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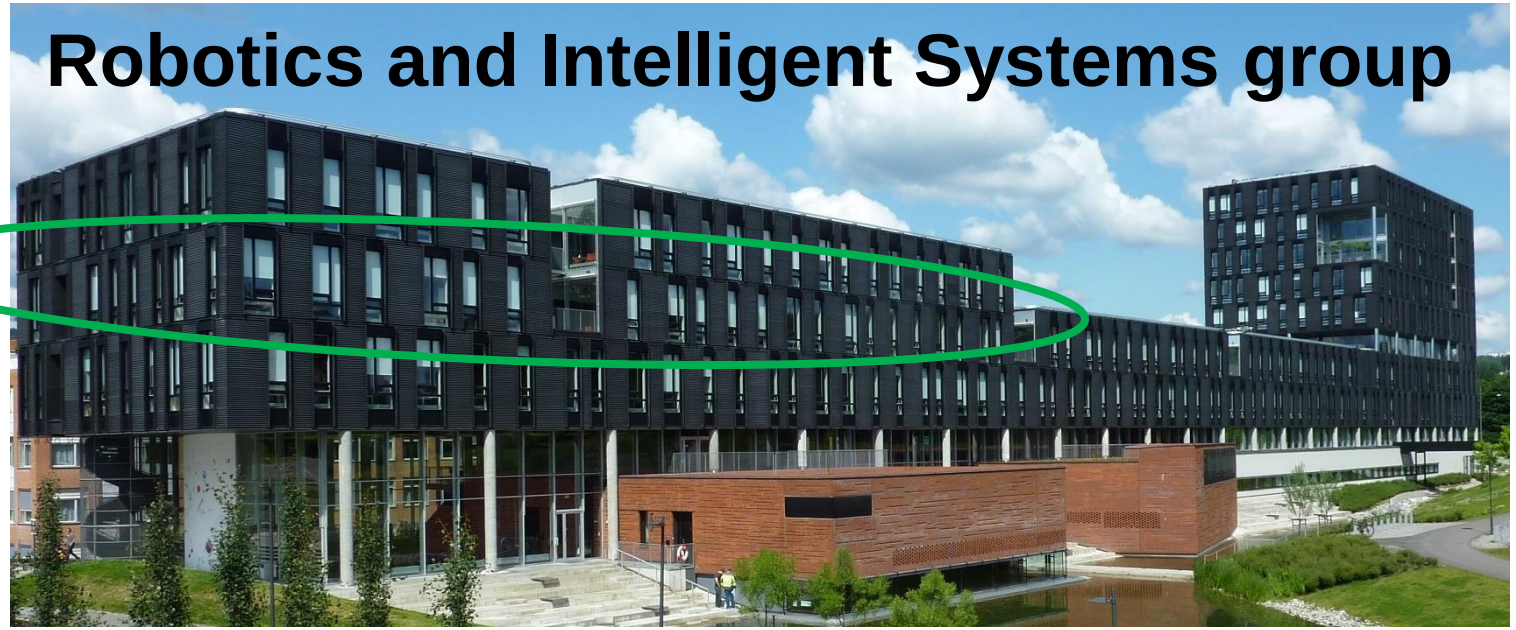
An overview of research (updated April 2024)



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Robotics and Intelligent Systems (ROBIN)

Jim Tørresen
Professor, Group leader

Mats Høvin
Assoc. Prof.

Kyrre Glette
Professor

Kai Olav Ellefsen
Assoc. Prof.

Yngve Hafting
Ass. Prof.

Vegard D Søyseth
Principal Engineer

Adrian Bergflødt
Assistant Engineer

Postdocs / researchers:
Benedikte Wallace (RITMO)

Diana Saplacan Lindblom (VIROS)

Adjunct positions (20%):

Alexander Wold (assoc.prof.)
Ole Jakob Elle (Prof.)
Roar Skogstrøm (lecturer)
Ståle Skogstad (assoc.prof.)
Md Zia Uddin (researcher)

PhD students
(ROBIN main superv.):

Adel Baselizadeh
Bjørn Thor Jonsson (RITMO)
Ege de Bruin
Emma H.S. Norstein
Ivar-Kristian Waarum (NGI)
Katrine L Nergård
Marieke van Otterdijk
Mojtaba Karbasi (RITMO)
Mateusz Wasiluk (BioAI)
Pedro Lucas (RITMO)
Shin Watanabe
Tom Frode Hansen (NGI)

Students: Bachelor ~200; Master: ~60
Robotics and Intelligent Systems program

Students hired on hourly basis:
Misc

Visiting researchers

https://www.mn.uio.no/ifi/english/research/groups/robin

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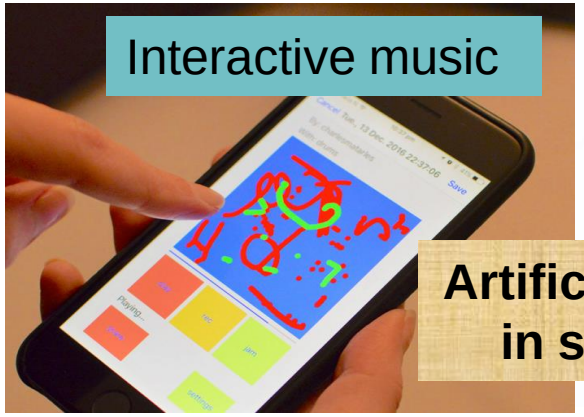
Robotics and Intelligent Systems (ROBIN) research group

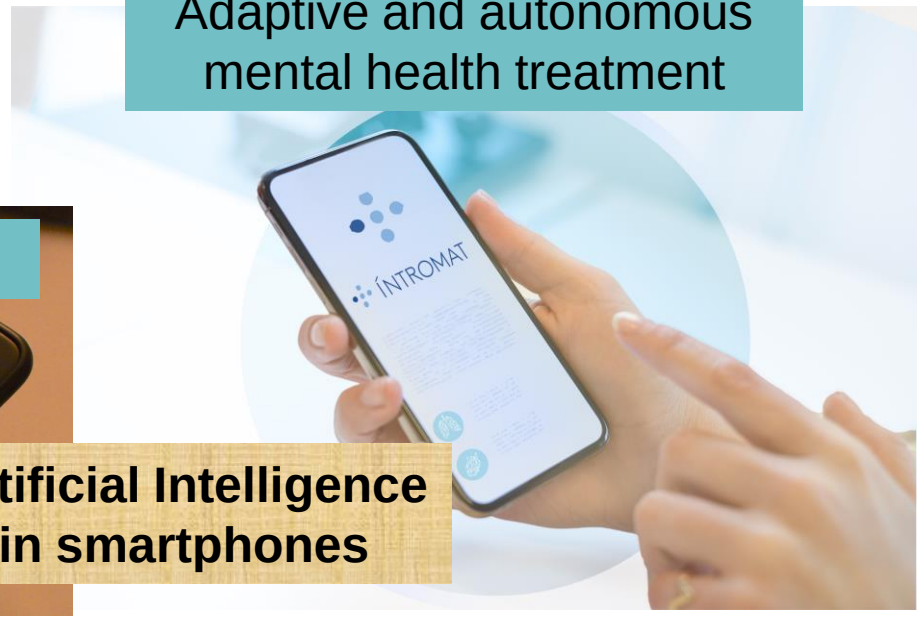
Artificial Intelligence in industrial applications



Interactive music

Artificial Intelligence in smartphones

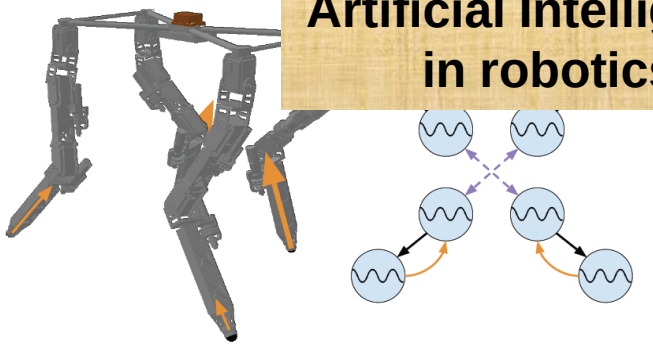
Adaptive and autonomous mental health treatment

