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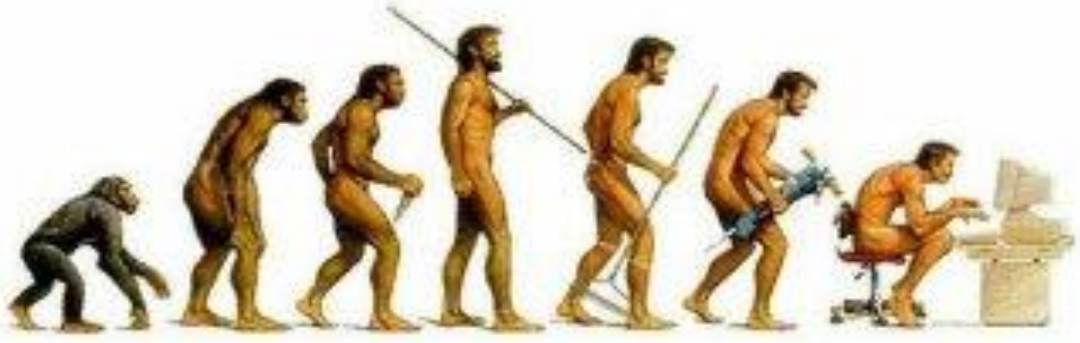
Bio-inspired Computing for Robots and Music

Jim Tørresen
Research group Robotics and Intelligent Systems



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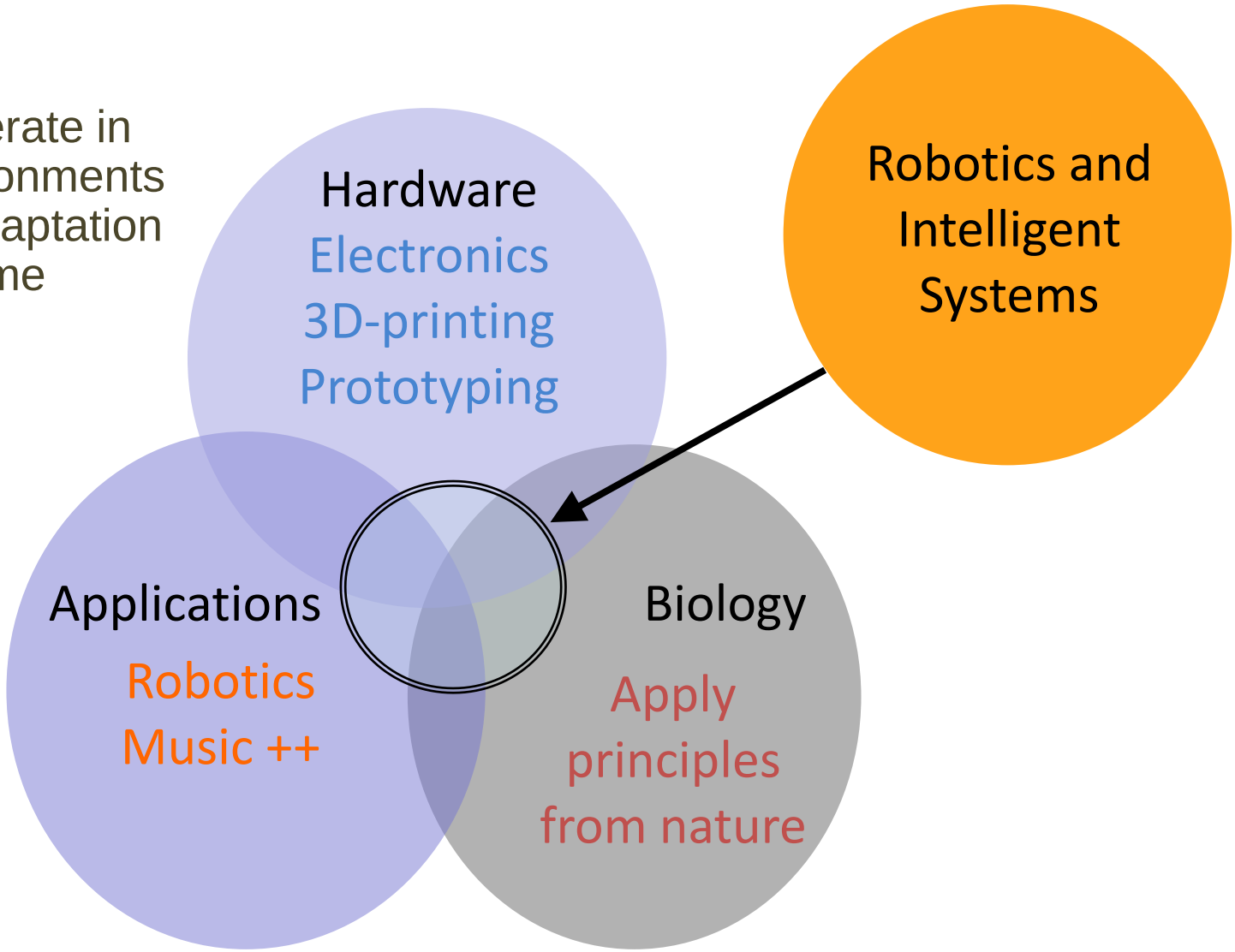
Robotics and Intelligent Systems group

