UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Platforms & Applications for Embedded Vision

Presenter:

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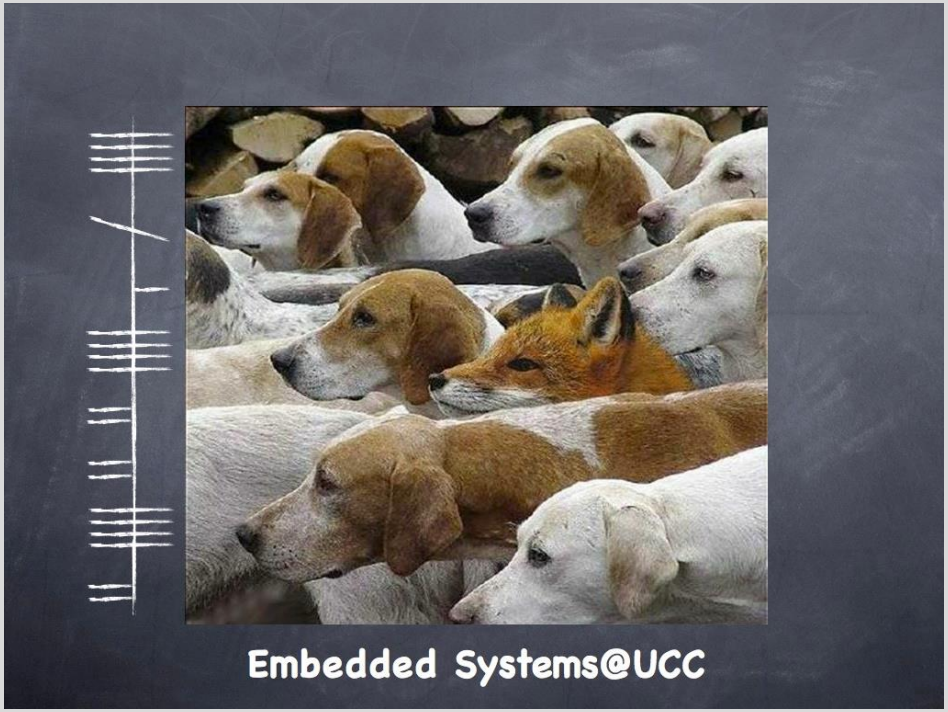


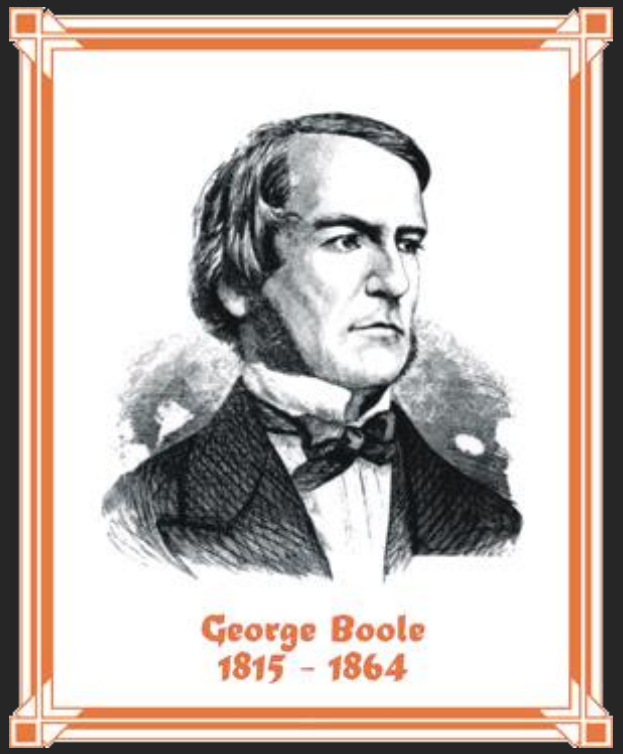
The Spring 2015 Computing Systems Week, May 5-7, Oslo

Embedded Computer Vision

"Vision is the art of seeing what is invisible to others." **Jonathan Swift**

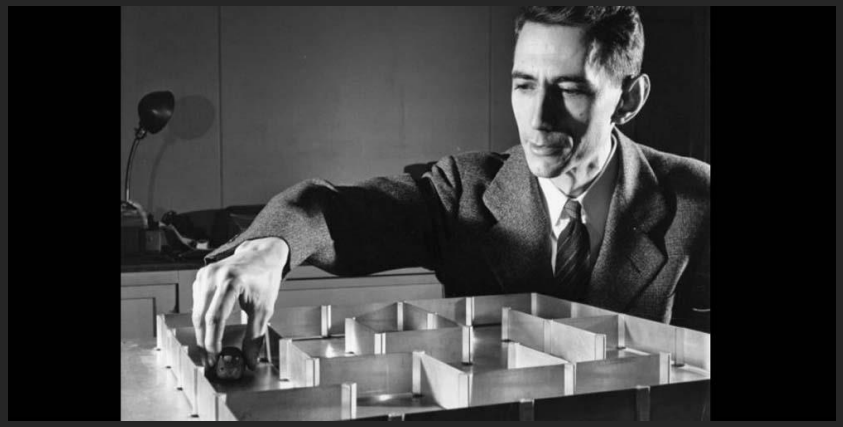
University College Cork(1845)

- Largest University in the South of Ireland
- George Boole was UCCs first Prof. of Mathematics
- www.georgeboole.com
- When Boole meets Shannon-2nd iRISC workshop, 1-2 Sept'15



Presentation Overview

- Embedded Vision
- Main Ingredients
- Some projects
- Sense the invisible
- Future developments



“I am always building totally useless gadgets just because I think they’re fun to make”, Claude Shannon

nD Embedded Vision

Our view

Embedded Systems

Collection of small components brought together into one system to serve the purpose of a specific situation

nD Vision

Vision is a very powerful sensor generating information rich data. A multi dimensional(nD) vision is about sensing beyond human capabilities.

Vision Technology

Departure from tradition with IR, Thermal, Lidar, ultraviolet, … enriched with a myriad of other sensors

Applications Requirements

Low Power is the norm

Applications for nD vision

Medical, entertainment, safety, security, automotive, education, environment, ….

Making Sensors Smart

Key is to provide low energy algorithms for image and sensor data processing, sensor fusion, machine learning, etc.

Efficient Vision systems rely on low energy Computation/Processing

Main Ingredients

Heterogeneous everything

Vision Sensors

CMOS cameras, Thermal imaging, IR, LIDAR, stereo vision, UV

Image/Video Signal Processing

Low resolution to high resolution, low frame rate to high frame rate, low power to not-so-low power

Other sensors

Accelerometers, Temperature, Humidity, Microphones, Gases, PIR, luminosity, …

Image/Video + Signal Processing

Sensor fusion for smarter, lower power vision systems

(Wireless) Processing Platforms

Inforce, Intel(Edison, Quark), Myriad, Rasberry Pi, SparkCore, TI, Aldebaran, Custom(ARM), Mikroelektonika, Movidius,…

Human/Robot Interaction

Sensors and processing everywhere. Power consumption is the key

Support and particularly compilers are essential ingredients in the design process

Some (serious) Projects

To the subject areas

U-Play

Toys and Interfaces for interacting with toys for children with disabilities

- Human - robot interactions
- Robot-robot interaction
- Visual and vision at core

i-BEES

Accelerometers, Temperature, Humidity, Microphones, Gases, PIR, luminosity, IR, …