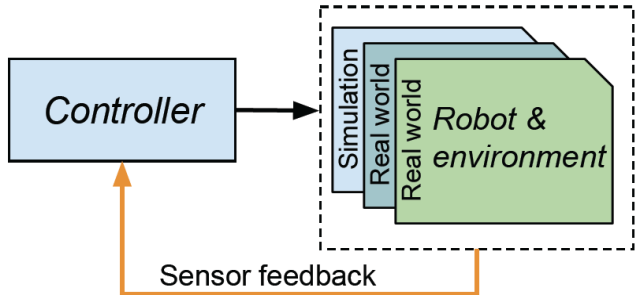


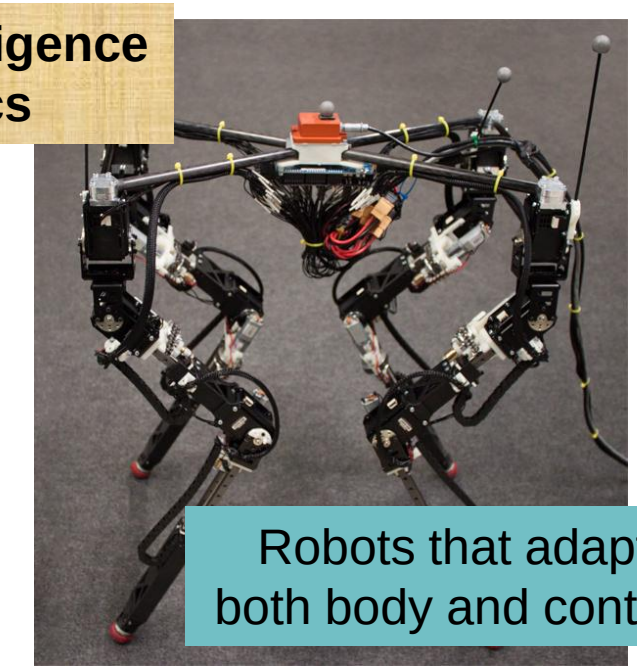
PAL TIAGo

Robots that look after and assist older people living at home

Artificial Intelligence in robotics







Robots that adapt both body and control

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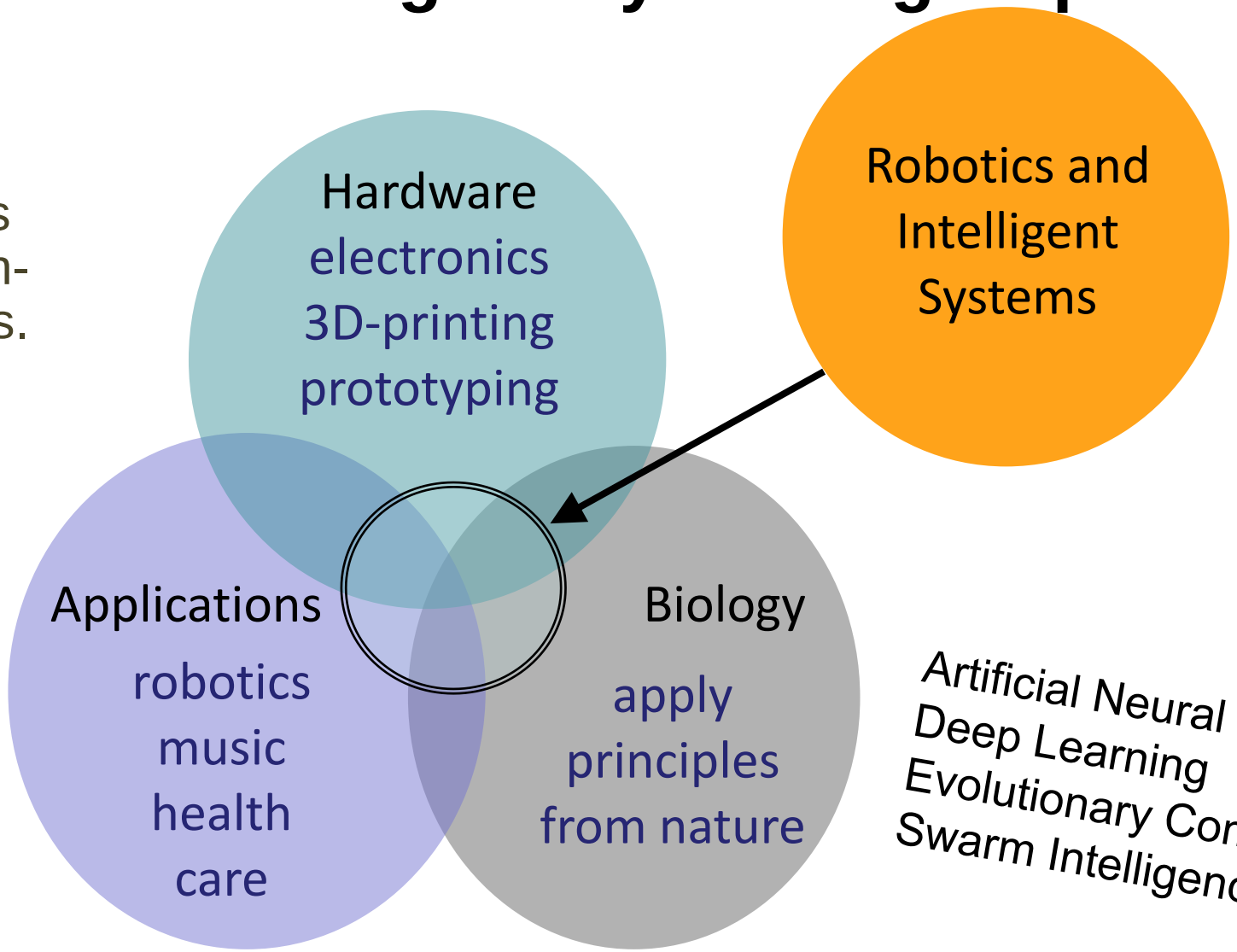
Robotics and Intelligent Systems group
ROBIN

Creating systems for demanding run-time environments.



Artificial Neural Networks
Deep Learning
Evolutionary Computation
Swarm Intelligence

Web page: Google for ”ROBIN IFI”

https://www.mn.uio.no/ifi/english/research/groups/robin

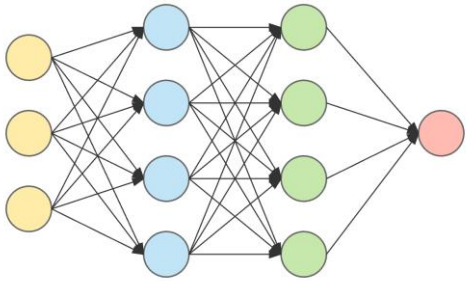
What is a Robot?

ROBOT = Sense, Think, Act

Sense → Sensors

Think → Artificial Intelligence

Act → Motors + Mechanics

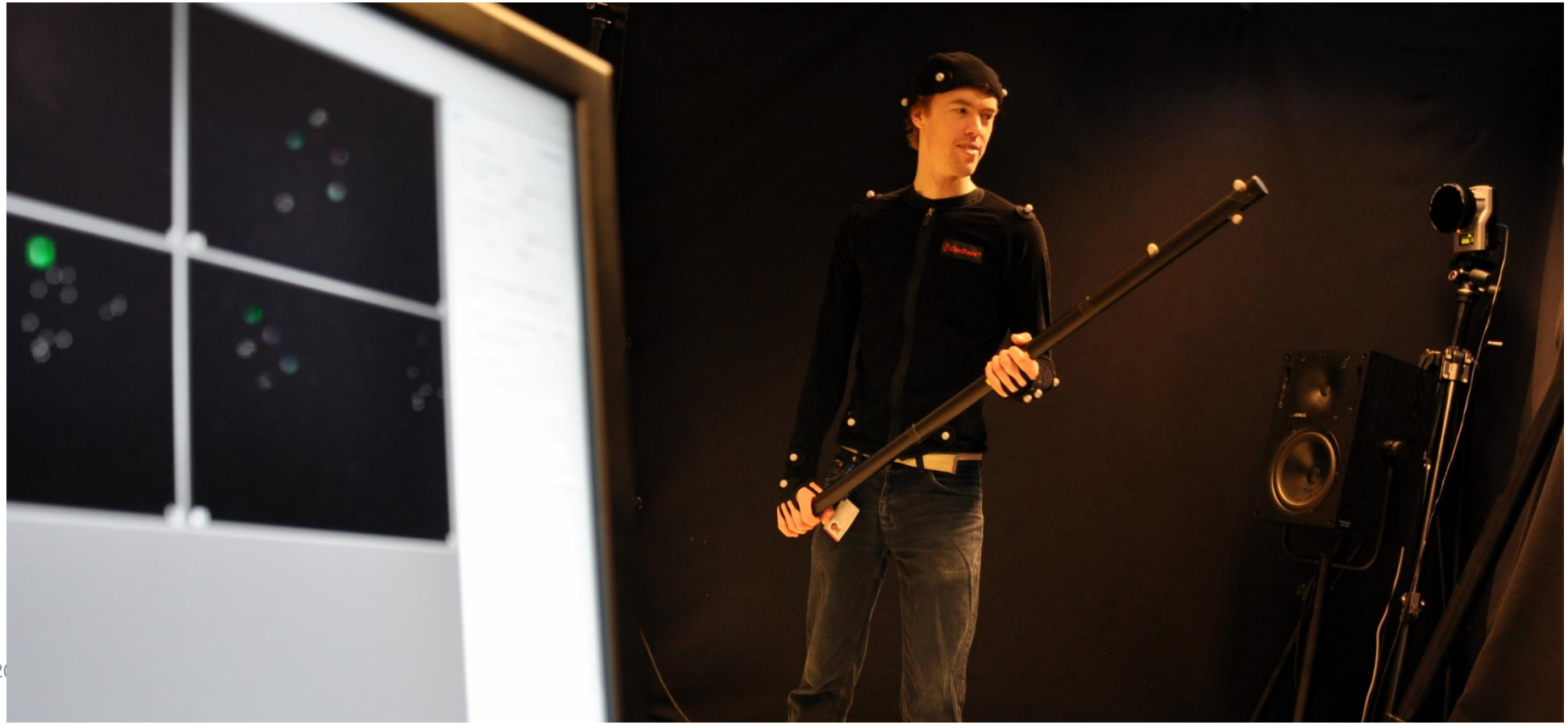


ROBIN group: AI and Machine Learning Techniqes

- Feature Extraction (PCA variants, OpenPose, ++)
- Deep learning
  - Classification: CNN
  - Forecasting: RNN
- Deep reinforcement learning (robot control)
- Evolutionary computation (robot design and control, neuroevolution)
- Neuro-fuzzy systems (robot control)
- Transfer learning/user adaptive models
- Training with sparse data (oversampling)