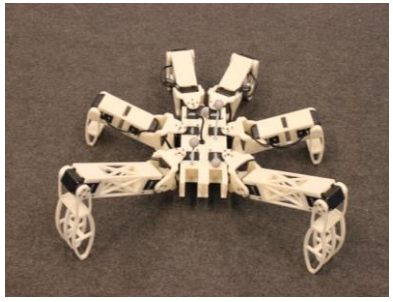
Systems operate in dynamic environments demanding adaptation at run-time

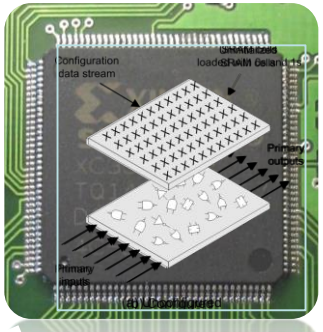


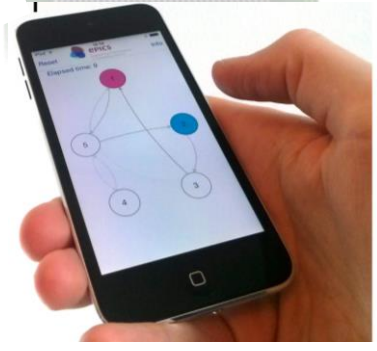
Web page: Google for ”ROBIN IFI”

Research

- Bio-inspirered systems and machine learning
  - Evolutionary computation
  - Ant colony optimization
- Robotics
  - Custom built robots (3D-printing/milling)
  - Self-learning of control
  - Robot surgery
- Reconfigurable logic (FPGA)
  - Dynamic change of configuration
  - Self-learning and adaptive systems
  - Development of remote teaching labs
- Music technology
  - Analyze motion for flexible music control
  - Develop active music systems

