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DejaView

A low-power, distributed, pervasive system for supporting memory

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Mobile Health at MobiHoc '11

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Outline

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- Motivation
  - Peoples' memory problems
  - Electronic memory aids
- Our system: DejaView
  - Our new design
  - Tests, power consumption, latency
  - Trials and future work

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Motivation

Peoples' memory problems

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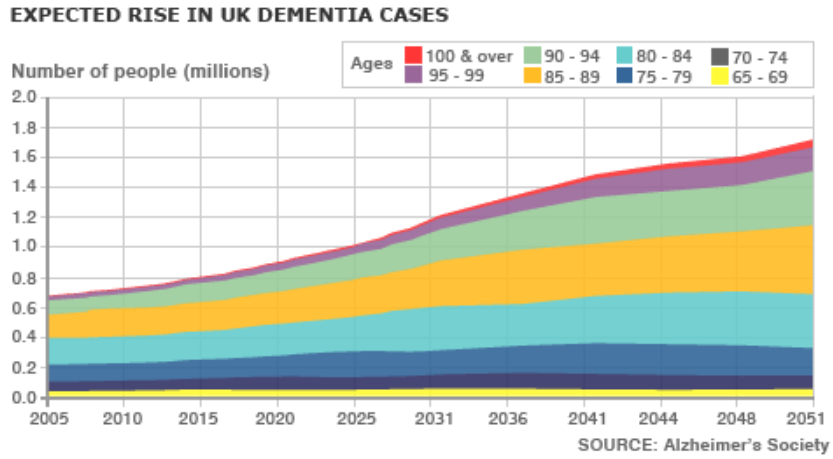
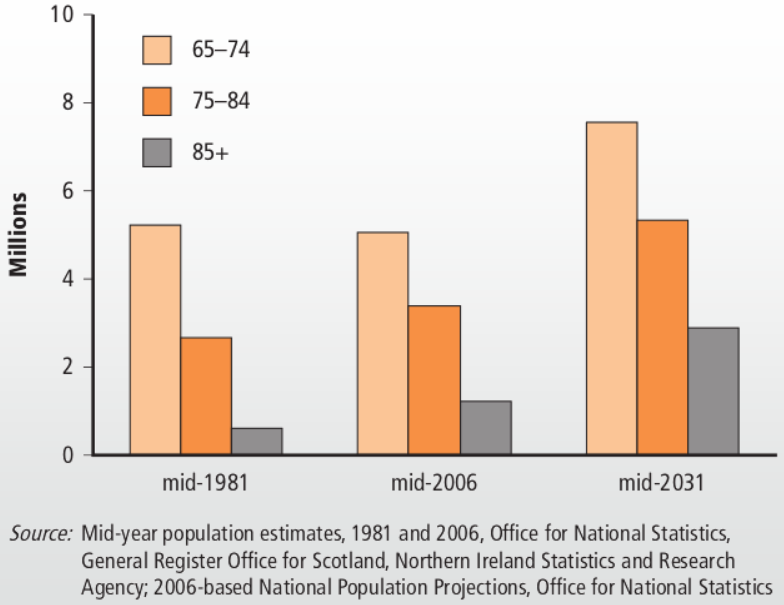
- **Disease, injury**: dementia, traffic accidents, alcoholism…
- Memory failure a key sign of Alzheimer's
- Memory impairment in 70% of head trauma cases
- Affects employability, socialising, **quality of life**





Source: Mid-year population estimates, 1981 and 2006, Office for National Statistics, General Register Office for Scotland, Northern Ireland Statistics and Research Agency; 2006-based National Population Projections, Office for National Statistics

Dementia graph: BBC blog (http://www.bbc.co.uk/blogs/grahamstewart/2009/05/do_care_homes_care_about_demen.shtml)
Age demographics graph: Office for National Statistics report

Memory assistance

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- Remembering future plans: jobs, chores, appointments (**prospective** memory)
- Remembering about the past (**retrospective)**
  - With recalling past experiences of holidays, events (**episodic** memory)
  - Knowing facts, such as peoples' names, dates, places (**semantic** memory)
- All affected separately in different people

Prospective aids

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Various kinds in the literature

- Automated pager/SMS messages
- Pre-recorded voice reminders
- Mobile phone calendars
- PDAs with custom software
- A robot which studies its owner