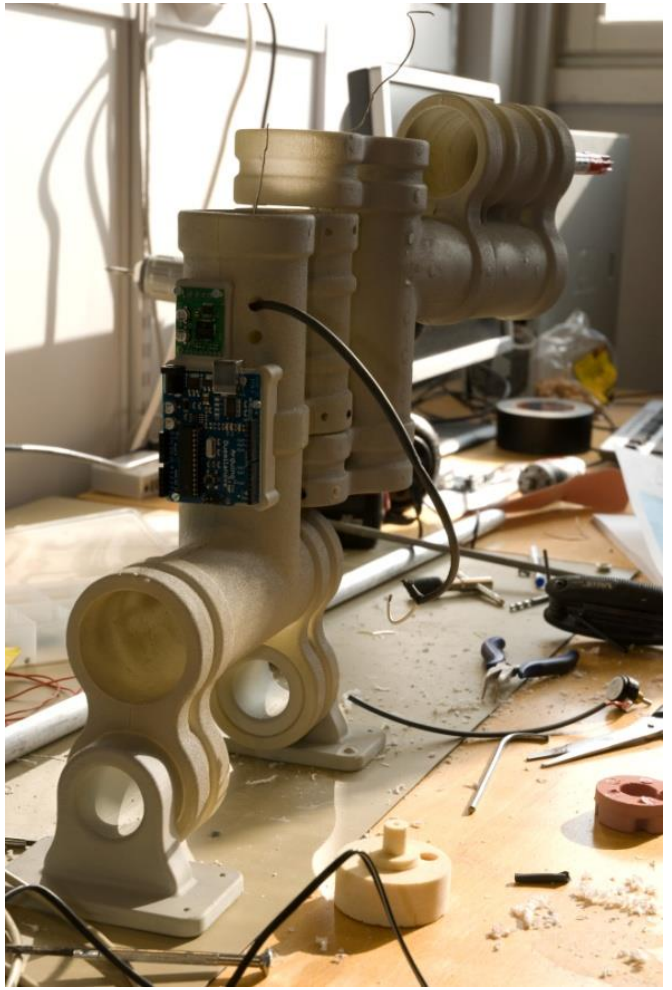
Motion Capture Facilities (ROBIN)

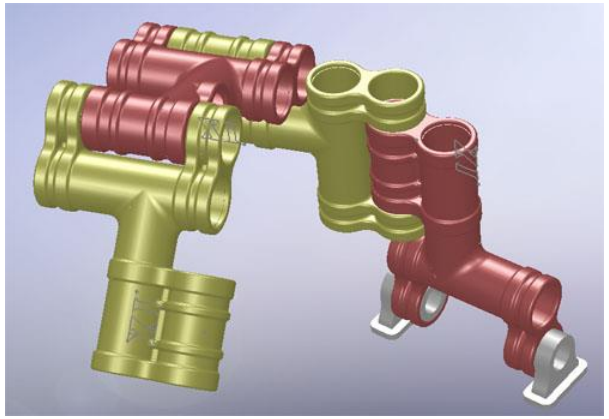
- Allows precise tracking of human and robot motion
- Camera-based and on-body motion capture



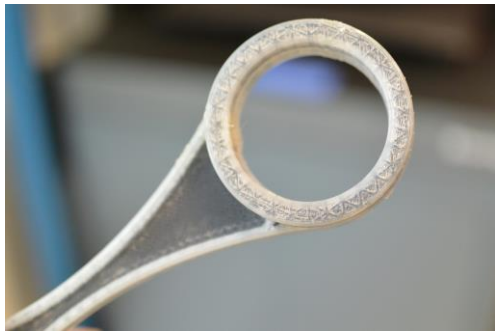
Rapid Prototyping Facilities (ROBIN)

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



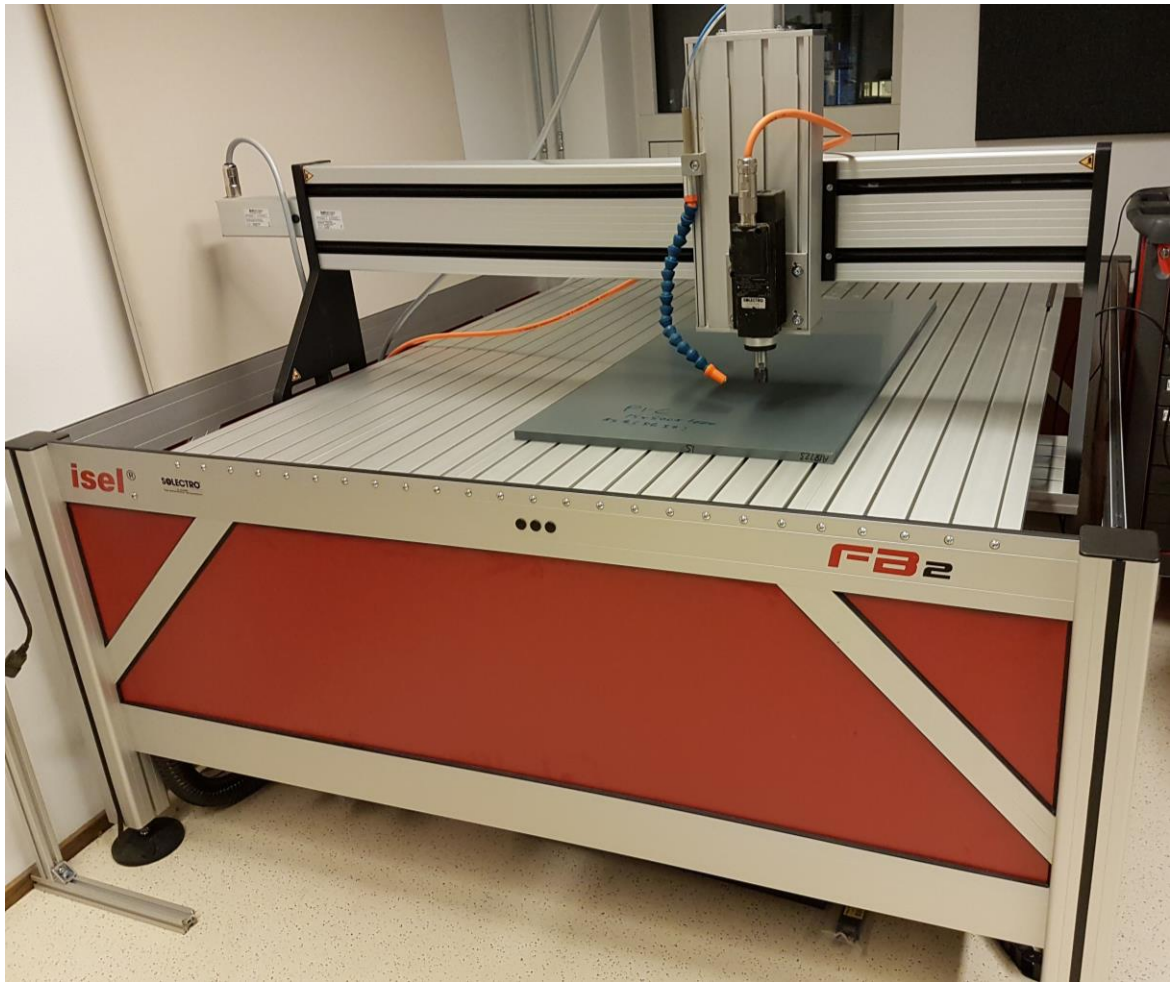


Rapid Prototyping Facilities
3D-printers (ROBIN)



Markforged Mark X
(carbon fiber 3D printer)

Rapid Prototyping Facilities
Milling Machines (ROBIN)



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RITMO Centre of Excellence for Interdisciplinary Studies in Rhythm, Time and Motion grant 262762 (2017-2027)

- The center study human and robot rhythm **mechanisms** in **perception, cognition** and **acting**.
- Interdisciplinary **collaboration** between **musicology, psychology, computer science** and **robotics.**
- Machine learning and robotics to be applied

https://www.uio.no/ritmo/english

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Norwegian Centre of Excellence