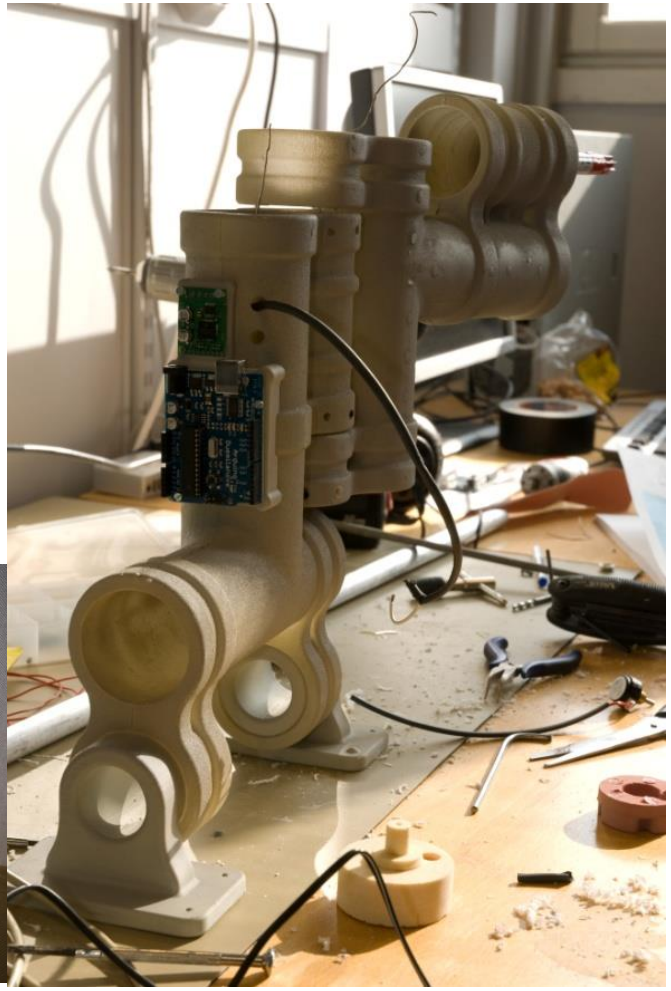


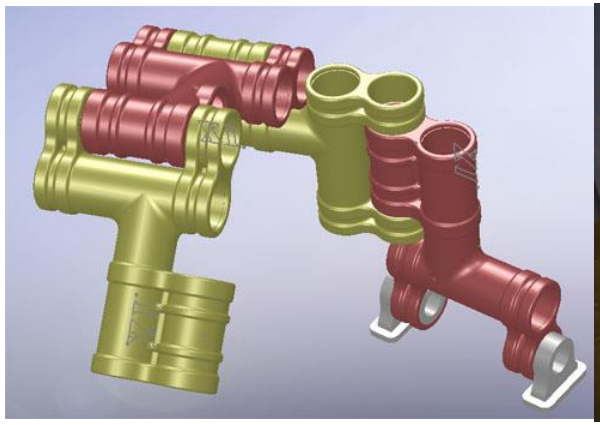




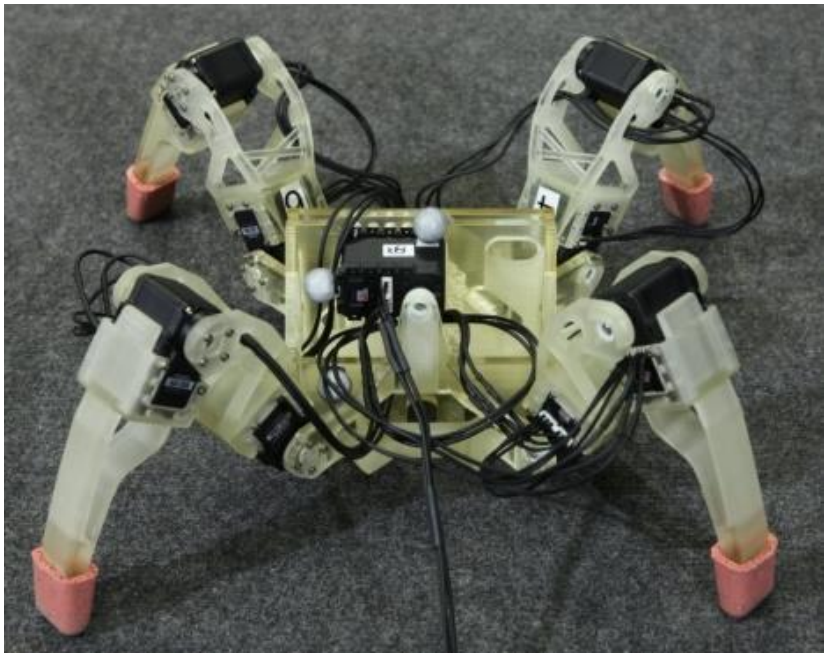
State-of-the-art Rapid Prototyping Facilities

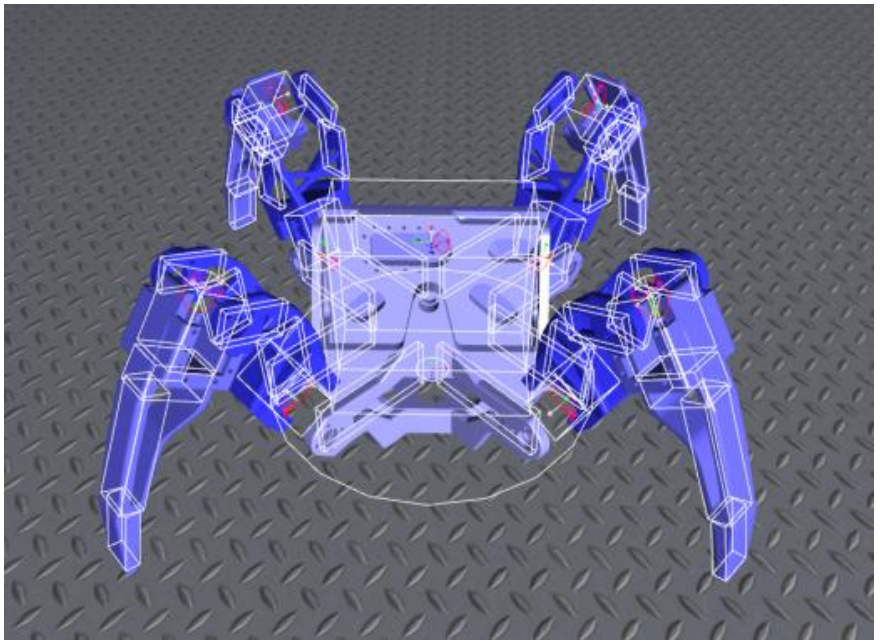
- 3D printers and milling machines
- Large potential for developing innovative robot systems.