IC recorder image: Sony.jp
Pager image from Vitachao on Wikimedia Commons,

Retrospective aids

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iRemember, Rememberance Agent, Forget-me-not…

- Some primitive context-awareness
- Real-time or delayed feedback
- Very task-orientated, mostly for work
- Some task aids (e.g. for cooking)

iRemember screenshot from *iRemember: a Personal, Long-term Memory Prosthesis;* Vemuri, Schmandt, and Bender (2006)
ParcTab photo adapted from *Forget-me-not: intimate computing in support of human memory;* Lamming and Flynn (1994)
Rememberance Agent photo from *The wearable remembrance agent: a system for augmented memory;* Rhodes (1997)

SenseCam

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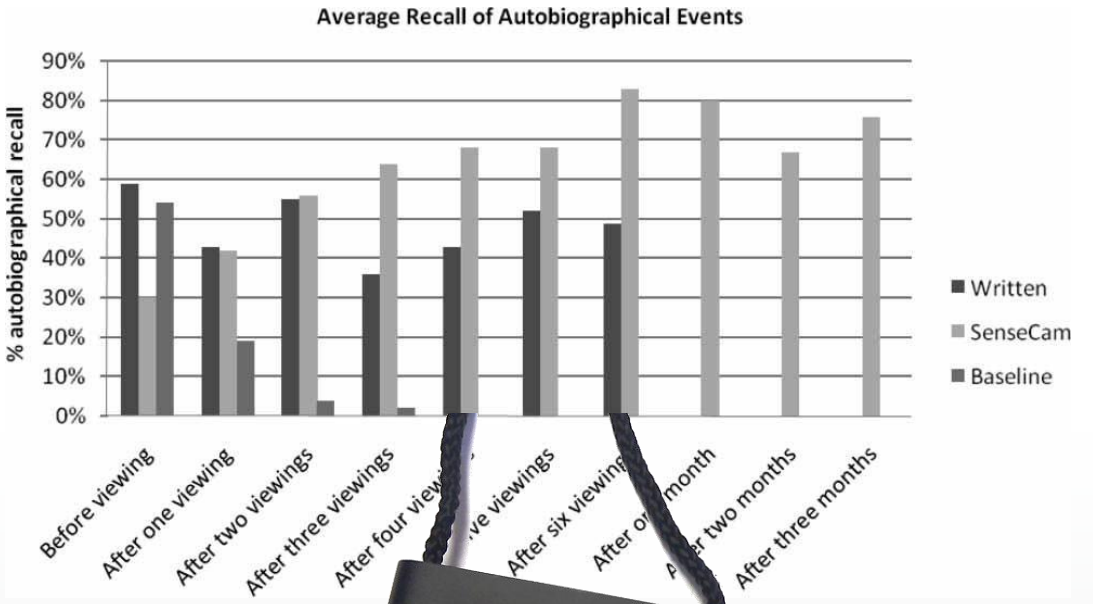
- Photos reviewed later
- Improvements in studies
- Lots of photos to sort through



SenseCam effect graph from *The use of a wearable camera, SenseCam, as a pictorial diary to improve autobiographical memory in a patient with limbic encephalitis: a preliminary report;* Berry, Kapur, et al. (2007)

SenseCam extensions

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- Grouping images by similarity
- Face recognition
- Activity detection with accelerometer
- Tagging with GPS data
- Adding a compass
- Detecting people with Bluetooth

SenseCam effect graph from *The use of a wearable camera, SenseCam, as a pictorial* … *cal memory in a patient with limbic encephalitis: a preliminary report;* Berry, Kapur, et al. (2007)

Discussion

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- Lots of thoroughly-studied prospective aids
- Limited number of retrospective aids
- Very few real-time aids, and only basic context-awareness
- Promising results from studies of SenseCam

- No system exists to provide real-time retrospective aid based on intelligently-inferred context