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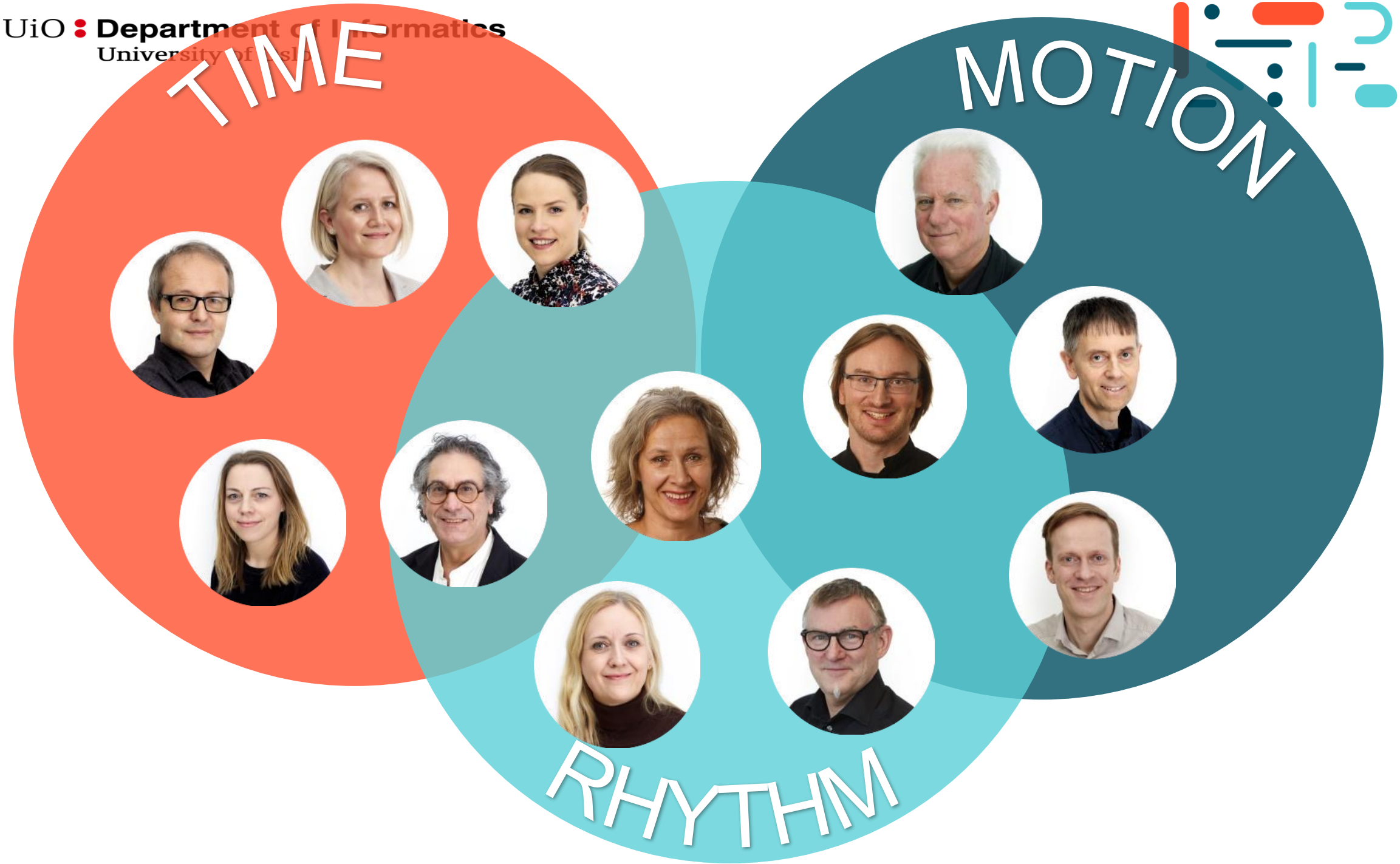
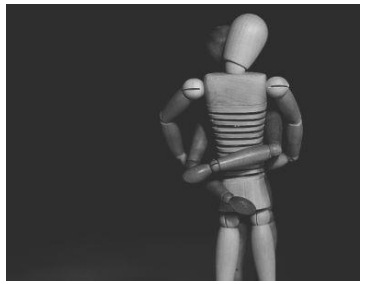


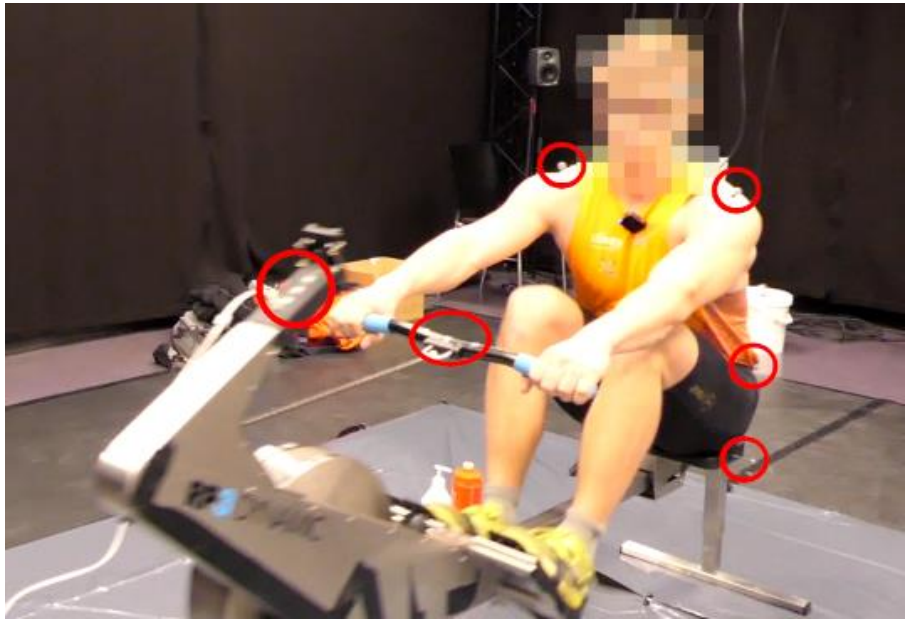
Four RITMO Clusters

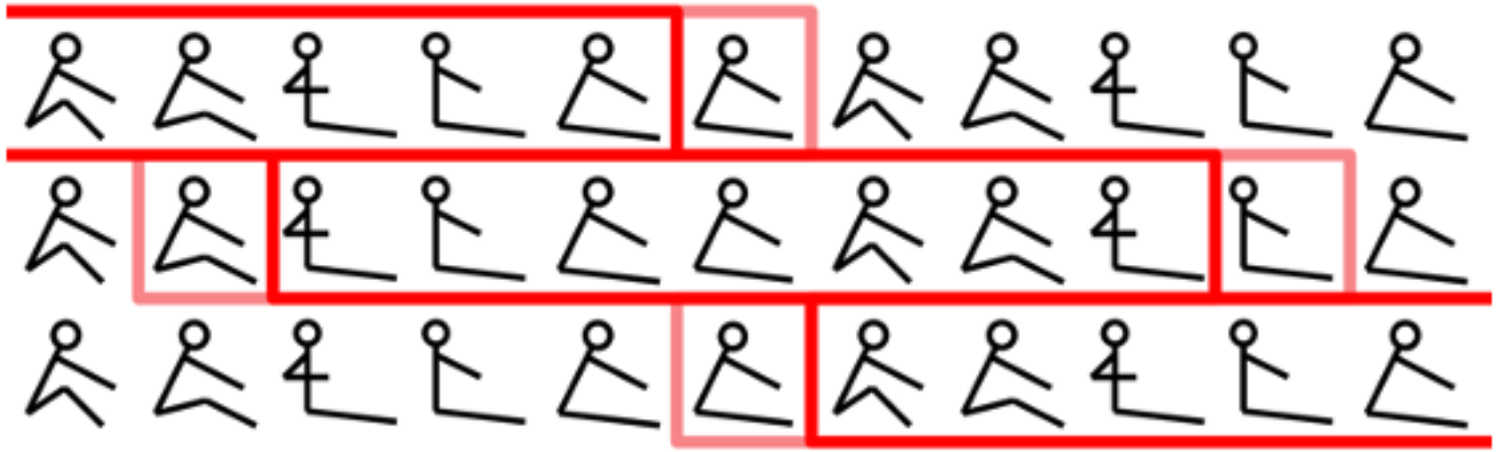


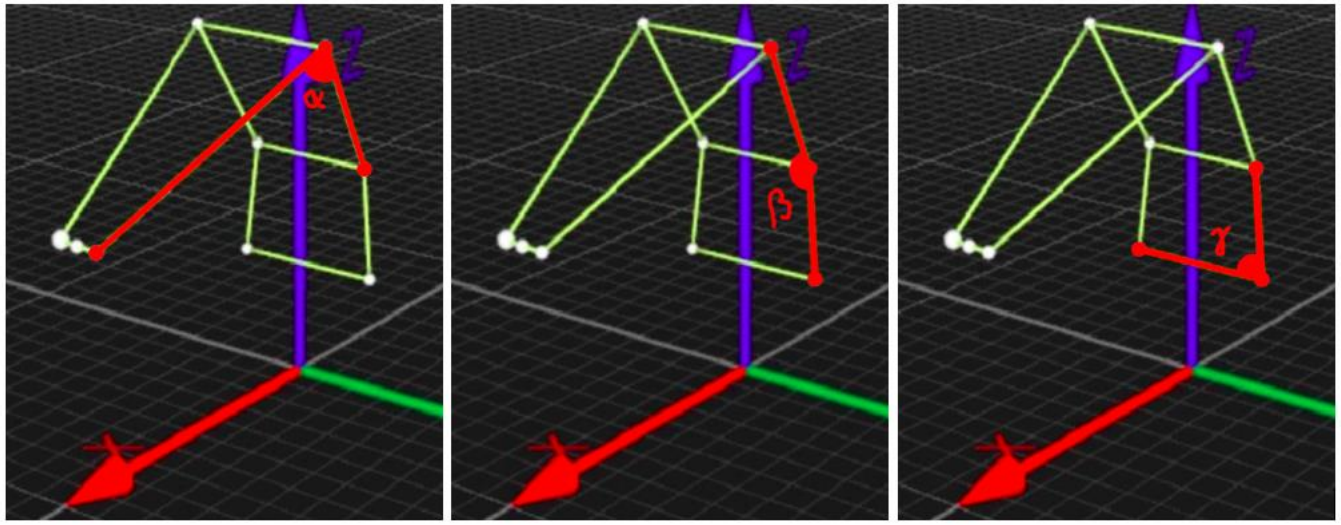



- **Interaction and pleasure**
  - Understand why rhythms make us move, and how rhythm facilitates entrainment and interaction.
- **Structure and time**
  - What are the basic features of musical rhythm and how do rhythm influence our experience of musical time
- **Structure and cognition**
  - How are rhythm and our sense of time constructed in the human mind?
- **Interaction and robotics**
  - Investigate aspects of rhythm and motion through robotics and technology

Can machine learning distinguish between elite and non-elite rowers?



