Self-aware and Self-expressive Active Music Systems

Jim Torresen, University of Oslo (UIO)
Bio Jim Torresen

• Jim Torresen is a professor at Department of Informatics at the University of Oslo. He received his M.Sc. and Dr.ing. (Ph.D) degrees in computer architecture and design from the Norwegian University of Science and Technology, University of Trondheim in 1991 and 1996, respectively. He has been employed as a senior hardware designer at NERA Telecommunications (1996-1998) and at Navia Aviation (1998-1999).

• Jim Torresen has been a visiting researcher at Kyoto University, Japan for one year (1993-1994), four months at Electrotechnical laboratory, Tsukuba, Japan (1997 and 2000) and he was a visiting professor at Cornell University for 12 months 2010/11.

• His research interests at the moment include bio-inspired computing, machine learning, reconfigurable hardware, robotics and applying this to complex real-world applications. He has published a number of scientific papers in international journals, books and conference proceedings.

• 10 tutorials and several invited talks have been given at international conferences. He is in the program committee of more than ten different international conferences as well as a regular reviewer of a number of international journals. He also acts as an evaluator for proposals in EU FP7.

• More information on the web: http://www.ifi.uio.no/~jimtoer
Outline of the Talk

• Introduction to the EPiCS EU project and the research group at University of Oslo
• What is active music?
• A sensor and compute platform for active music
• Self-awareness/expression applied to active music, including examples of active music implementation.
Engineering Proprioception in Computing Systems (EPiCS)

• EU ICT 7th framework programme project (Integrated Project (IP) under Objective ICT-2009.8.5 Self-Awareness in Autonomic Systems).
• 8 partners
• Project period: August 2010 – August 2014
• UiO contribution: Nature-inspired computation and Active music
Proprioceptive Computing Systems (PCS)

- **PCS characteristics**
  - use proprioceptive sensors to monitor “one self” (concept from psychology, robotics/prosthetics, …, fiction)
  - reason about their environment and behaviour (self-awareness)
  - effectively and autonomously adapt their behaviour to changing conditions (self-expression)

- **engineering PCS**
  - transfer concepts of self-awareness/-expression to computing and networking domains
  - optimise performance and resource usage in response to changing conditions
  - analyse limits for designing and operating technological systems
Three Applications in EPiCS

• Heterogeneous compute cluster for financial modelling.
• Distributed smart cameras for object tracking.
• Active music for an enriched music experience.
Robotics and Intelligent Systems Research Group Focus (Univ of Oslo)

- Electronics (FPGA)
- Robots
- 3D-printing

- Applications
  - Robotics
  - Music

- Biology
  - Apply principles from nature

- Robotics and intelligent systems
Robotics and Intelligent Systems at UiO

- Bio-inspired computation and hardware applied in robotics, music and other applications.
- Systems operate in dynamic environments demanding adaptation at run-time.
- State-of-the-art lab facilities for robotics prototyping (3D-printing) and motion capture.
- Interdisciplinary collaboration on projects and lab facilities with the UiO music department
- Scaled up with people, labs and publications since established 6 years ago
Robot Design Lab: 3D Printing

Larger potential for developing innovative robot systems compared to when using commercial robots.
Computer Science + Musicology

fourMs

Music, Mind, Motion, Machines
State-of-the-art lab Motion Capture Facilities

- Qualisys optical motion capture system
- NaturalPoint Optitrack optical motion capture system
- Xsens kinetic ambulatory motion capture system
Sound Saber
Sound Saber
Active Music

- Listener/user can adjust a flexible musical composition
- Adjust the tempo, mood etc in the music
- Musical interaction based on human motion and expression
- Self-aware and self-expressive mobile media devices
- Human in the loop
- Distributed system
Degrees of Control in Active Music

• Direct control: User can directly control the music by short latency commands
  – Typically user commands directly chosen on the media device
  – Allow for Hypermusic

• Indirect control: User indirectly control the music through sensors
  – Sensors in the media device or on the body of the user is applied to control and shape the music based on e.g. motion speed, heartbeat, mood etc.
  – The music is slowly changing.
Sensor Platform Based on WiFi

• Off-the-shelf iOS device
  – iPod, iPad, iPhone
  – More computing power
  – Flexibility for SW development

• Essential sensors built in
  – Accelerometer, gyroscope, GPS, touch, camera, battery status, ...
  – Reduced communication overhead

• Built in user feedback
  – Audio, visual

• Custom sensor interface unit
  – For external sensors (e.g. force)
  – Practical sensor connectors
  – Microcontroller board
Sensor and Compute Platform Low rate Zigbee Communication

• An interface for low rate ZigBee sensor data collection including a custom designed printed circuit board.
• Comparison of different sensor configurations for low rate communication.
• An application for identification and communication of smart phone specification (Android).
Sensor and Compute Platform for Interactive Media Systems

• A flexible WiFi based sensor interface including a custom casing.

• A framework for reading iOS sensor data and communicating (through OSC) with a laptop.

• Comparison of smartphone sensor data with a high precision motion capture equipment.

• Compute platform: Apple iPod touch
WiFi based Sensor Interface
Comparison of Motion Data from iPod and Qualisys

- Time Lag (48ms)
- Time Jitter (iPod > Qualisys)
- Accuracy and Precision in Orientation, Acceleration and Position Estimates
Compute Platform

- Apple iOS device
  - iOS application

- Laptop computer (prototyping)
  - MAX/MSP
  - Python
  - Soft synthesizers

- Communication
  - Serial link to external sensors
  - OSC / UDP over WiFi to prototype computer and other nodes
Analysing Music-related Actions

- Action
- Multimodal perception
- Analysis
- Action-sound mapping
- Hypermusic engine
- Sound / music

Sensor technologies
Machine learning
Cognition + HCI
Music theory + DSP
Self-awareness/expression applied to Active Music

Sensing inputs from human and neighbours

Placing bids and generating music
Sensor and Compute Platform GUI
Self-awareness/expression Implementation

• SoloJam: Shaking iPod for making rhythmic patterns (conflict resolution)

• Tilting iPod for selecting chords

• Pheromone trail based chord navigation (simulation only)
SoloJam Demonstrator

- Rhythm «jamming», band playing solos
- Market based handover of «solos»
  - Bidding in auction
  - Utility function defines the suitability of the bid
- Nodes controlled by human or AI
- Decentralised system
- Extra features:
  - Chords (tilt, majority voting)
  - Momentum build-up (shaking)
  - Filter control (touch controls)
Clip 1: Chords and Sound Effects
Ant Colony Optimization (ACO)

• ACO is a population based, general search technique which is inspired by the pheromone trail laying behavior of real ant colonies.

• Ants find shortest path to food source from nest.

• Ants deposit pheromone along traveled path which is used by other ants to follow the trail.

• We apply ACO for generating chord sequences
Visit of Minister and UiO Rector, April 17, 2012

Minister of Education and Research Kristin Halvorsen
AWASS 2012 Use Case: Classifying Human Motion

- Classify Human Motion in Accelerometer Sensor data
- Compare different classification algorithms for the given task
- Responsible: Dr. Arjun Chandra
FPL’2012 in Oslo, Norway
August 29-31
Including workshop on Self-Awareness in Reconfigurable Computing Systems

www.fpl2012.org
Summary

Research:
Make music controllable during listening either by direct control or indirect control through a sensor systems.

More information:
Web:
http://www.mn.uio.no/ifi/english/research/groups/robin/
http://www.ifi.uio.no/~jimtoer
E-mail: jimtoer@ifi.uio.no (Jim Torresen)