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Our system: DejaView

DejaView system concept

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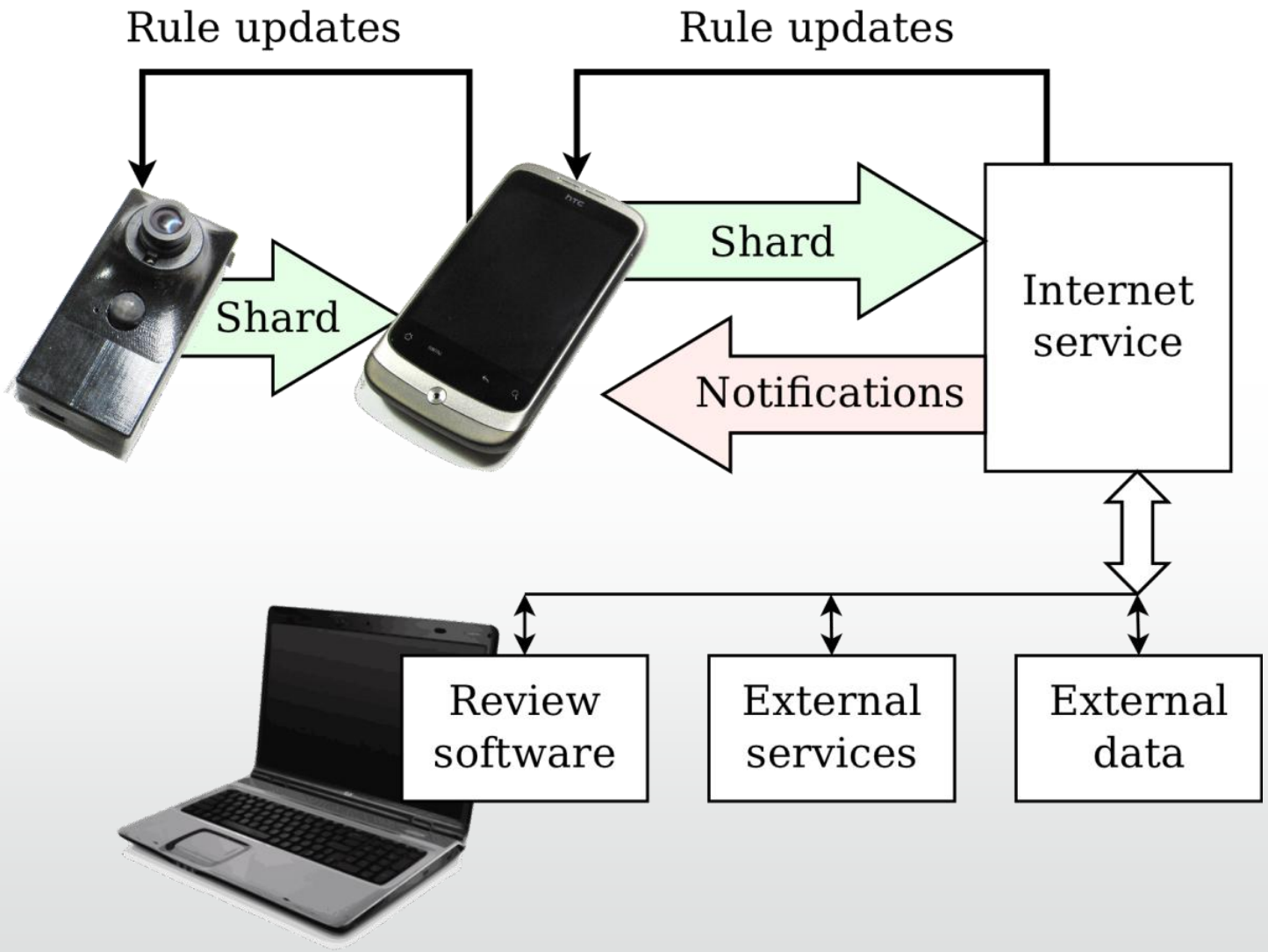

Design requirements

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- Three-tier architecture means we must optimise for **latency**
  - on the device
  - in transmission
- Wearable device must last for a day without charge, so must be **low power**
  - vary frequency of taking photos
  - use only effective sensors

An example

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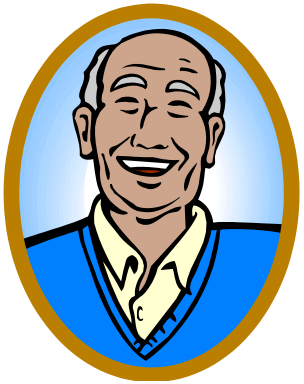

Mr. Jones is speaking to his neighbour, Anne, but can't remember when or where he last saw her.

The system recognises her face and retrieves information on when they last met, where they were, who with, etc.

You last saw Anne on Wednesday afternoon at Lily's house with Roger and Colin. You are going for lunch together tomorrow at one o'clock.