- Non-intrusive Health Status
- Inside the hive view
- Bee tracking
- More than bees

Safe/Secure Farm

Inforce, Intel(Edison, Quark), Myriad, Rasberry Pi, SparkCore, TI, Aldebaran, Custom(ARM)

- Detecting intruders using energy neutral vision?
- Detecting alive things

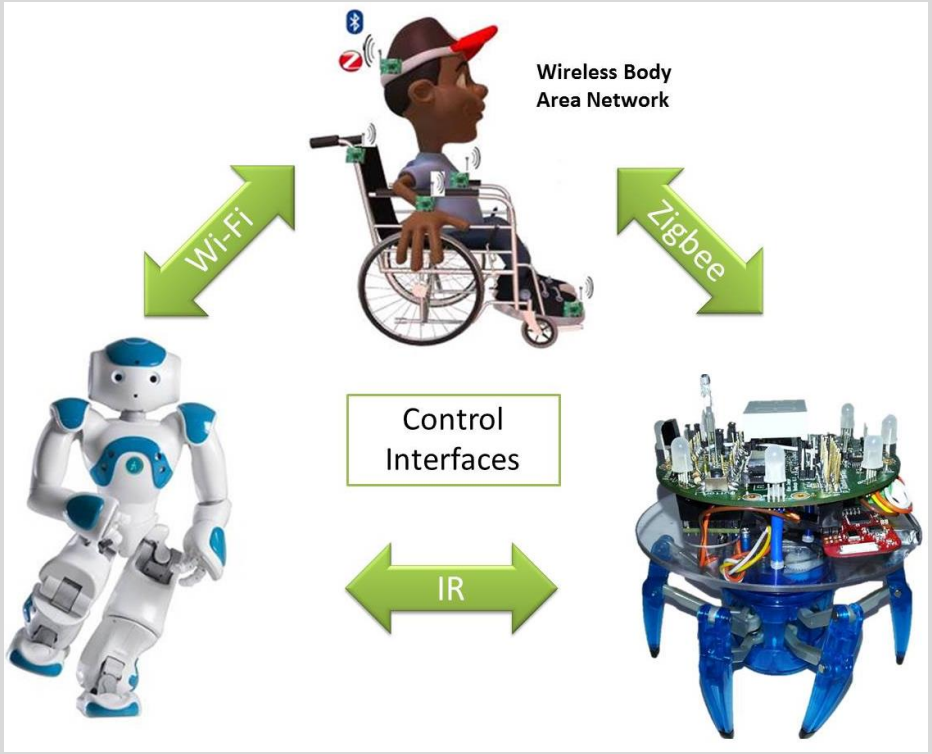
Interdisciplinarity generates best ideas

U-Play2:

2nd Prize, IEEE/IBM Smarter Planet Challenge, 2013

Team:

M. Donovan, J. Cunningham, F. Edwards-Murphy, T. Jezequel, T. Lambe, A. Zagoneanu, M. Bradley, J. McCarthy, E. Popovici



Main Project Aims and Goals

U-Play 2

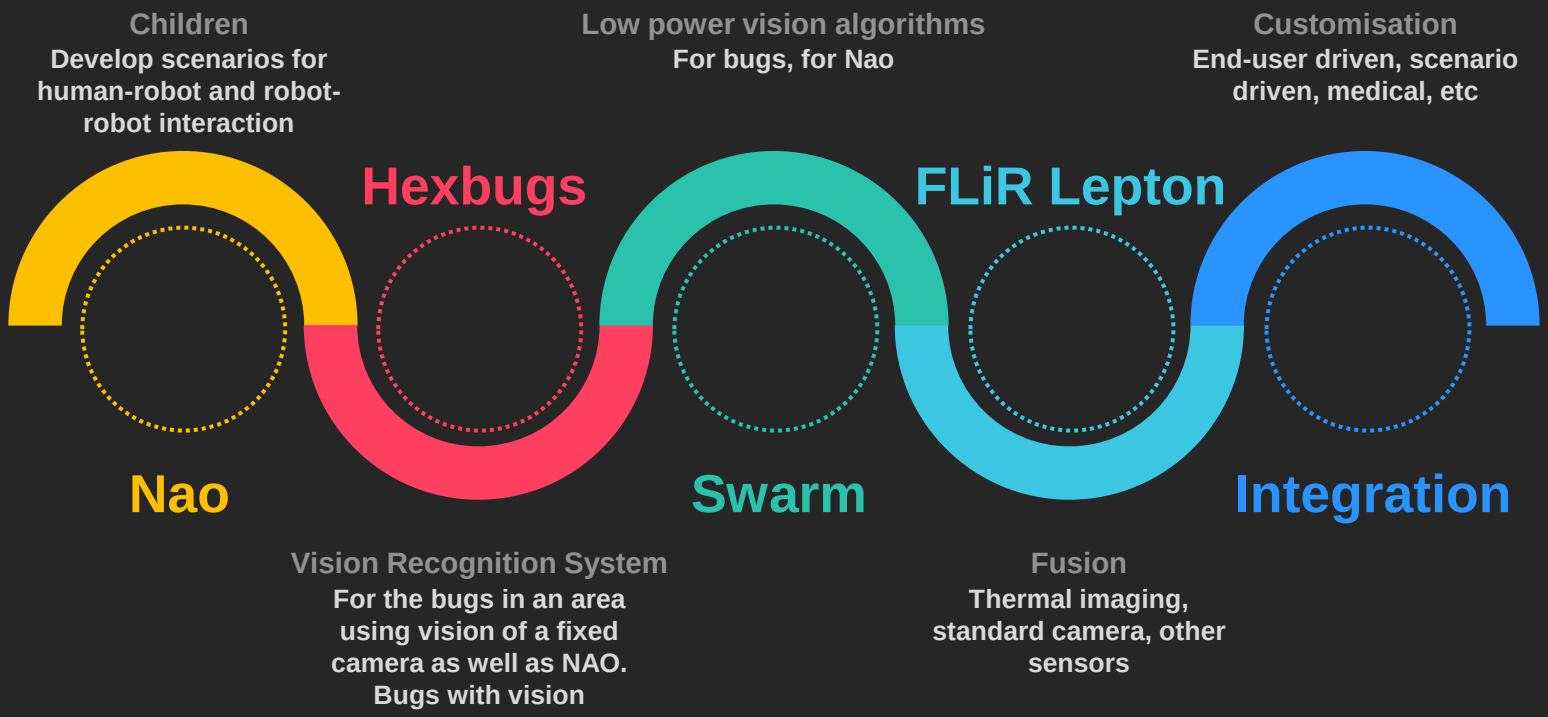
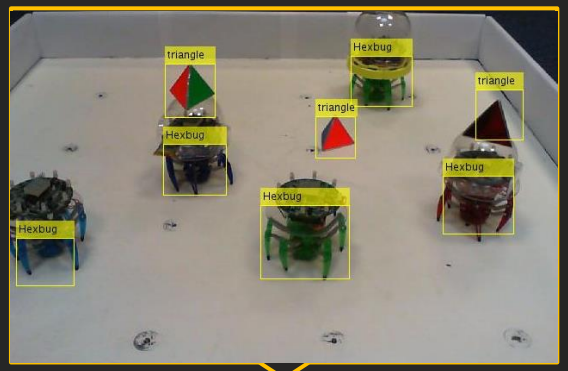


Image Processing

Low Power



Cascaded Object Detectors

Detects objects whose aspect ratios don't show significance variance

Color Detection System

Using RGB imaging examine individual pixels to detect desirable colors

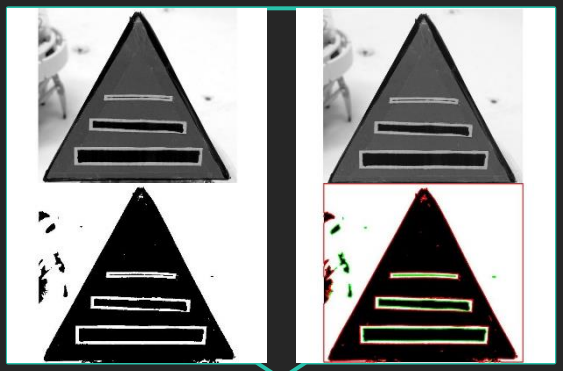


Image Segmentation

Dividing an image into multiple parts to extract any relevant information from it

Cascaded Object Detection

Two cascaded object detectors have been created. One detects the Hexbug form the other detects the triangles form.

