Wearable Computing and Autonomous Computing Platform

Steve Beeby
Geoff Merrett, Gopal Ramchurn, Sebastian Stein, Alex Wedell, Obaid Malik
Centre for Machine Intelligence
Agents, Interaction and Complexity Group
ECS
University of Southampton
Project Focus

The integration of **wearable systems** networked with **smart city** and building **information systems**, and the management of collected **data**.
Platform Grant Details

• 5 year grant (1\textsuperscript{st} April 2017 – 31\textsuperscript{st} March 2022)

• Investigators: Steve Beeby, Geoff Merrett, Gopal Ramchurn, Bashir Al-Hashimi, Alex Weddell, Seb Stein

• Use the grant to do pump priming research that will lead to collaborations and further research proposals
Project Themes

Themes

- Devices
- Circuits & Algorithms
- Smart Software
- Applications

Aims

- New Ideas and Applications
- Retain Key Staff
- International Networking
- Develop Careers
Theme 1: Devices

• Wearable devices aspect of the IoT
• Aim to develop wearable devices that are networked with the smart city
• Wearable sensors and autonomous power supplies
  • Location, activity, pollution monitoring sensors
  • Ferroelectret energy harvesting
• Move away from traditional wearables (e.g. watch) – move to garments.
Theme 1: Devices (cont.)

• Leverage technologies developed in other projects
  • FETT project integrating sensors and electronics in yarns
  • SPHERE project – ambient assisted living (wearable devices and data interpretation)
THEME 2 – CIRCUITS AND ALGORITHMS

Novel circuits, algorithms and protocols to enable efficient integration of energy harvesting sources into low-power IoT systems

• Energy harvested from environmental sources is typically highly dynamic

• Theme is focussing on battery-free systems, removing all energy storage
  • Reduces complexity, cost and size; ideal for mass-produced pervasive IoT devices
THEME 2 – EXAMPLE BATTERY-FREE APPLICATIONS

Step Counter

- Powered by wearer’s steps (ferroelectric insole)
- Speed estimated from shape of voltage pulse
- Wirelessly transmits step count and speed

Cycle Computer

- Powered by small magnet on rotating wheel
- Speed estimated from shape of voltage signal
- Wirelessly transmits speed, distance and time


THEME 2 – CHALLENGES

A wide range of challenges still exist to enable efficient and effective battery-free systems and applications, e.g.:

• Transient computing: compute when there’s power, survive when there isn’t
  • Efficiently detect failure, retain and restore volatile state
• Power neutral operation
  • Continually adapt to efficiently use available energy
• Software/tool support for battery-free computing
  • E.g. Arm mBed library released

www.transient.ecs.soton.ac.uk

Theme 3: Smart Software

How to manage noisy and excessive data?

How can people interact with the data to make better decisions?

How to incentivise effective participatory sensing?
Theme 3: Smart Software

- We address these challenges using:
  
  - **Machine learning and artificial intelligence**: to detect key patterns in the presence of uncertainty and noise.

  - **Human-agent interaction mechanisms**: to enable powerful human-agent collectives that can jointly make good decisions.

  - **Incentive engineering**: to provide the right incentives for citizens to collect data.
Smart Software: Autonomous IoT
IoT to A-IoT

• *An Autonomous IoT* would 'actively' manage data and decisions on behalf of users.

• However, it is critical to still *allow users to make informed choices* about their general needs and comfort.
Interactions with A-IoT

• How should interactions with autonomous systems be engineered to support users' daily activities?

• To what extent may users be willing to delegate agency to A-IoT systems in everyday contexts?
A-IOT Examples

**Autonomous Food Ordering:** autonomous ordering of goods and food. This will be based on sensing and inference of the level of stock available in the home, and opportunities for autonomous group buying.
A-IoT for Food
Smart Kitchen Scales for Autonomous Food Ordering

Fig. 8. The scales installed by two participants in their kitchens
Smart Kitchen Scales for Autonomous Food Ordering

Fig. 2. The dashboard, which is the index page of our website. It includes the scale data, the budget and the current orders.

Fig. 4. The consumption page shows a plot of the user’s data since the last refill. The blue line projects the consumption and predicts the date the user will run out.
A-IoT for Food
Barcode Scanner for Autonomous Food Monitoring and Ordering
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A-IoT for Food
Autonomous Agents for Food Ordering

• Provide users ability to choose level of autonomy:
  • **Low autonomy:** When a product is about to run out, the agent notifies the user suggesting them to make an order. Nothing happens if the user doesn’t react.
  • **Medium autonomy:** When a product is about to run out, the agent provisionally creates an order for replenishing it. The user is notified and they have one hour to modify or cancel the order, otherwise the order is placed.
  • **High autonomy:** When a product is about to run out, the agent directly places an order for replenishing it.
A-IoT for Food Wastage
Smart-Bin (In progress)

- Reduce food wastage.
- Inform users of wasted items.
- Record weight, temperature, fill level.
- Record multiple gas emissions using electronic nose.
- Intelligent algorithms to classify binned items.