Information we need

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- We can help with retrieval of memories by providing good **cues**
  - **people**
  - **places**
  - **objects**
  - **actions**

- These have been studied in the literature
- Shown to be very important in SenseCam studies
- Need to select appropriate sensors to detect and capture them

Example behaviour

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Recognised faces. Talking to Ian, Steve, Richard. Remind the user when and where they last spoke to these people. Increase photo capture rate.

Detect we are indoors. Calendar shows an appointment in fifteen minutes. Remind the user of the appointment and where they are.

Recognise objects. We are in the kitchen. Has the user put milk back in the fridge before leaving the room? A memorable action may be performed.

Sensors considered

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Sensor	Energy/S	Vol. (mm^3)	Use
Microphone	84.4nJ	22	Person
Compass	450nJ	21	Action
Light level	672nJ	1	Place
Accelerometer	39.4µJ	15	Action
PIR	24.3mJ	1621	Person
Heart rate	*10.8µJ*	*1416*	*Health*
Humidity	*56µJ*	*96*	*Place*
Temperature	*2.25mJ*	*36*	*Place*
GPS	*743mJ*	*1142*	*Place*
Blood pressure	*120J*	*131040*	*Health*

The wearable device

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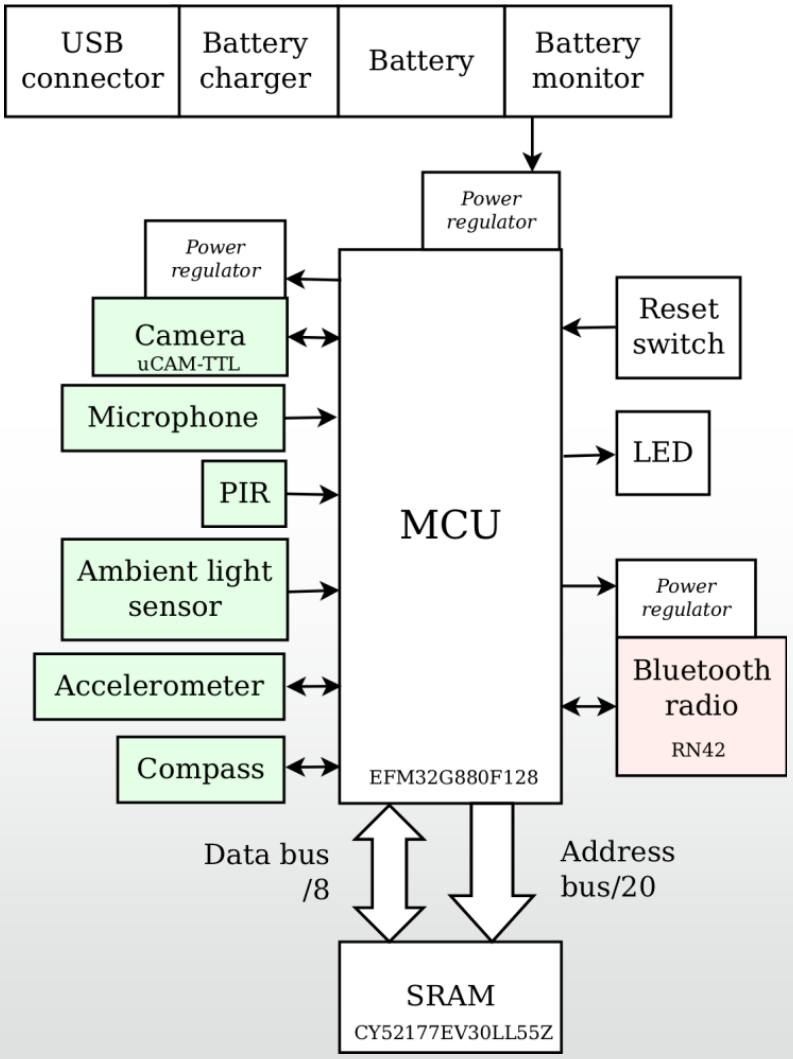
- Very low-power MCU
- Interrupt-driven design
- Dynamic clock control
- Dynamic power control
- Multiple voltages
- Dynamic ‘rules’ determine when to take a photo