Color Detection

A color detection algorithm has been completed to a prototype stage but requires further refinement

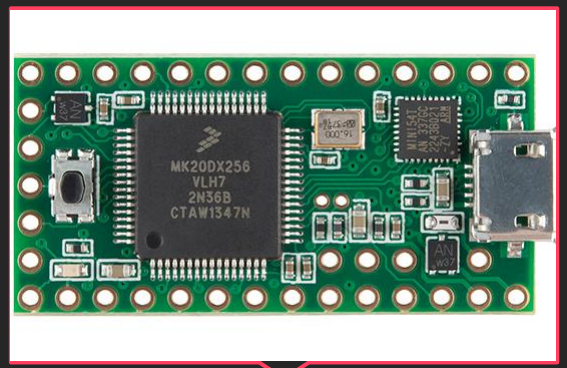
Identification

Lines and triangles have been segmented. An algorithm to distinguish between different blobs is underway

Hexbug U-Play Platform

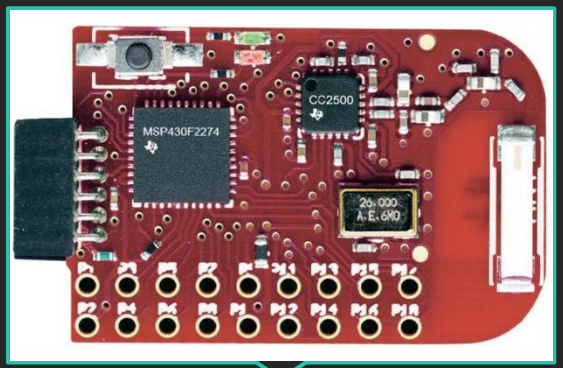
U-Play Chassis & PCB

A smart microcontroller & PCB with sensors, transceiver & microphone mounted on a donor spider body.



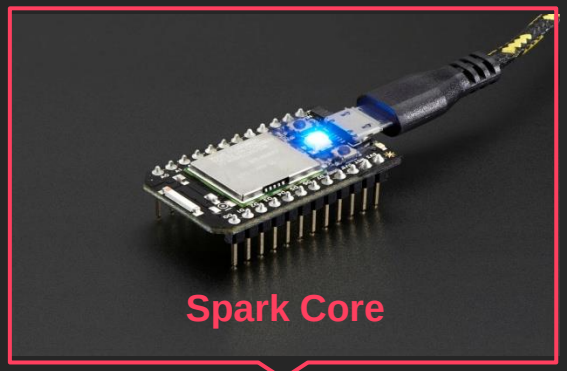
Teensy 3.1 Microcontroller

Low cost, small ARM processor with large amount of I/O.



TI eZ430-RF2500 Radio

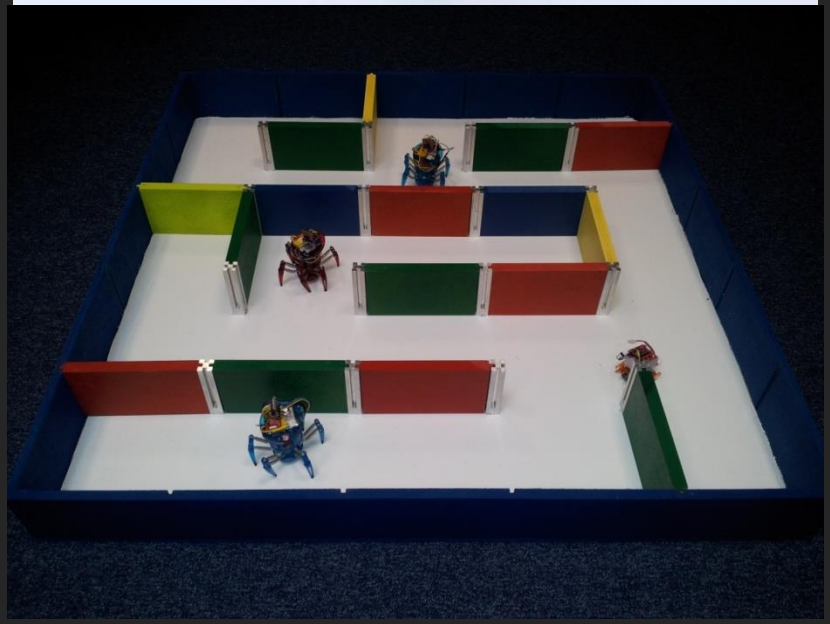
Connects Hexbugs in a mesh network to pass commands from users to a specific node.

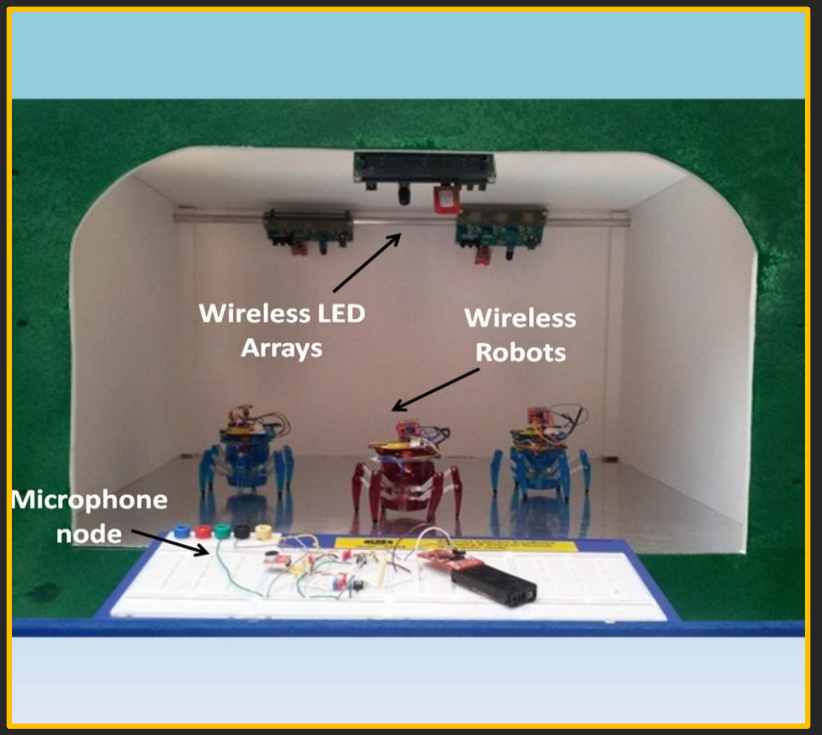


Spark Core

A first step towards smart toys

Focus on toys





Cost efficiency

Explored the existing platforms and integrated the smart processing, communication, vision/sensor systems