Robot Simulation in NVIDIA PhysX

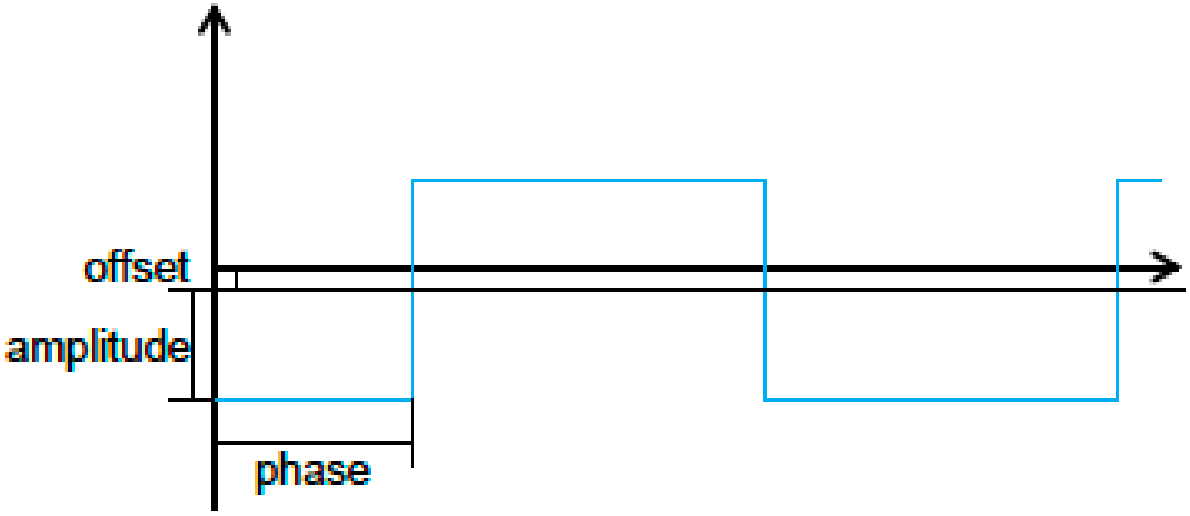




- Work with real robot and simulator/models
- Co-evolve robot shape and walking pattern
- Study and try to reduce gap between reality and simulation

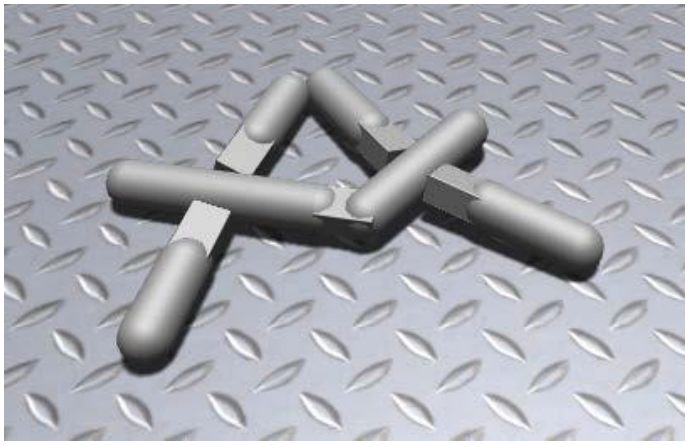
Evolved Control Systems

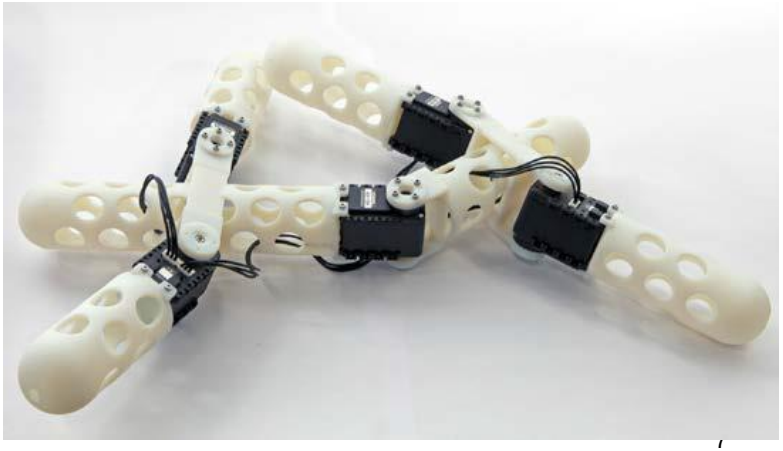
- We can evolve movement patterns!
  - Parameterize periodic functions for each joint
  - Evolve all those parameters