Phone software

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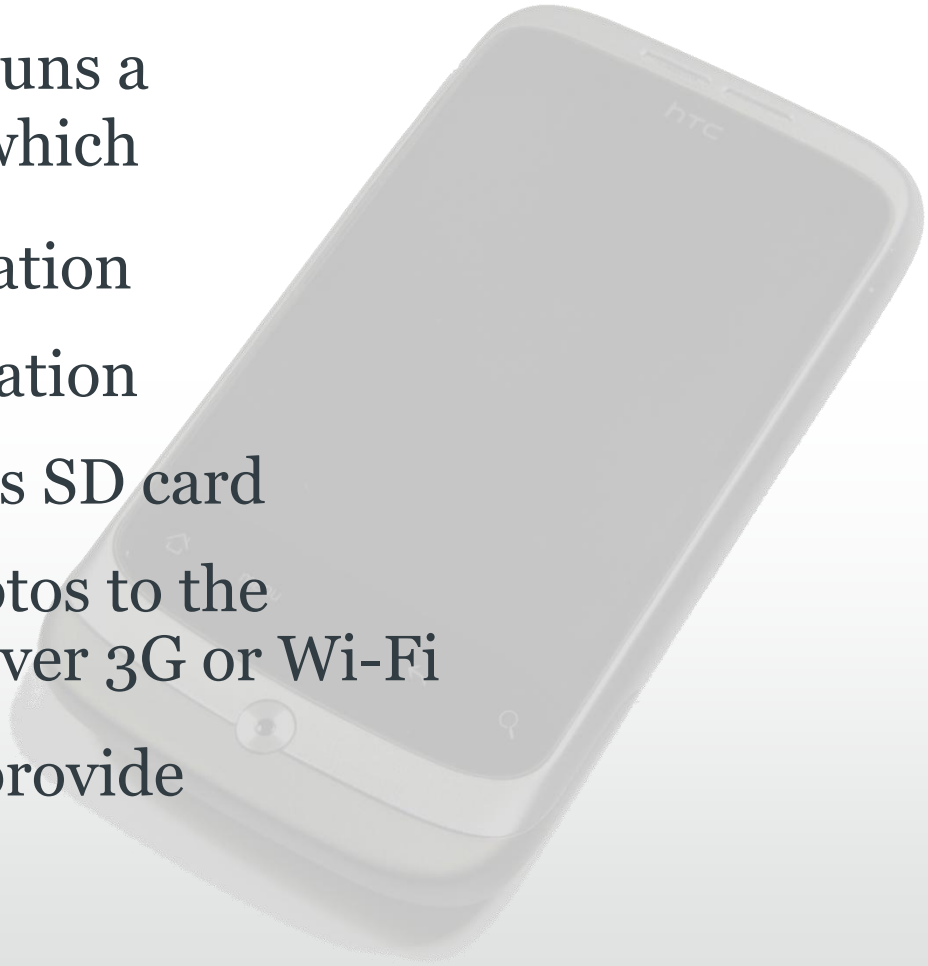
- The Android phone runs a background service which
  - adds GPS information
  - adds time information
  - saves images to its SD card
  - transmits the photos to the Internet service over 3G or Wi-Fi
- Also runs an app to provide feedback to the user