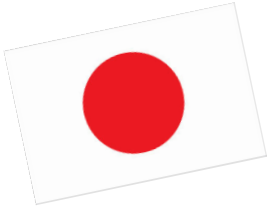




Collaboration on Intelligent Machines Norway (COINMAC)

←→ US, Brazil and Japan

Project manager: Jim Torresen



- Short term mobility stay for meetings
- Sharing and development of curriculum and teaching material for courses
- Long term mobility stay (students)
- Intensive course/student workshop
- Workshop/conference org. activities
- New collaborations/guest lectures (can be in Canada, China, ++)

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Funding: *INTPART 2017-2025*

https://www.mn.uio.no/ifi/english/research/projects/coinmac/index.html

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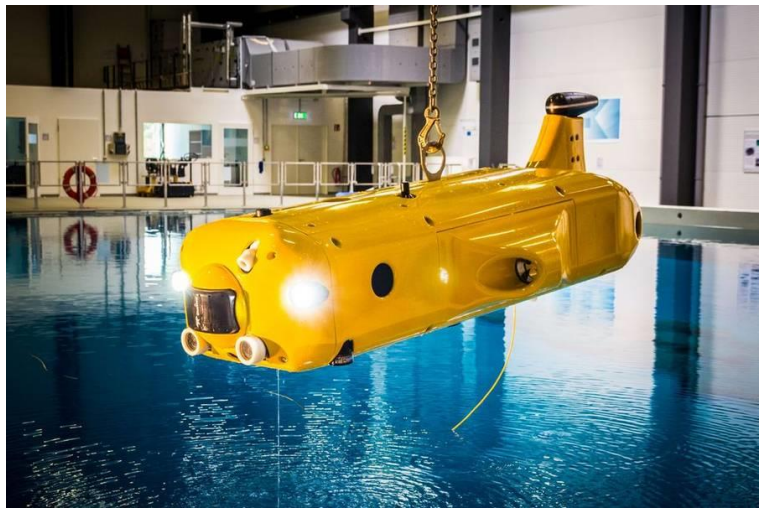
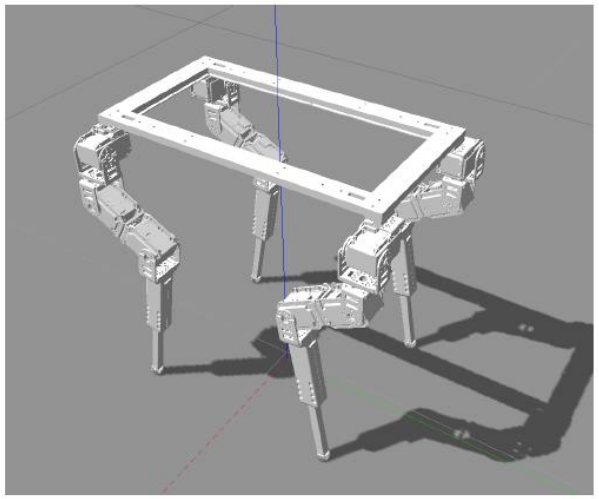
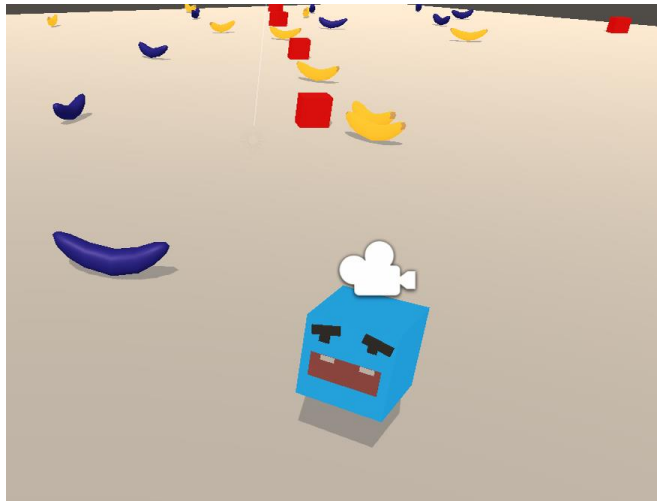
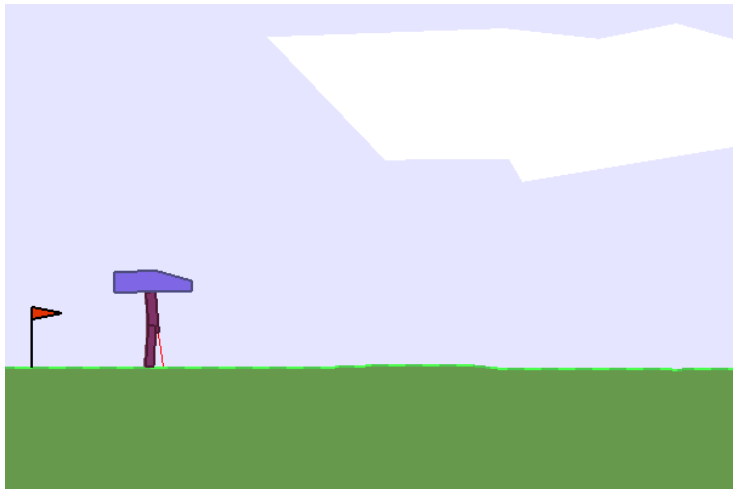
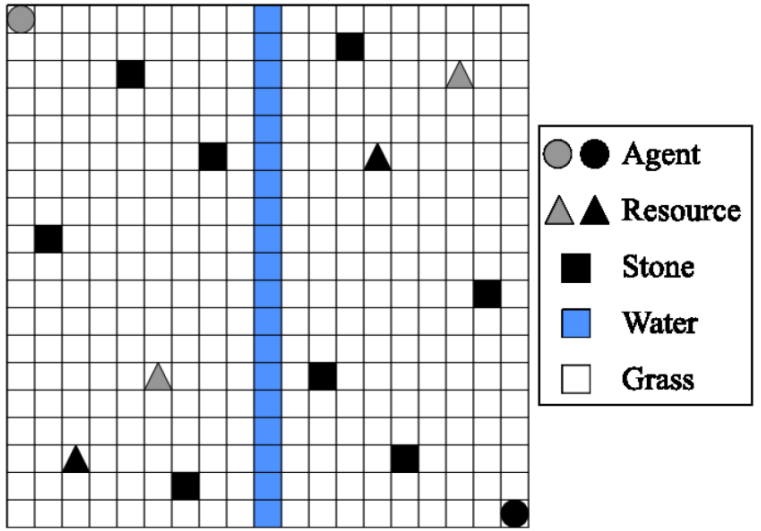
From Simple Simulation Models to Real-World Performance