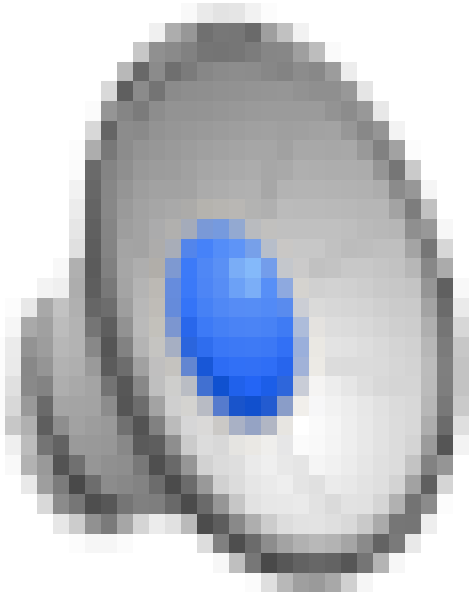
Evolved Robot Design

- Robot bodies could be difficult to design by hand.
- We use evolutionary algorithm to evolve both body and control system simultaneously.





Video Reuters



Bio-inspired Computing for Music

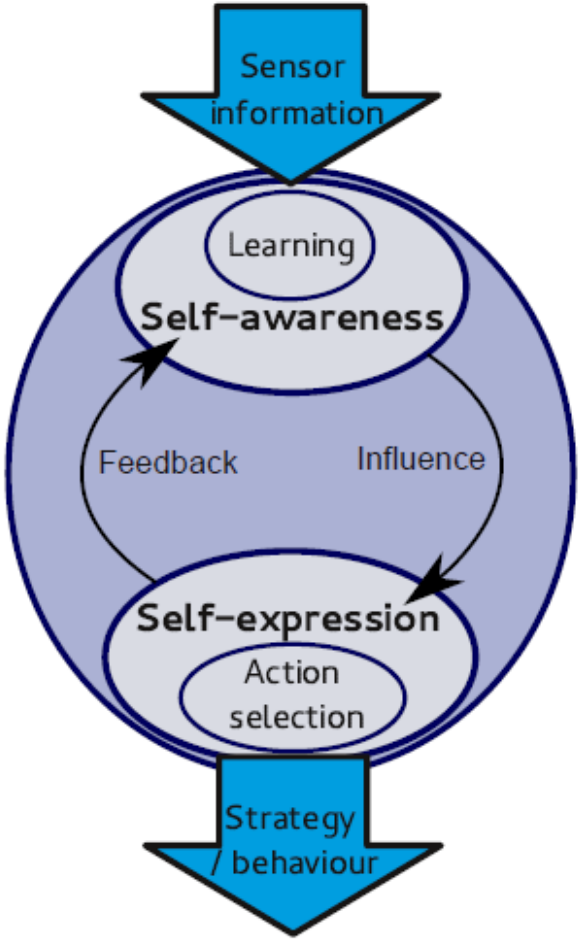
State-of-the-art Motion Capture Facilities

- Allows precise tracking of human and robot motion
- Camera-based and on-body motion capture

Sound Saber

Sound Saber

EPiCS – Self-aware systems (EU proj.)

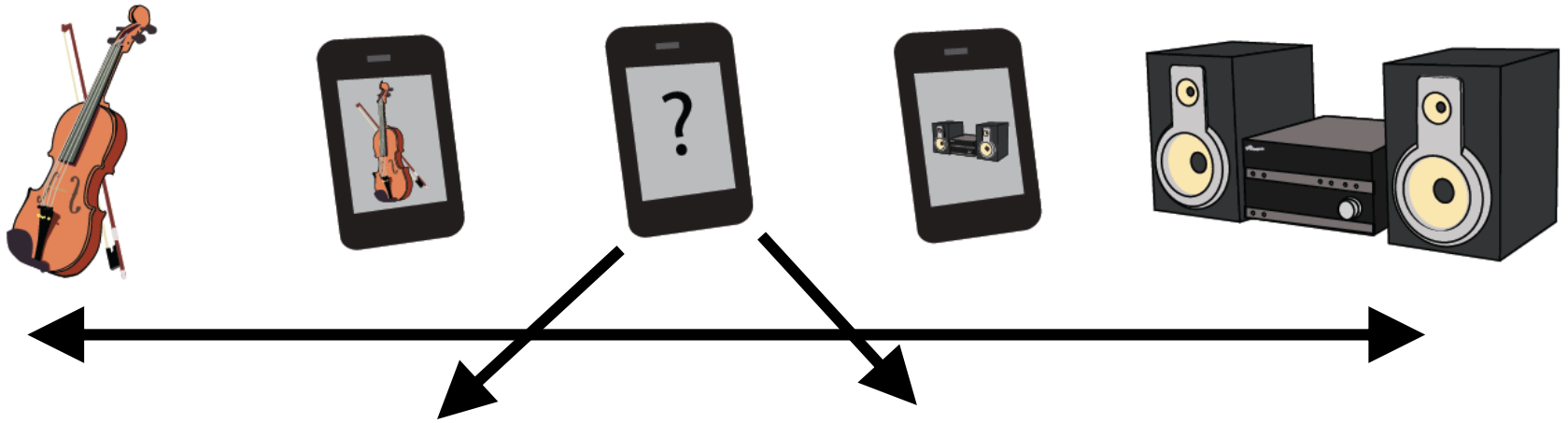


ePICS

Engineering Proprioception in Computing Systems

- Human/nature-inspired algorithms for self-awareness and self-expression
- Application: active music
- Collab: 8 European partners