Internet services

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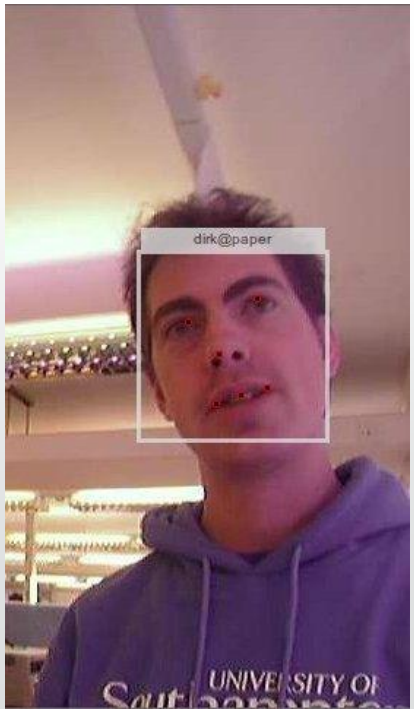
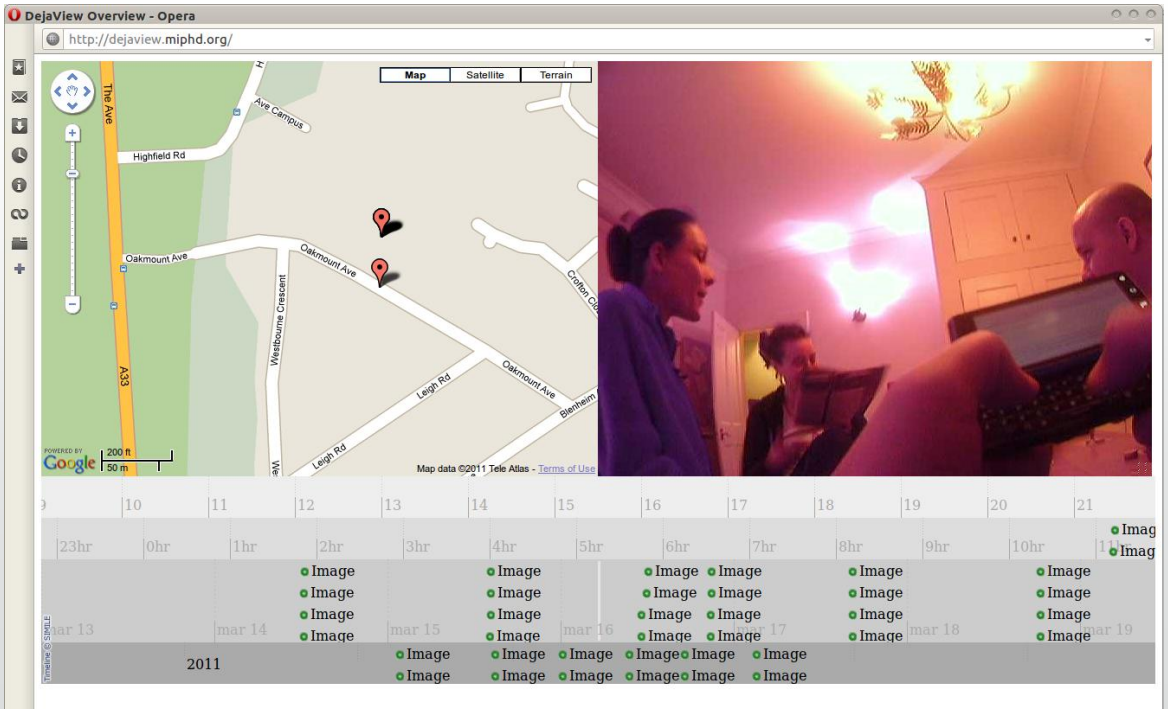
- The Internet service
  - runs uploaded images against Web services
  - makes images available for review through Web interface





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Testing and evaluation

Current implementation

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- Device takes photo based on sensors
- Photos uploaded to server
- Face.com checks photo for faces
- Any faces found are identified on phone