Power consumption

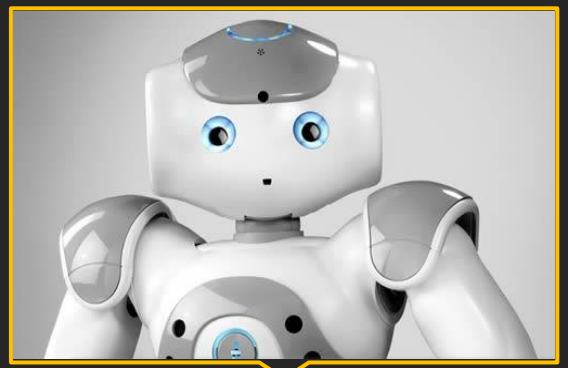
Working transfer of data using the Texas Instruments eZ430-RF2500 modules

Learning from others how to play

Interacting with doctors, teachers, psychologists, gaming/computer scientists

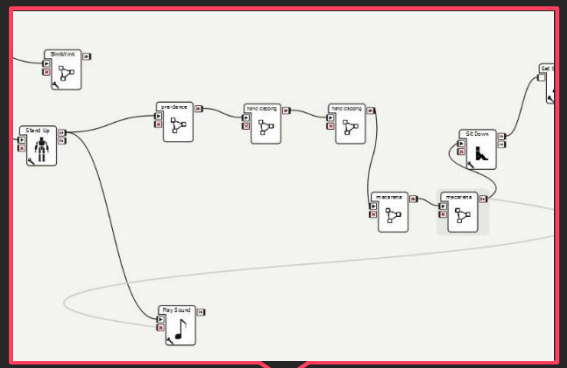
Nao Robot and Hexbugs

Our toys



Hardware

Nao is a highly versatile, humanoid robot equipped with many sensors and actuators including: 2 cameras, tactile sensors and directional microphones to facilitate interaction with its environment.



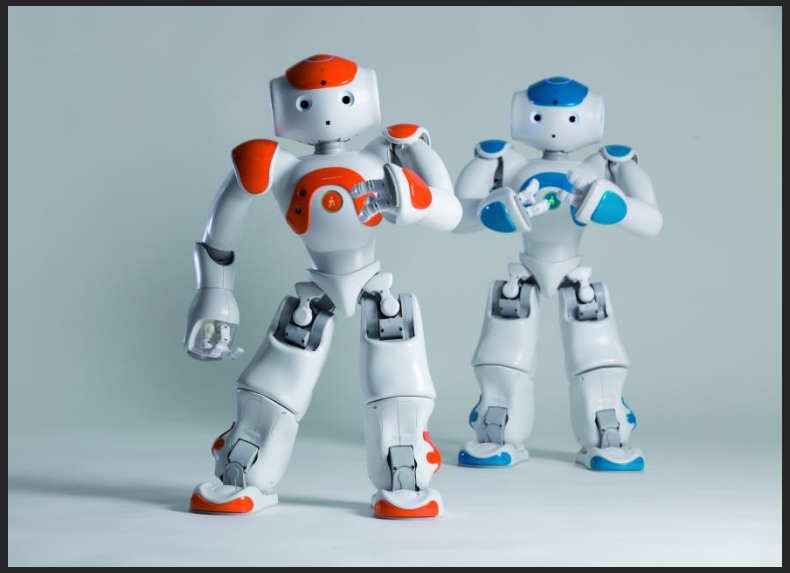
Choregraphe Environment

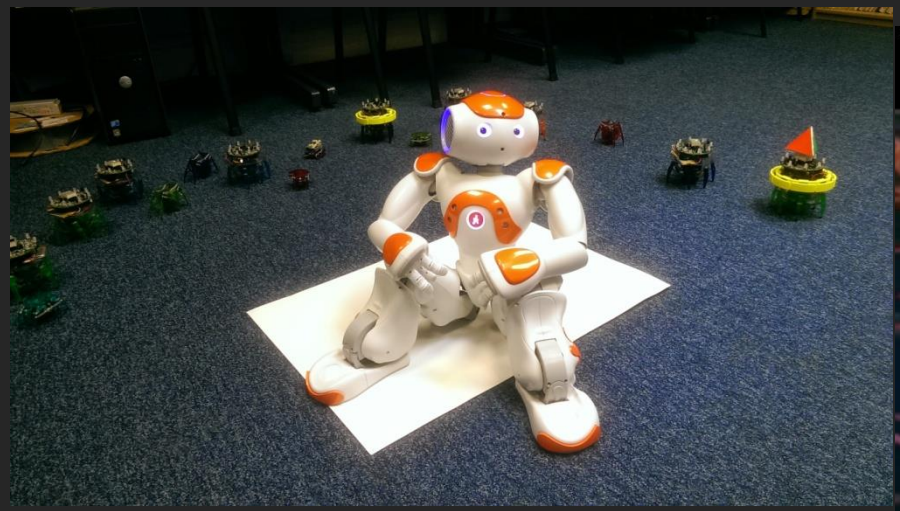
Programming software with intuitive graphical user interface containing both standard and advanced functions for creating user defined movements and behaviors.

Toys and Kids

Applications for kids with physical and learning disabilities, autism, but also promoting engineering

Some implementations

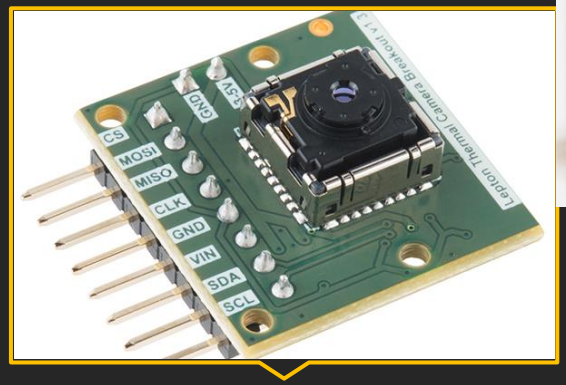




IEEE ISTAS 2015

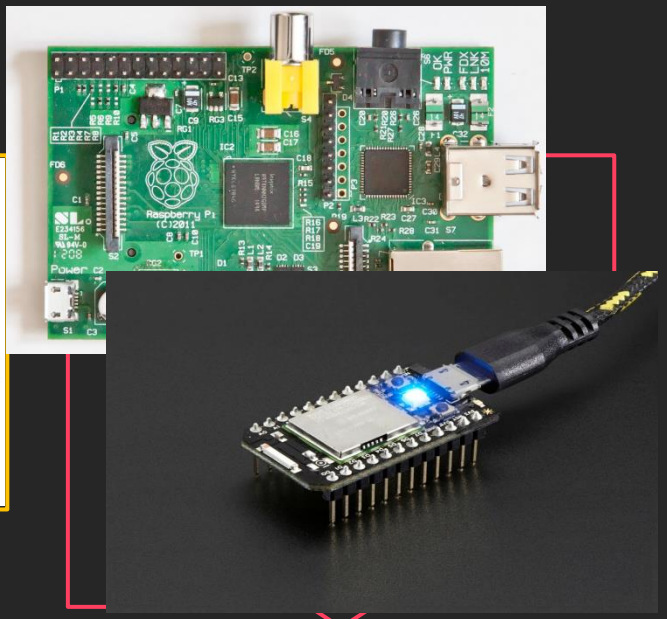
FLiR Lepton Thermal Camera

A new dimension for toys



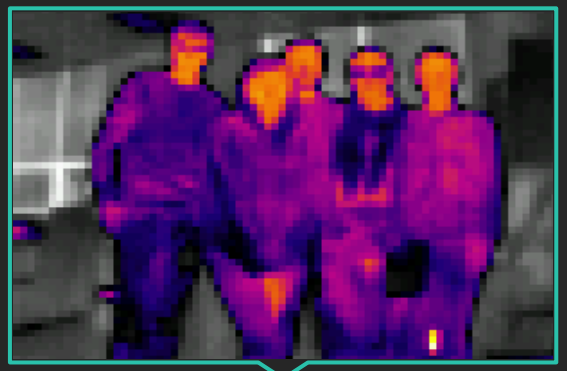
Hardware

The Lepton transmits data over SPI and I2C to the microcontroller. The camera captures 80x60 pixel images through the reception of infrared radiation.