(Inter) Active Music



Direct Control

- Navigate within the song
- Control certain instruments (e.g. keep playing the chorus drumbeat in the verse)
- Change the tempo of the song

Indirect Control

- Use on-body sensors to adapt the music to the mood of the user
- Listen to music that pushes you to work out harder
- Fuse the musical preferences of multiple users into one song

Ant Colony Optimization (ACO)

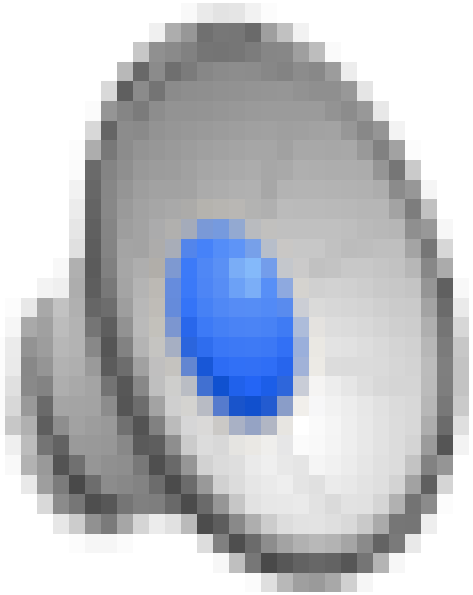
- Ants find shortest path to food source from nest.
- Ants deposit pheromone along traveled path which is used by other ants to follow the trail.
- This kind of indirect communication via the local environment is calle

Funky Sole Music

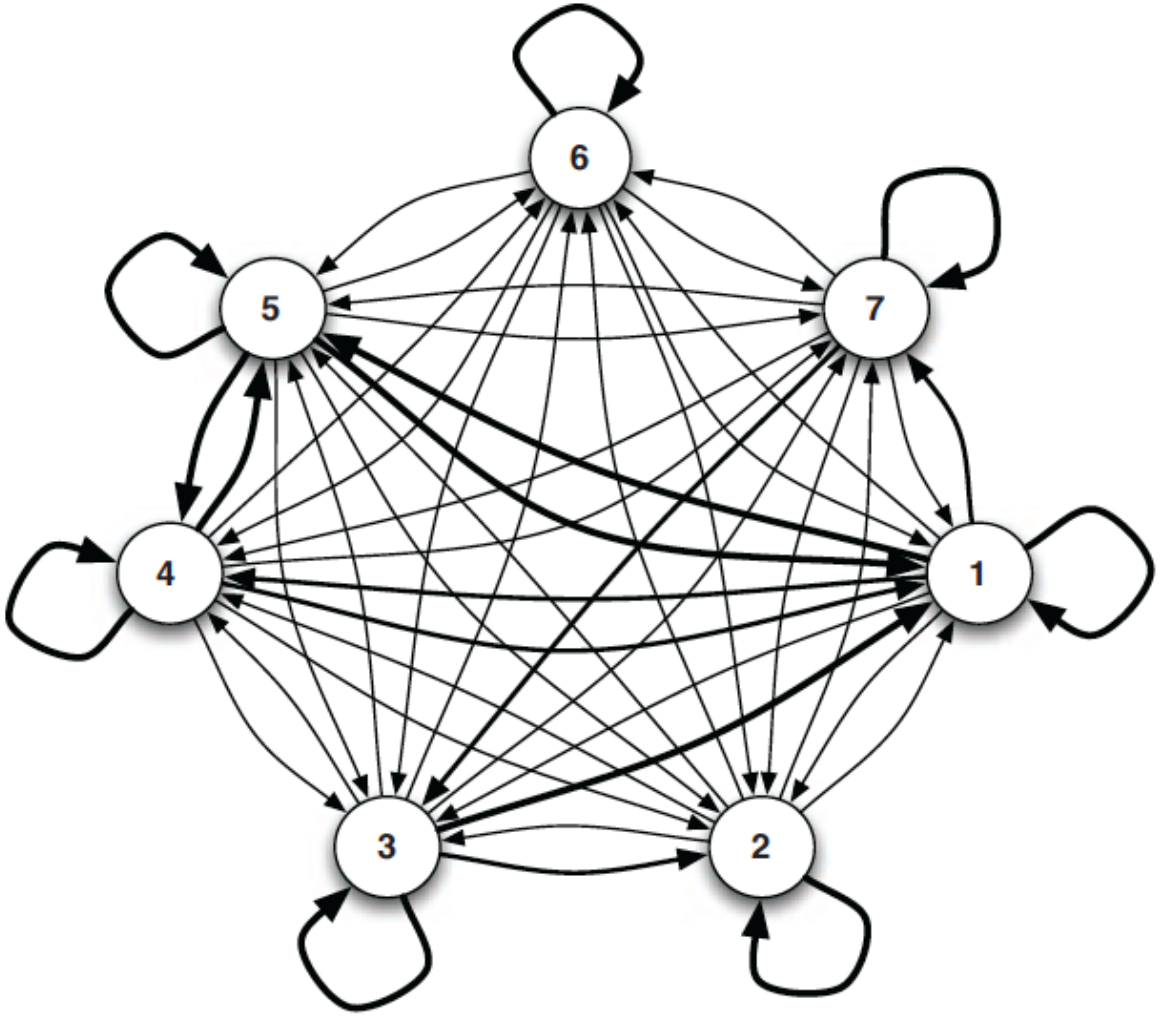
previous state \ current state	1-FullRelease	2-ToePress	3-HeelPress	4-FullPress
1-FullRelease	2	0	1	0
2-ToePress	1	2	0	0
3-HeelPress	0	0	1	1
4-FullPress	0	1	1	1