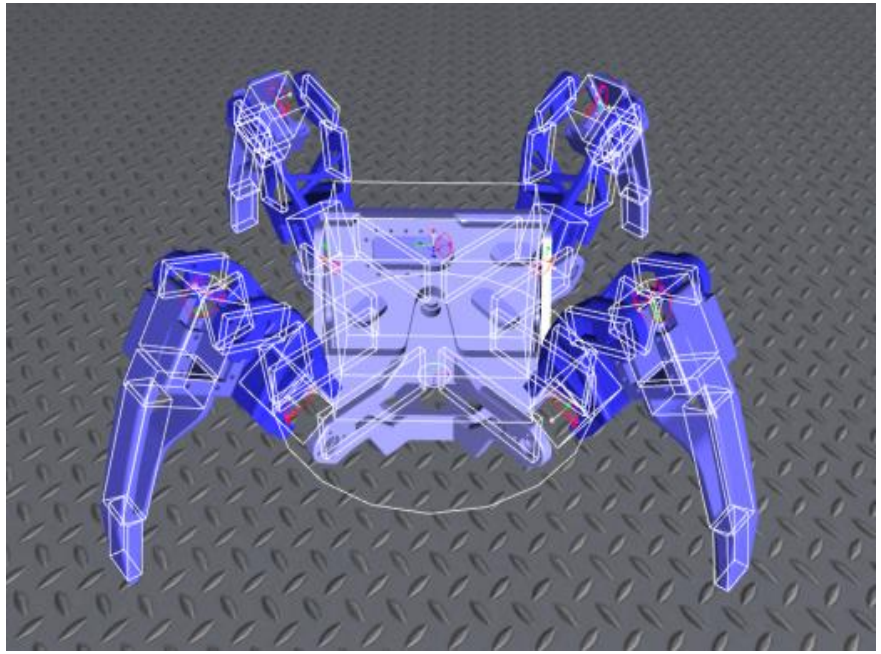


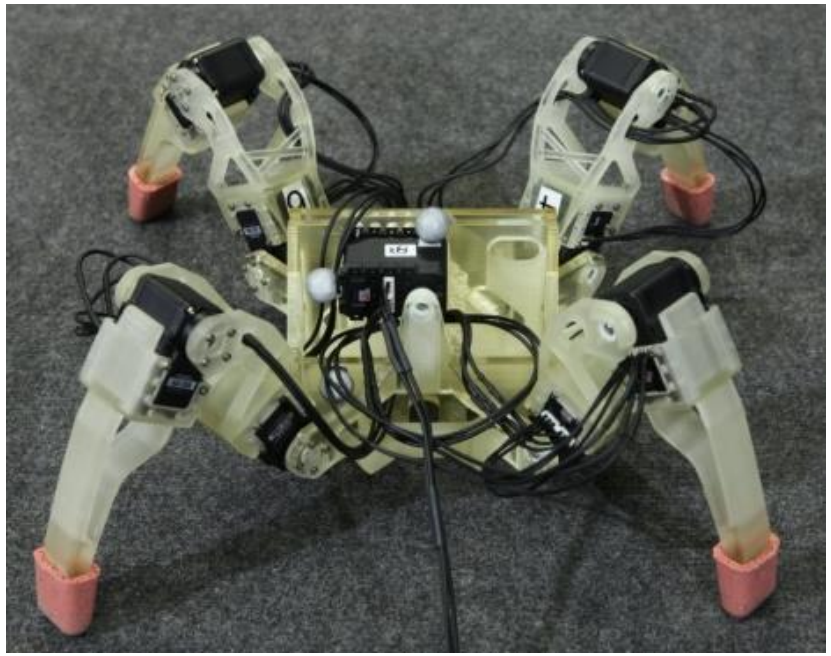






Robot Design, Simulation, Assembly and Evaluation

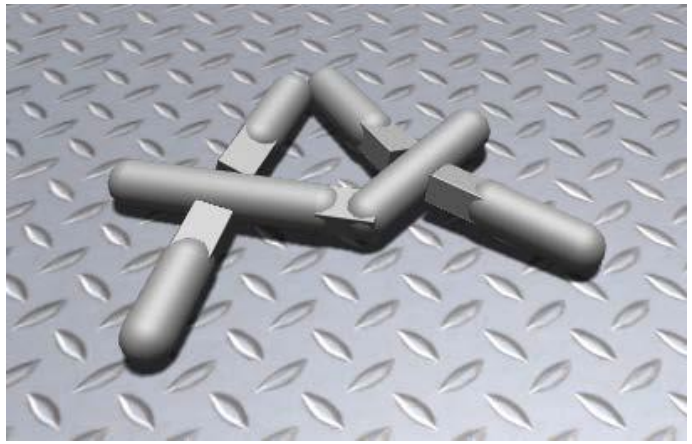




- Work with real robots and simulations.
- Reduce gap between simulation and reality.
- Create novel methods for design (e.g., evolution) and dynamic body shapes (morphology).

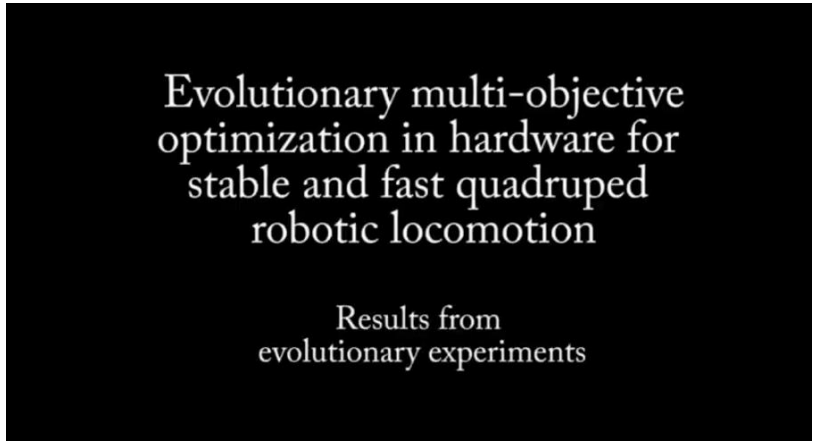
Evolved Robot Design

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

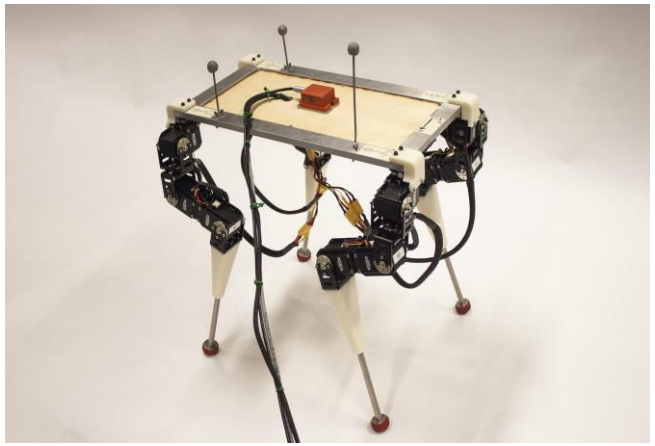


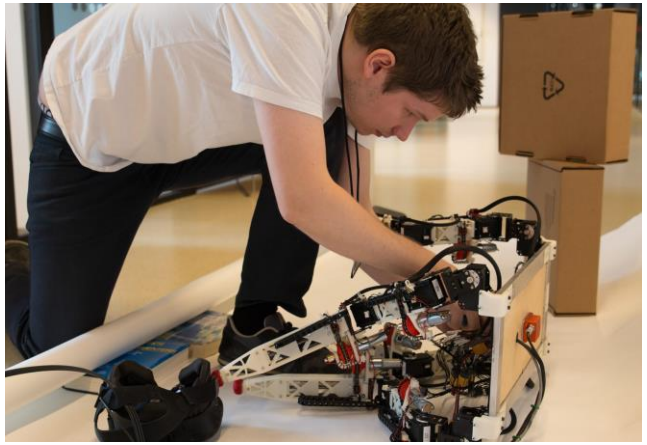
Dyret: A low-cost self-modifying quadruped

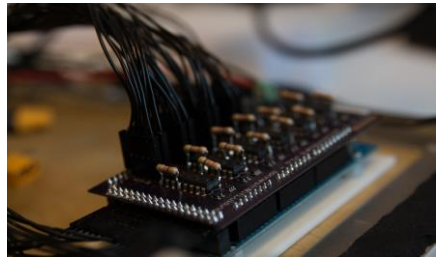
- Our most advanced legged robot to date
- Used for evolutionary experiments and research in self modelling and control