Energy use of device

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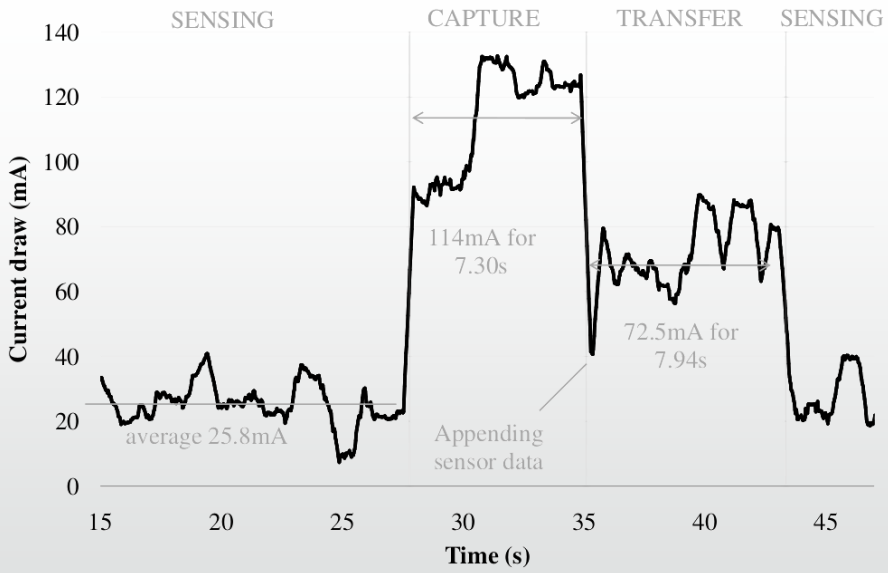
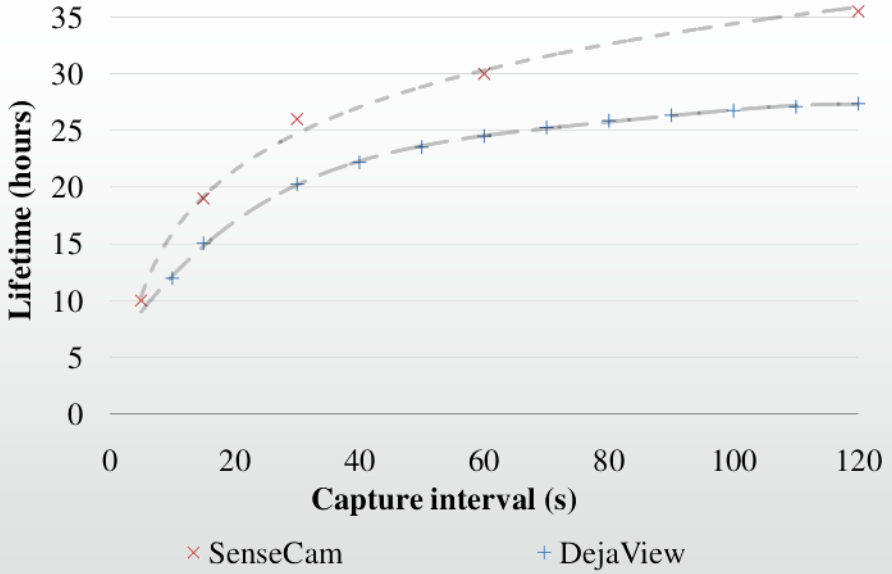
Phase	I (mA)	t (s)	E (J)
Capture	114	7.30	3.40
Transfer	72.5	7.94	2.36
Sensing	25.8	—	—

Interval	I (mA)	Lifetime
15s	53.1	15.1h
30s	39.5	20.3h
60s	32.6	24.5h





System latency

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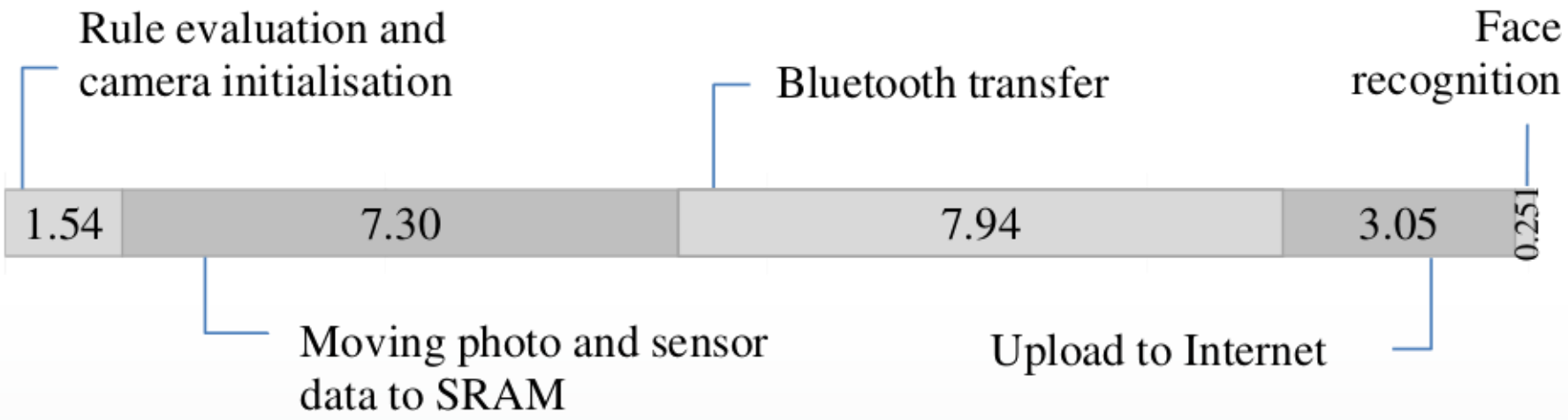

- Moving photo to SRAM much faster with new camera
- Bluetooth performance improved recently