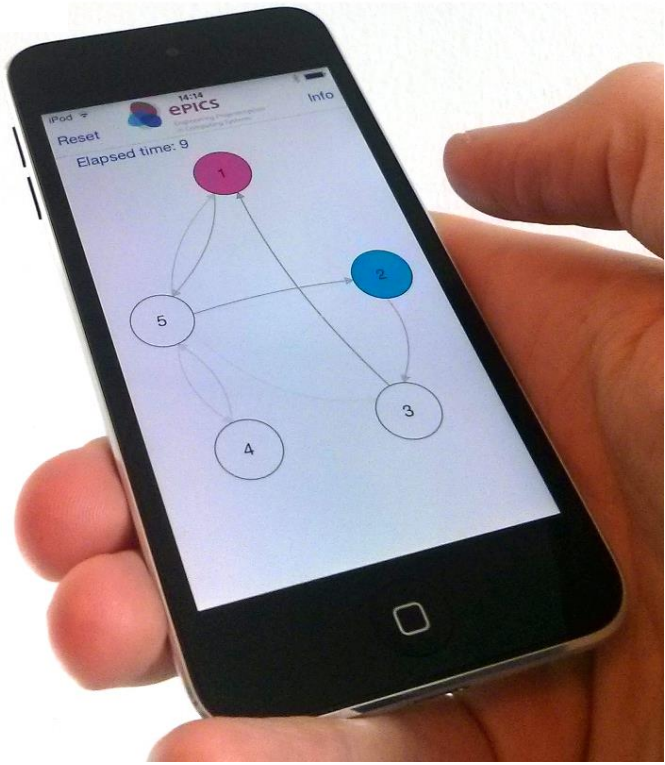
- Combination of sound samples and synthesis
- Hierarchy of loops, controlled by the user
- Various sound effects are controllable when in different “states” (i.e., for different walking patterns)