Raspberry Pi/ Spark core

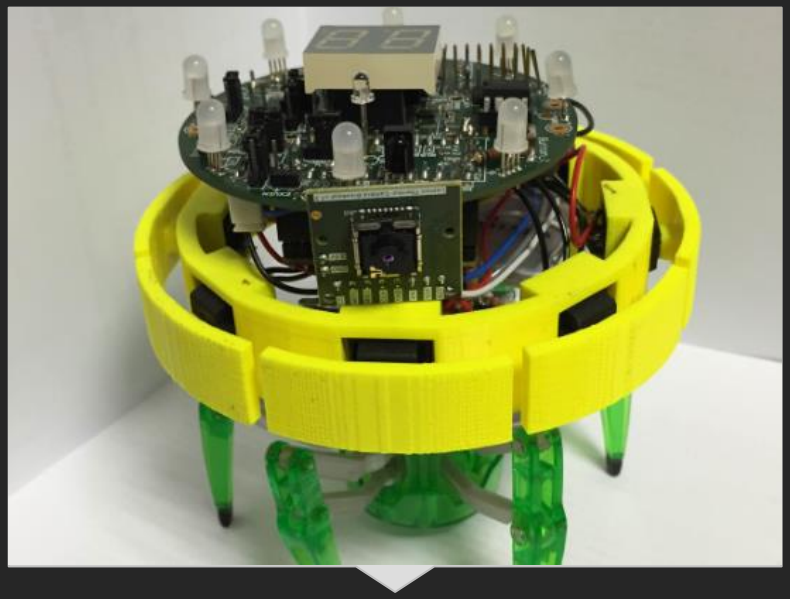
Data transferred from the camera module is encoded, stored or communicated wirelessly



Cool Group

The images and videos captured feature an auto-scaling temperature function adapting to the hottest object in the room.

Implementations



I4Santa

System to catch Santa(using cameras, PIR sensor and imagination)

Other Interfaces

Speaker ID, gesture recognition, wireless commands, EOG/EMG/ECG interfaces

Sensor Fusion

Swarm of toys built; distributed processing; etc

i-BEES

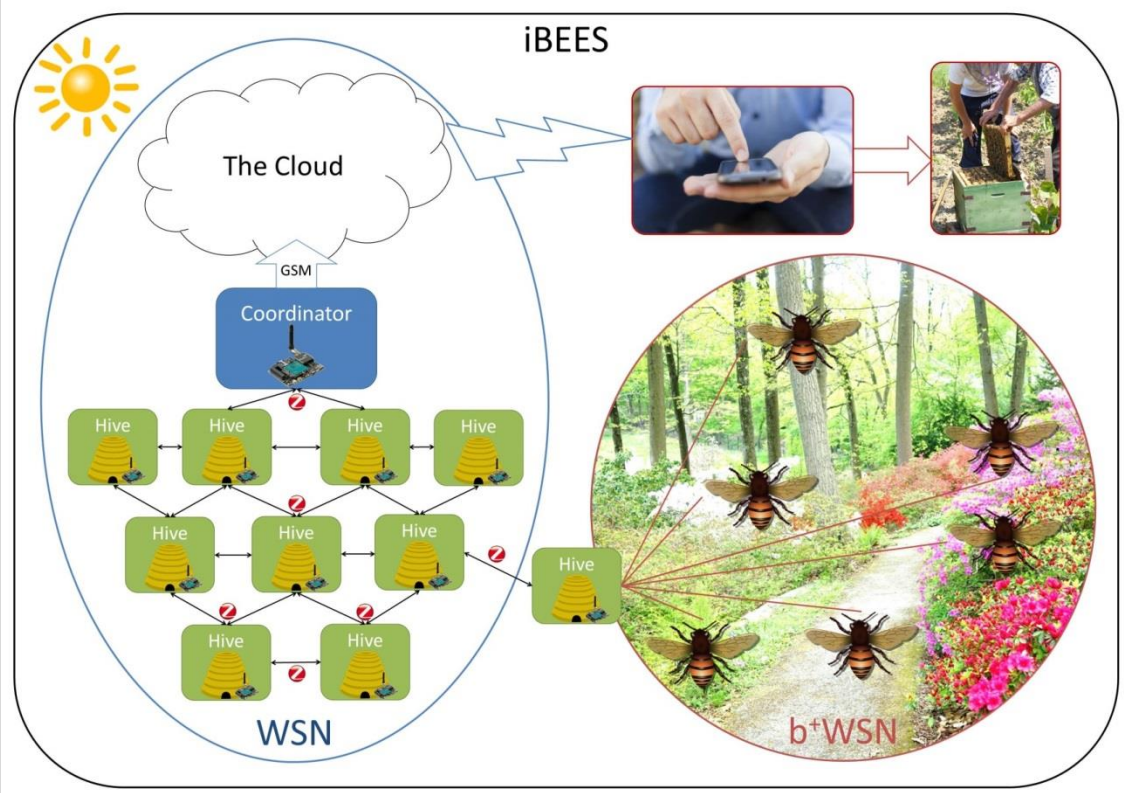
redefining the hive

1st Prize, IEEE/IBM Smarter Planet Challenge, 2014

Team:

F. Edwards Murphy, P. Whelan, L. Pinson, L. O'Leary, K. Troy, K. Hetherington, E. Lahiff, E. Popovici

A project funded by the Irish Research Council



Main Project Aims and Goals

i-BEES

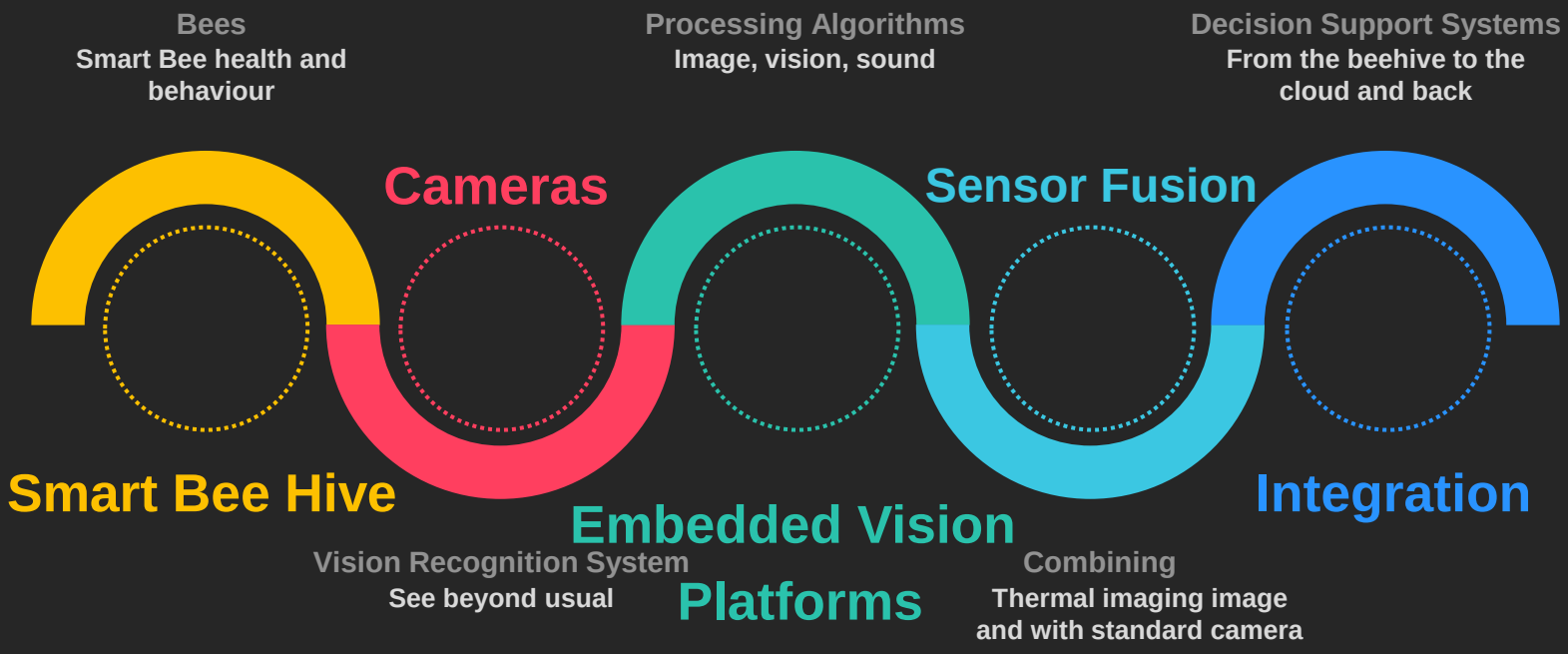
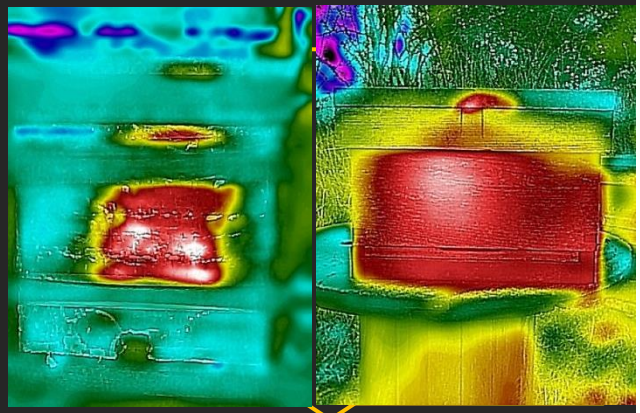
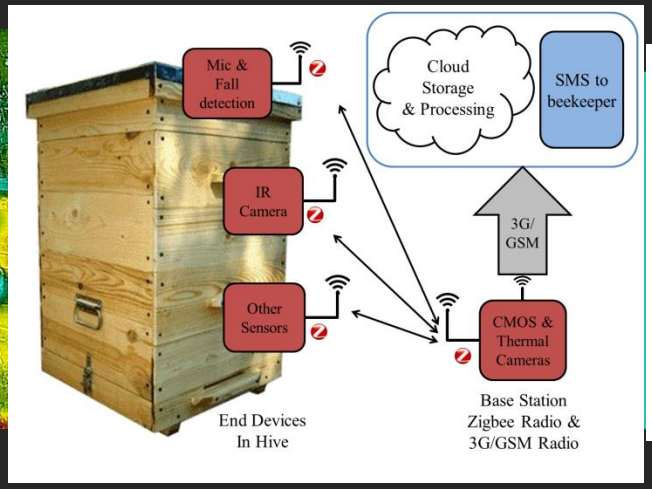


Image and Video Processing (IWASI 2015)



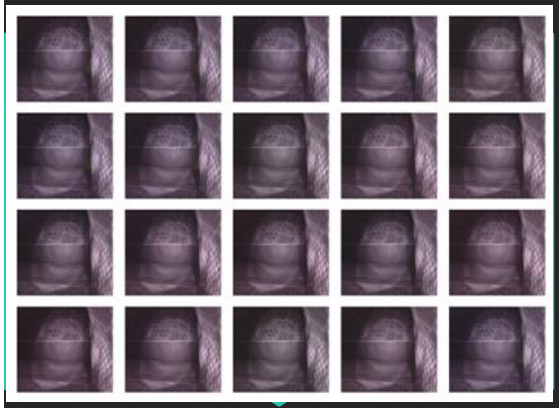
Thermal camera

Detect beyond the hive: health, status, temperature, etc



System at a glance

Energy neutral operation



IR camera

Used for visualisation inside the hive

Thermal imaging

Cost, low power, operating range, algorithms for image and video analysis

3B(Big Brother for Bees) System

Solar powered, energy optimisation, accurate decisions, adaptive sensing algorithms

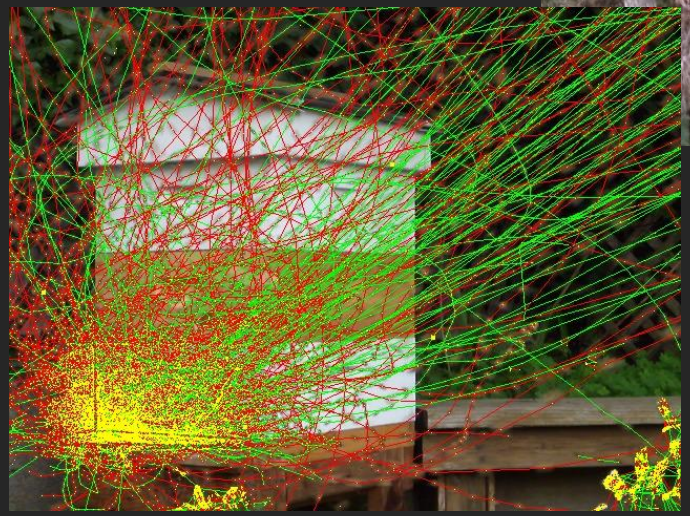
IR camera

Low power, event/user triggered, night vision, security, etc

From Bees to Bits to Information

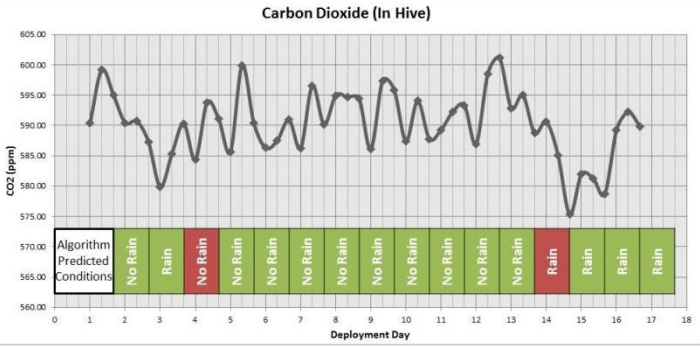
Colony Status and Weather Forecast (SAS2015)