https://www.youtube.com/watch?v=fit4c3dMqQk



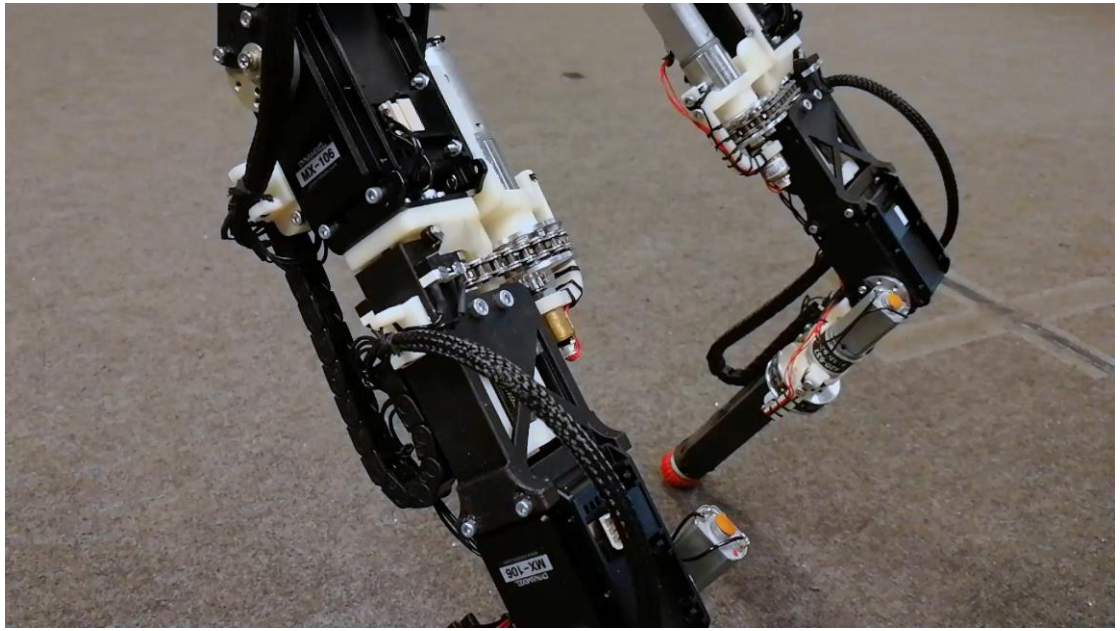


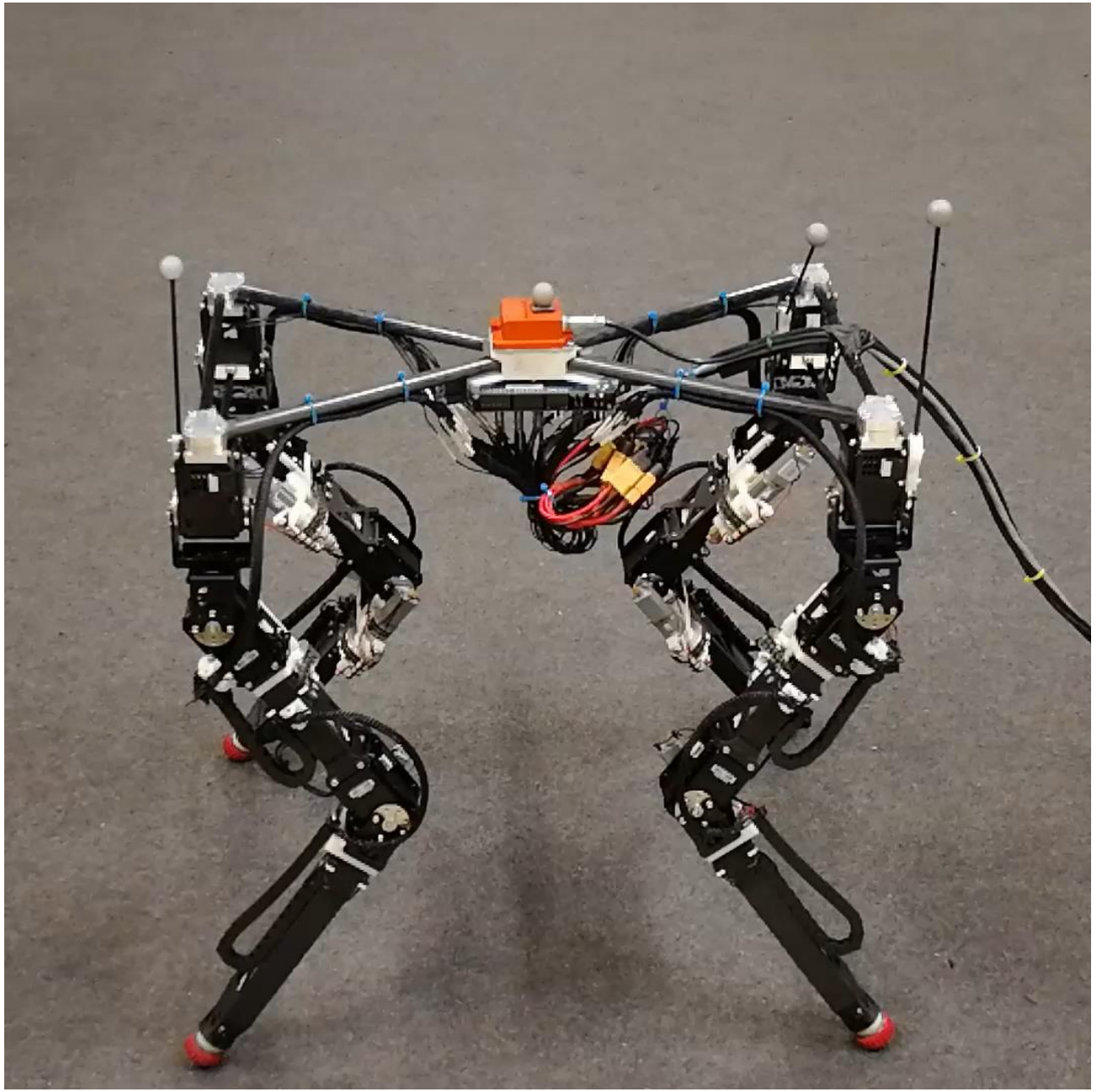


Automatically adjusts leg lengths outdoors

Nygaard, T.F., Martin, C.P., Torresen, J. *et al.* Real-world embodied AI through a morphologically adaptive quadruped robot. ***Nat Mach Intell*** (2021). https://doi.org/10.1038/s42256-021-00320-3

Real-World Adaptive Robot: Dynamic Robot for Embodied Testing (DyRET) (Norwegian for "the animal")





A Morphologically Adaptive Quadruped in the Wild

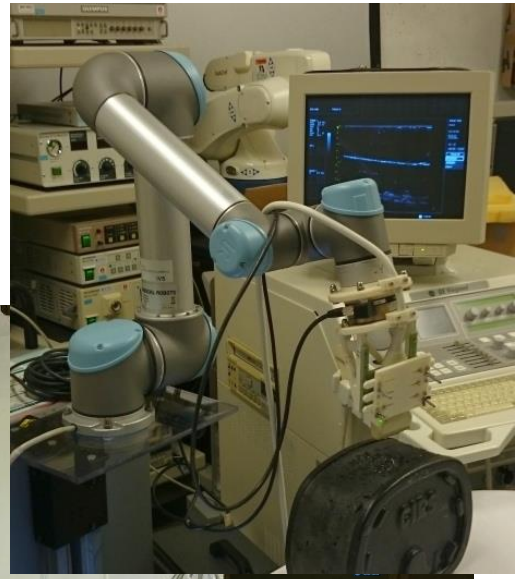
https://www.youtube.com/watch?v=Oug9pkZMUnc

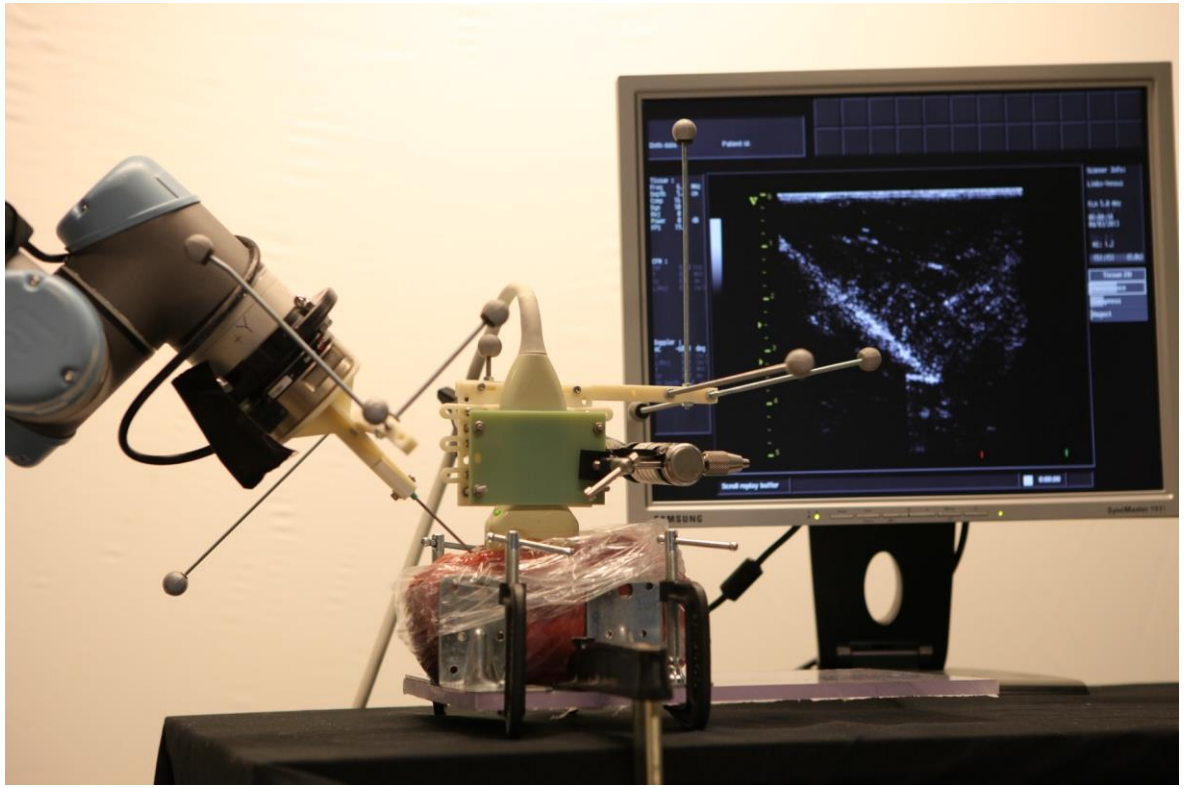
Infrasound design to enhance music and dance experience (Mats Høvin)

- Infrasound is sound that cannot be heard by our ears but can be experienced by our body
- Infrasound is believed to have the capacity to affect our psyche in different ways
- We want to explore how this can be utilized to enhance the experience of music and dance

Robot Surgery (National University Hospital)
Ole Jakob Elle (ROBIN)

Interaction:
- Robot-Robot
- Human-Robot





Recent and ongoing ROBIN Research Projects and Centre Funded by the Research Council of Norway