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Conclusion

Future work

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- Finishing new model of wearable device
  - reduced latency (by around 50%)
  - higher-resolution photos
- Intelligent processing to extract more information for lower energy and latency overheads
- Optimise the energy trade-offs between on-device processing and delegation to higher layers
- Talking to clinicians about trialling on patients with memory disorders

Summary

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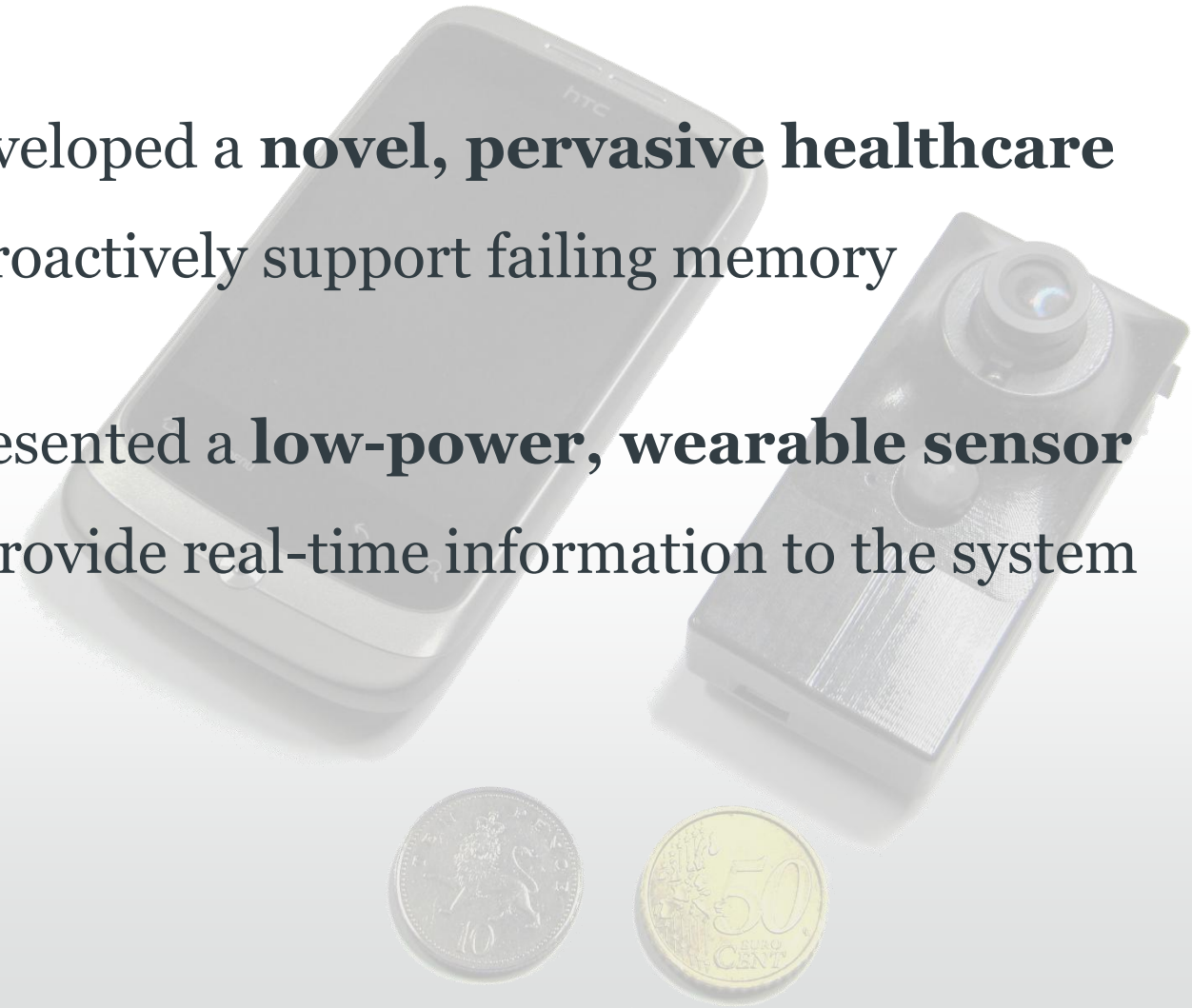

- We have developed a **novel, pervasive healthcare** system to proactively support failing memory
- We have presented a **low-power, wearable sensor device** to provide real-time information to the system