Video Reuters



PheroMusic: Navigating a Musical Space



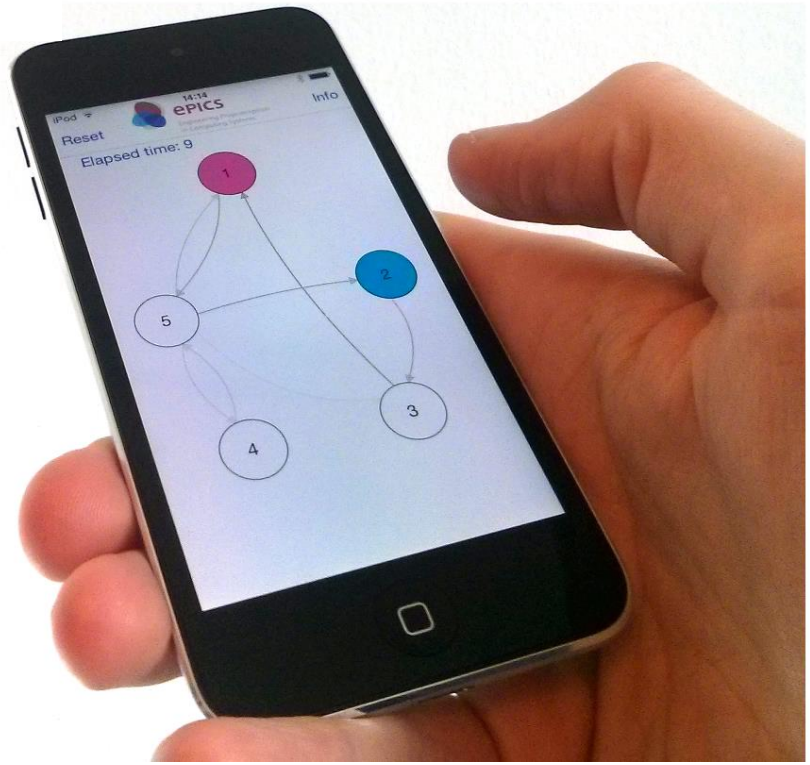


Direct + Indirect Control Combined

ePICS
Engineering Proprioception in Computing Systems

PheroMusic app

- Control by ant colony optimization



Download on the App Store

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INTROMAT: INtroducing personalized TReatment Of Mental health problems using Adaptive Technology (2016-2022)

Goal: Increase access to **mental health** services for common mental health problems by developing **smartphone technology** which can **guide patients**.

Funding: *IKTPLUSS Lighthouse, Research Council of Norway*

The Research Council of Norway

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MECS: Multi-sensor Elderly Care Systems

1 PhD (Trenton Schulz) + 2 postdocs (2015-2019)

Goal: Create and evaluate multimodal mobile **human supportive systems** that are able to **sense, learn and predict future events**.

Project consortium:

- Robotics and Intelligent Systems group (coordinator)
- DESIGN group (IFI)
- National:
  - Oslo Municipality (Oslo kommune, Gamle Oslo)
  - Norwegian Centre for Integrated Care and Telemedicine (Tromsø)
  - XCENTER AS (3D sensor)
  - Novelda AS (ultra wideband sensor)
- International:
  - University of Hertfordshire
  - University of Reading Whiteknights
  - Giraff Technologies AB

Funding: *IKTPLUSS, Research Council of Norway* (10% of proposals funded)

The Research Council of Norway

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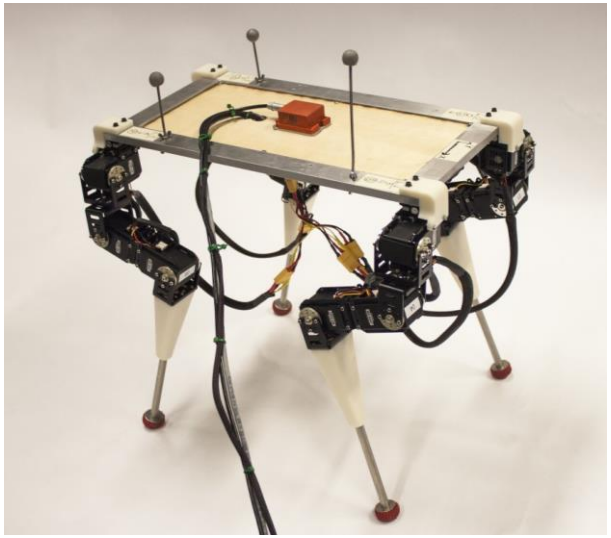
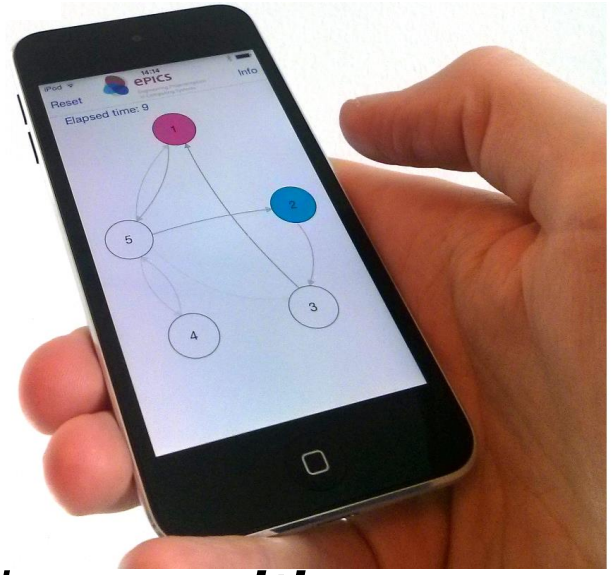
EPEC: Prediction and Coordination for Robots and Interactive Music

1 PhD (Tønnes Nygaard) + 2 post-docs (Charles Martin and Kai Olav Ellefsen) 2015-2019





Goal: *Design, implement and evaluate* ***multi-sensor systems*** *that are able to* ***sense, learn and predict*** *future actions and events.*

Funding: *FRIPRO, Research Council of Norway*

The Research Council of Norway