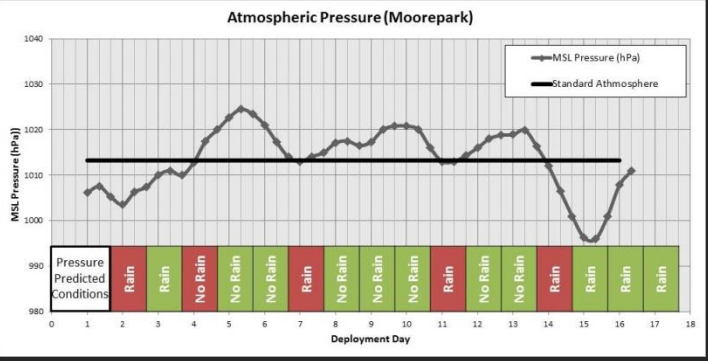
Tom Goddard(USF), bee tracking

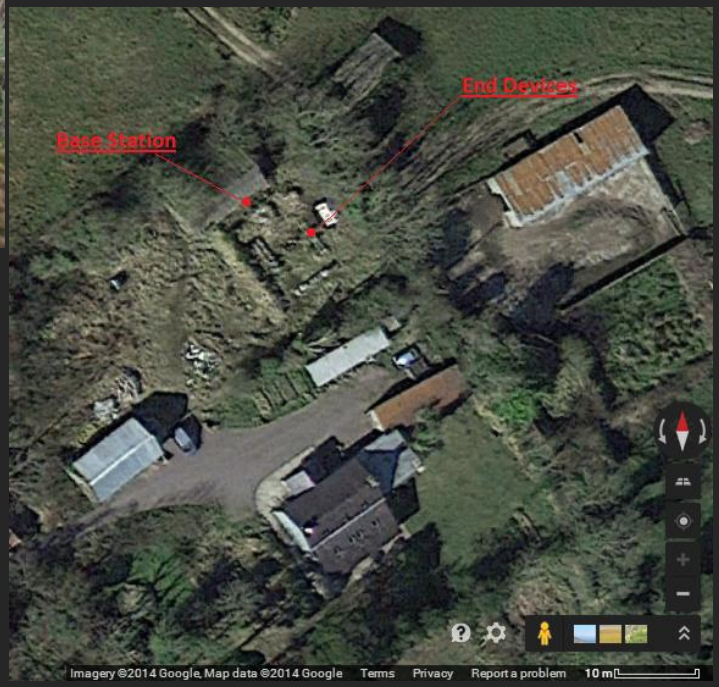


Tom Goddard(USF), bee tracking

Bee Counting and tracking

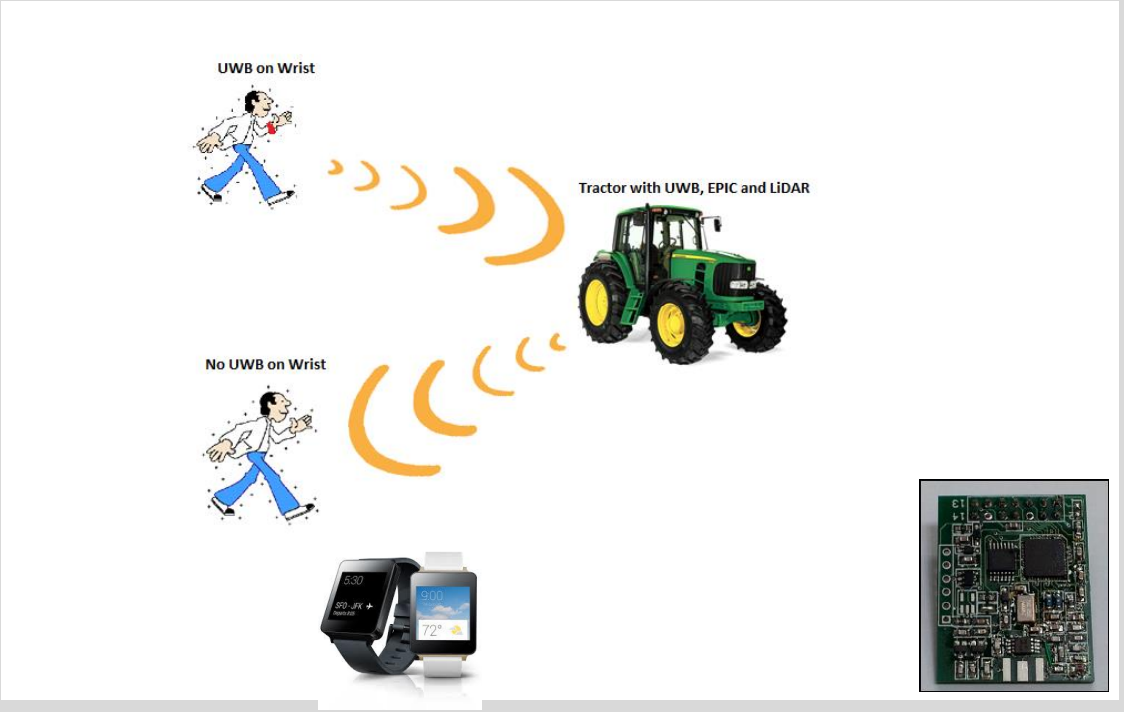






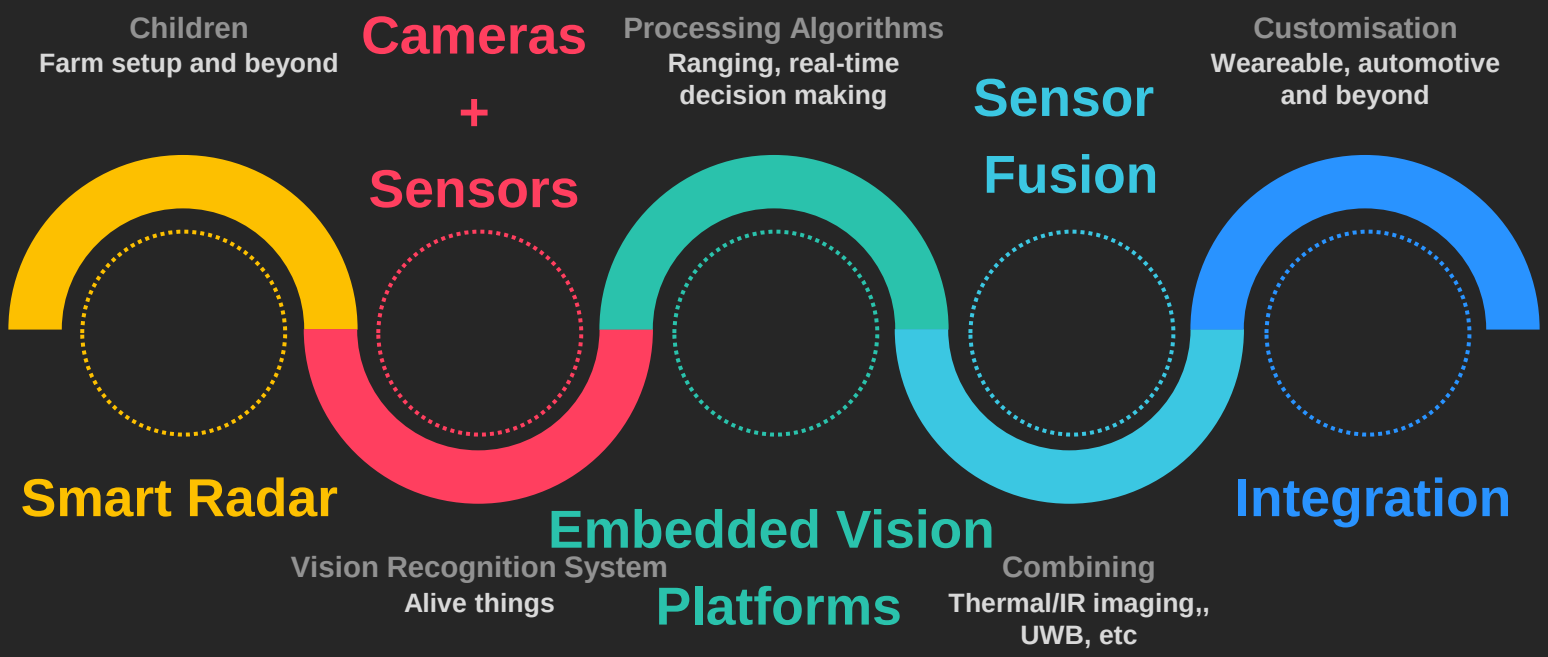
S-Farm: Smart/ Safe/ Secure Farming

Team:
Jack McCarthy, William Healy, Jonathan Hourihane, L. Marnane, E. Popovici



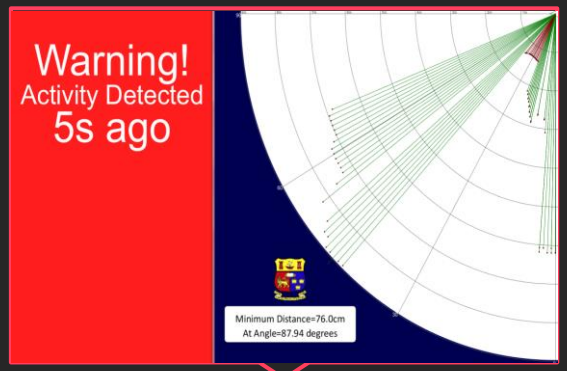
Main Project Aims and Goals

s-Farm

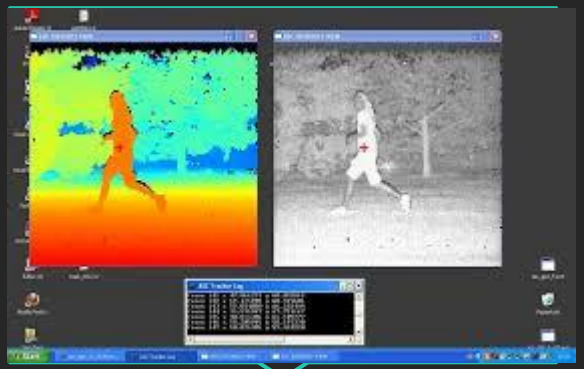


Processing

Smart processing requirement



(Fraunhofer Institute)



System design

Smart radar detecting alive objects

Visualisation/Warning system

Key for usability

nD Vision

Accuracy is key goal

Processing
Low power, real-time, heterogeneous vision

