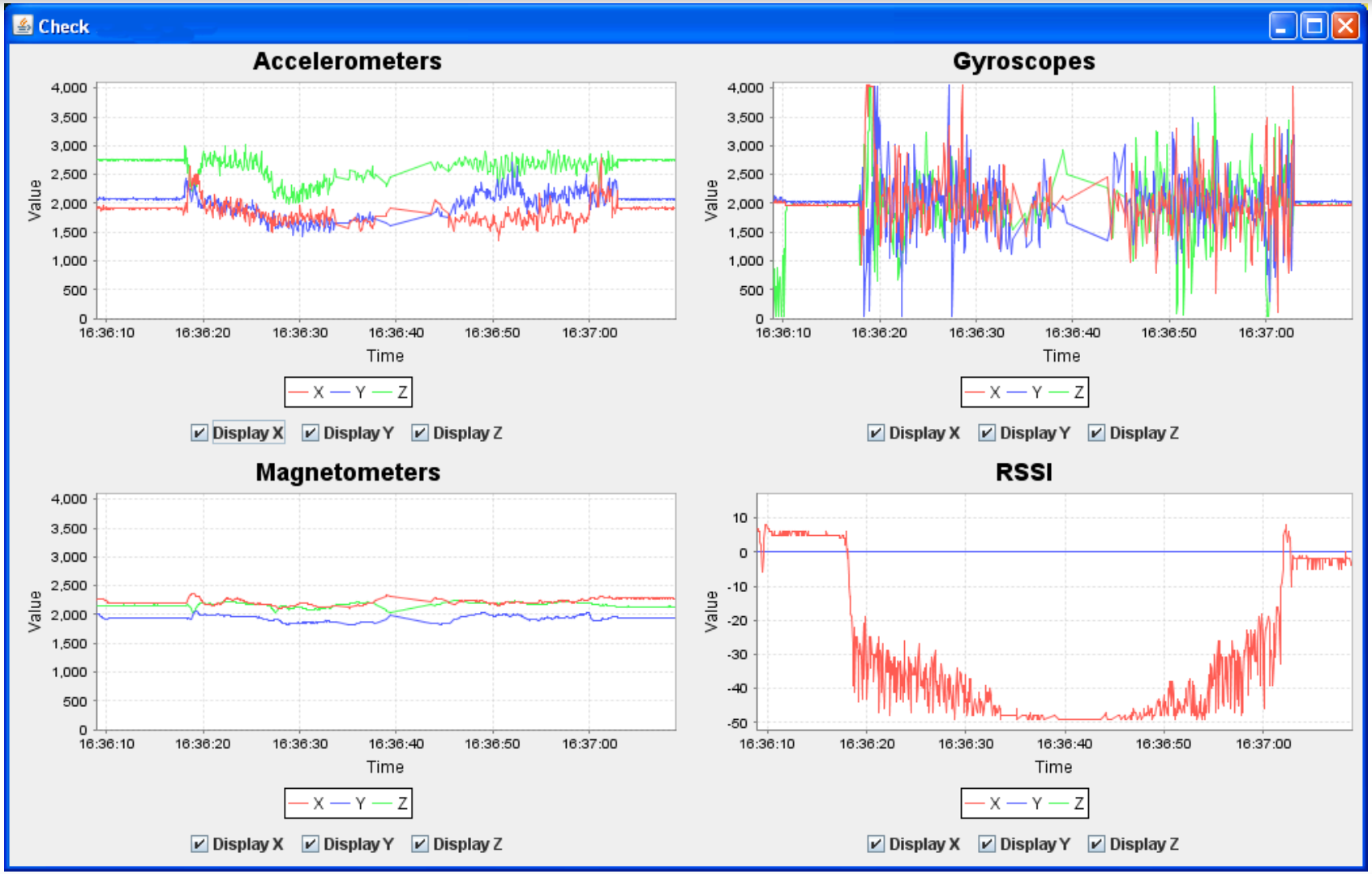
- Walking the corridor
- Walking the grid
- Comparison with our Ubisense infrastructure

Indoor versus outdoor

- Environmental factors?
- Compare against a range of location technologies
- … and publish



Sample raw results



What's obvious even now

Antenna design and direction make a *huge* difference

Environmental factors are extremely prominent

- Reflections, absorbtions, …

Sensor fusion is definitely possible

- Can see changes on the other sensor modalities

Middleware solutions are promising

- Standard fusion algorithms and ontologies in Construct
- Insulate applications from the details of *how* they locate themselves

Interactions and extensions

This process has helped us in a number of ways

- A useful contribution to an open source project
- Practical platform for sensor fusion experimentation
- Deepened our understanding of hardware
- Given us extremely valuable programming experience with an extensible mote platform

These experiences are being extended within other projects

- Lero – sensor fusion
- NEMBES – embedded sensing, programmability of sensor networks