AWASS 2013 Case Study
Computational Self-awareness in Smart-Camera Networks

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Outline of this talk

• Overview of the EPiCS Project
• Surveillance and Camera Networks
• Smart-Cameras
• Multi-Camera Tracking of Objects
• Challenges in Smart-Camera Networks for the week
• Self-Awareness in Smart-Camera Networks
• Prerequisites
The EPiCS Project: Motivation

• What are the characteristics of future complex systems?

- Large
- Heterogeneous
- Dynamic
- Decentralised
- Uncertain
The EPiCS Project: Motivation

- We are increasingly faced with systems that are ...

  - Large
  - Heterogeneous
  - Dynamic
  - Decentralised
  - Uncertain

... and often have conflicting requirements!
The EPiCS Project: Motivation

• Requirements of the application domain can conflict in functionality, performance, resource usage, costs, reliability, safety and security.

• Design systems as collections of self-aware and self-expressive nodes.

  – Use online learning and adapt to specific scenario

  – Algorithm selection during runtime focused on goals of node

  – Interaction between nodes to drive global behaviour.
• High performance computing cluster for financial applications

• Multi-camera networks for multi-object tracking

• Hypermusic
Surveillance and Camera Networks

up to
4.2 million
CCTV cameras in the UK


Surveillance Cameras

• Use of Camera Systems
  – Traffic monitoring
  – Crime prevention
  – Crowd control
  – Surveillance production lines
  – Building monitoring
  – Person & Object tracking

Image: http://www.fh-wien.ac.at/uploads/pics/080611_Asfinag.JPG
Person & Object Tracking

- Tracking is the process of identifying and locating a (moving) predefined ‘model’ within consecutive frames of a video.
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• Drawbacks of using ‘dumb’ cameras
  – Raw video data
  – Data has to be transmitted & stored
  – Data has to be processed
  – Privacy issues
Smart-Cameras

• Smart cameras combine processing unit with image sensor
  – General purpose smart-cameras from off-the-shelf components
  – Special purpose smart-cameras for specific applications

• Allows to process images on the camera
  – Raw image data does not need to leave the camera
  – Operator only gets relevant and/or aggregated data
  – Operator only gets information about certain events
Smart-Cameras

• Flexible high-performance platform running Linux
  – PandaBoardes as main board with USB / CSI / GPMC connected components
  – TI OMAP 4460 processor, 2x ARM Cortex A9 @ 1.2 GHz, 2x Cortex M3
  – 1GB DDR2 SDRAM
  – SD-Card, USB, DVI, HDMI, audio
  – 802.11 b/g/n
  – Bluetooth 2.1 + Bluetooth 4 Low Energy
  – Ubuntu 12.04 Linux

• Camera modules
  – USB
  – Camera Serial Interface (CSI)
  – External module connected via GPMC using FPGA
Multi-Camera Tracking of Objects

- Which camera to continue tracking?
- Identify next camera *a priori* or use a server or operator.
- What about dynamics / uncertainties?
Distributed Tracking

• Use auctions for exchanging tracking responsibilities
  - Cameras act as self-interested agents, i.e., maximize their own utility
  - Selling camera (currently tracking object) opens the auction
  - Other cameras return bids with price corresponding to “tracking” confidence
  - Camera with highest bid continues tracking; trading based on Vickrey auction

Fully distributed approach
no a-priori topology knowledge required
Challenges in Multi-Camera Tracking

• On the node level
  – How maximise utility while minimise communication
  – When and how to advertise objects to other cameras
  – How to value objects within the field of view of a camera

• On the network level
  – How to define good camera strategies to optimise the network-wide outcome
Self-awareness in Multi-Camera Systems

• Cameras build models/knowledge about the behaviour of the objects to be tracked
• Cameras derive models/knowledge from the objects behaviour about themselves
• Cameras create models/knowledge about their immediate environment
• Cameras derive models/knowledge about their neighbouring cameras
Self-awareness in Multi-Camera Systems

• You will be provided:
  – The open-source simulation environment CamSim allowing you to simulate object tracking in multi-camera networks
  – Various scenarios for the simulation tool
  – Matlab scripts for evaluation of your simulation results

Main objective for the week:

Come up with a distributed way to assign tracking responsibilities in a smart camera network; preserving resources and keeping high tracking utility alike.
Self-awareness in Multi-Camera Systems

• During the week, you can expect to do the following:
  – Learn about the difficulties in camera coordination for distributed tracking
  – Work with provided strategies for distributed coordination of tracking responsibilities
  – Build your own scenarios with the provided simulation tool
  – Come up with your own strategy or modify one of the existing strategies to assign tracking responsibilities in a distributed camera network
  – Optionally, you may want to relax one of the assumptions made in the simulation tool or come up with your own project for self-awareness in distributed smart-camera networks
Prerequisites

• **Proficiency** in Java
• At least one member in the team with some experience with machine learning tools and techniques (the more the better).
• Knowledge of Matlab is a plus
• **HOW?**
  Compose a self-contained, short video explaining self-awareness accessible to a broad audience

• **WHEN?**
  Submission Deadline: July 31, 2013

• **DETAILS**
  www.epics-project.eu/contest