Processing
Real time decision support system

Processing
Sensor fusion, high accuracy

InfiniTime system(M. Magno ETH Zurich)

ACCELEROMETER (VIBRATIONAL WAKE UP) ADXL362

SPI

GPIO

E-PAPER DISPLAY

GPIO

SPI

ADC

EN DC-DC

ANALOG MICROPHONE ADMP404 MEMS

EN DC-DC

OPA 433

ADC

MSP430FR5969

EN DC-DC

GPIO

ADC

ANALOG CAMERA

Display

Electronics

ENERGY HARVESTER + BATTERY

Solar Panels

NFC/UWB & Wake up Radio

Wrist

Q

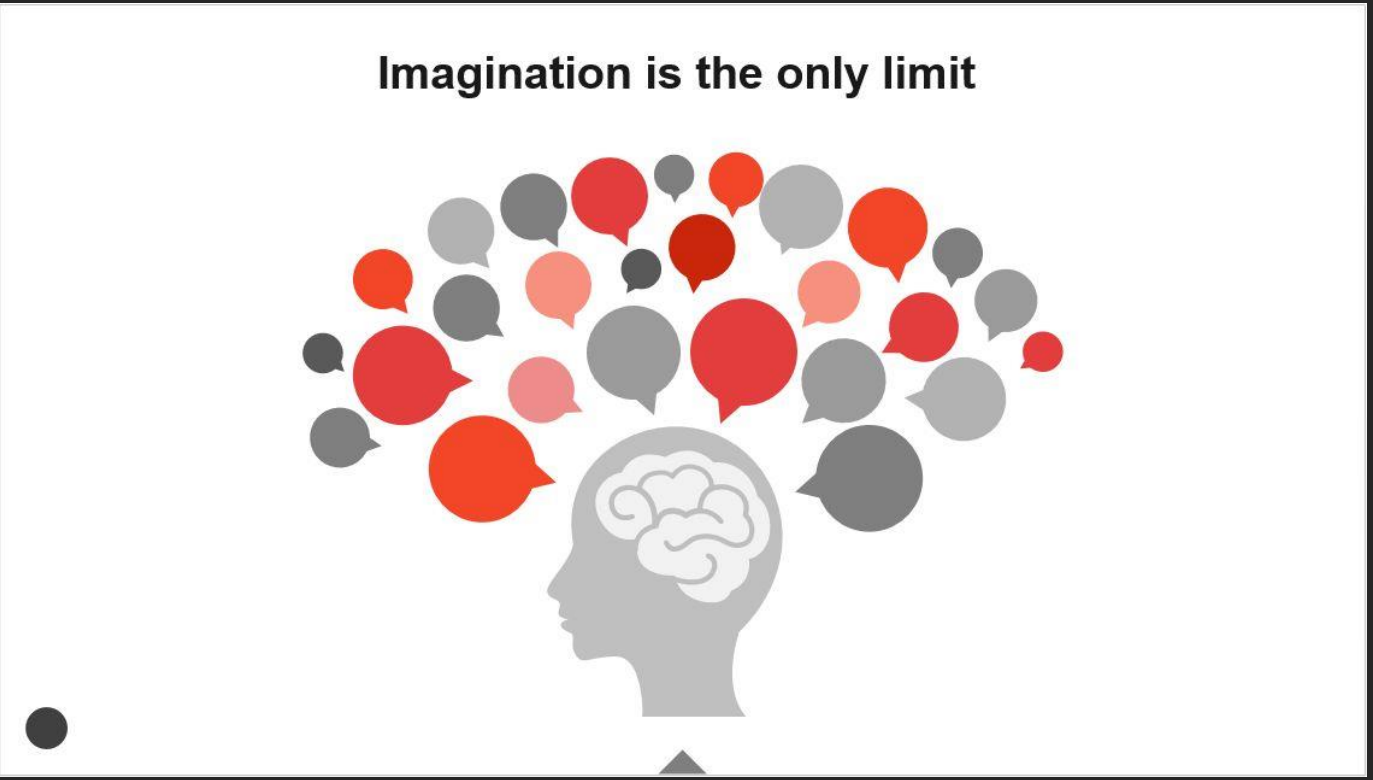
Versatility

Cost, low power, operating range, algorithms for image and video analysis

Energy neutral system

Solar powered, energy optimisation, accurate decisions, adaptive sensing algorithms

Thank you!



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