- **Multi-sensor Elderly Care Systems/Robots** (MECS, 2015–2021, IKTPLUSS)
- **INtroducing personalized TReatment Of Mental health problems using Adaptive Technology** (INTROMAT, 2016-2021, LightHouse project)
- **Vulnerability in the Robot Society** (VIROS, 2019-2024, IKTPLUSS)
- **Predictive and Intuitive Robot Companion** (PIRC, 2020-2027, IKTPLUSS)
- **Centre of Excellence for Interdisciplinary Studies in Rhythm, Time and Motion** (RITMO, 2017-2027, CoE)

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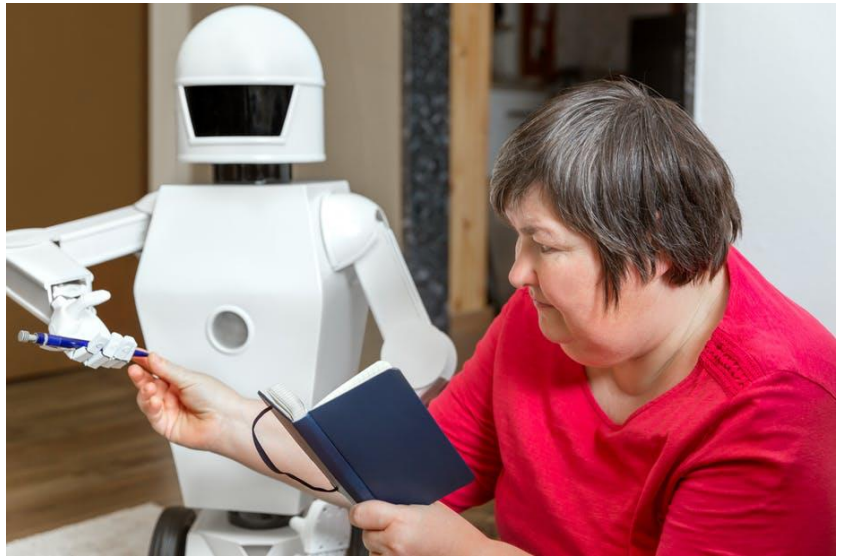
Robots Getting Closer to Human



Time

Human – Robot Interaction – Slow Versus Safe Robot

Trustworthy robot assistant trade-offs:

- too slow vs sloppy
- must have a number of capabilities vs quality in task performance

Ethical Countermeasures

- **Designers, procurers and users need to be aware** of possible ethical challenges that should be considered
  - e.g. avoiding misuse and allowing for human inspection of the functionality
- The **systems** should **themselves** be able to **do ethical decision making** to reduce the risk of unwanted behavior
  - Decide when a human is to be contacted or the machine should stop

Jim Torresen (2018). A Review of Future and Ethical Perspectives of Robotics and AI. *Frontiers in Robotics and AI*.

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IEEE Robotics & Automation Society

TECHNICAL COMMITTEE FOR ROBOT ETHICS

Robot ethics is a growing interdisciplinary research effort situated in the intersection of applied ethics and robotics with the aim of understanding the ethical implications and consequences of robotic technology, in particular, autonomous robots.

Jim Tørresen is the contact co-chair

Interested in getting involved?

Please register your contact info here:

https://nettskjema.no/a/365696

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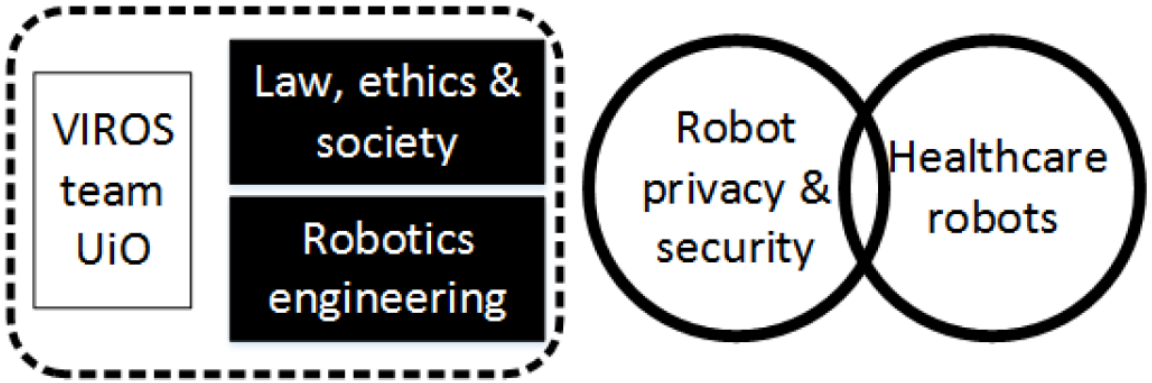
VIROS: Vulnerability in the Robot Society (2019-2024)

Research Council of Norway grant 288285

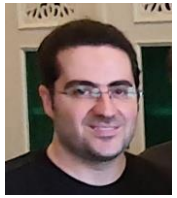


Dep. of Private Law +
Dep. of Informatics and other depts/partners

Goal:

Develop technology and proposals for **regulatory measures** to reduce vulnerabilities regarding robotics.
Focus on privacy, security and safety, particularly in healthcare contexts.
Technology partner: Robotics and Intelligent Systems (**ROBIN**) group

Diana Saplacan
Researcher



Adel Baselizadeh
PhD student

Funding: *IKTPLUSS, Research Council of Norway*

The Research Council of Norway

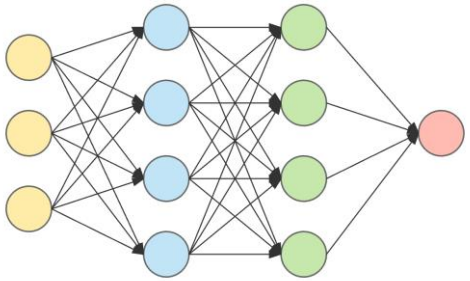
https://www.jus.uio.no/ifp/english/research/projects/nrccl/viros/index.html

VIROS focus areas: **1.Privacy** **2.Security** **3.Safety**

ROBOT = Sense → Think → Act

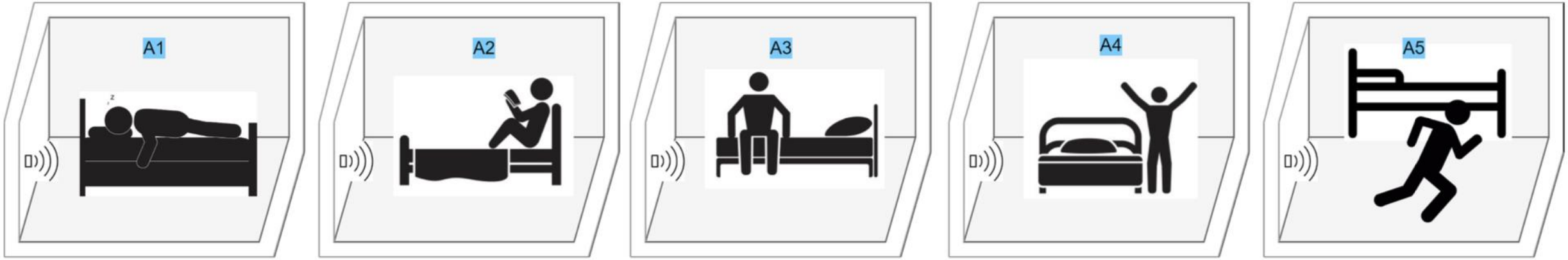
Sense → Sensors

Think → Artificial Intelligence



Act → Motors + Mechanics

Ultra-Wideband (UWB) Radar-Based Activity Recognition



- **LSTM-based activity recognition** approach performed better than conventional approaches, with an **accuracy of 99.6%**.
- We applied 5-fold cross-validation to test our approach.

F. M. Noori, M. Z. Uddin and J. Torresen, "Ultra-Wideband Radar-Based Activity Recognition Using Deep Learning," in *IEEE Access*, vol. 9, pp. 138132-138143, 2021, doi: 10.1109/ACCESS.2021.3117667.

Privacy challenges / paradoxes

- **How much data to collect:** The more data that are used during research and development, the less data is needed when a system is to be applied.
- **What kind of sensors:** The more sensors, the more accurate and safer the robot will be.
- **Consent**: A personalised robot will act better and safer: the more you know about a friend, the more you tend to adapt to the person. (ref. web page cookie preferences will give easier use and more personalised web page view)

Torresen, J., Saplacan D., Baselizadeh, A., and Mahler, T., "Machine Excellence Tradeoffs to Ethical and Legal Perspectives," *2023 IEEE Conference on Artificial Intelligence (CAI)*, Santa Clara, CA, USA, 2023, pp. 237-240, doi: 10.1109/CAI54212.2023.00109.

Ethical Concerns: 2. Security

rawpixel.com

- Concern 1: **Sensing** – possible theft and unwanted distribution of sensor data from a robot.
- Concern 2: **Control** – risk of misbehaviour of the robot in similar ways as computers can be attacked with malware.
- **Mitigation** 1: Regular security measures with **passwords and authentication**
- **Mitigation** 2: Add an **external user assessment** module that can consider the current context (ref. ethical reasoning engine)

Torresen, J., Schulz, T., Uddin, Z., Khaksar, W. and Prestes, E., “Robot Companions for Older People – Ethical Concerns”, ICRES 2018: International Conference on Robot Ethics and Standards, New York, USA, 20-21 August 2018. https://doi.org/10.13180/icres.2018.20-21.08.016

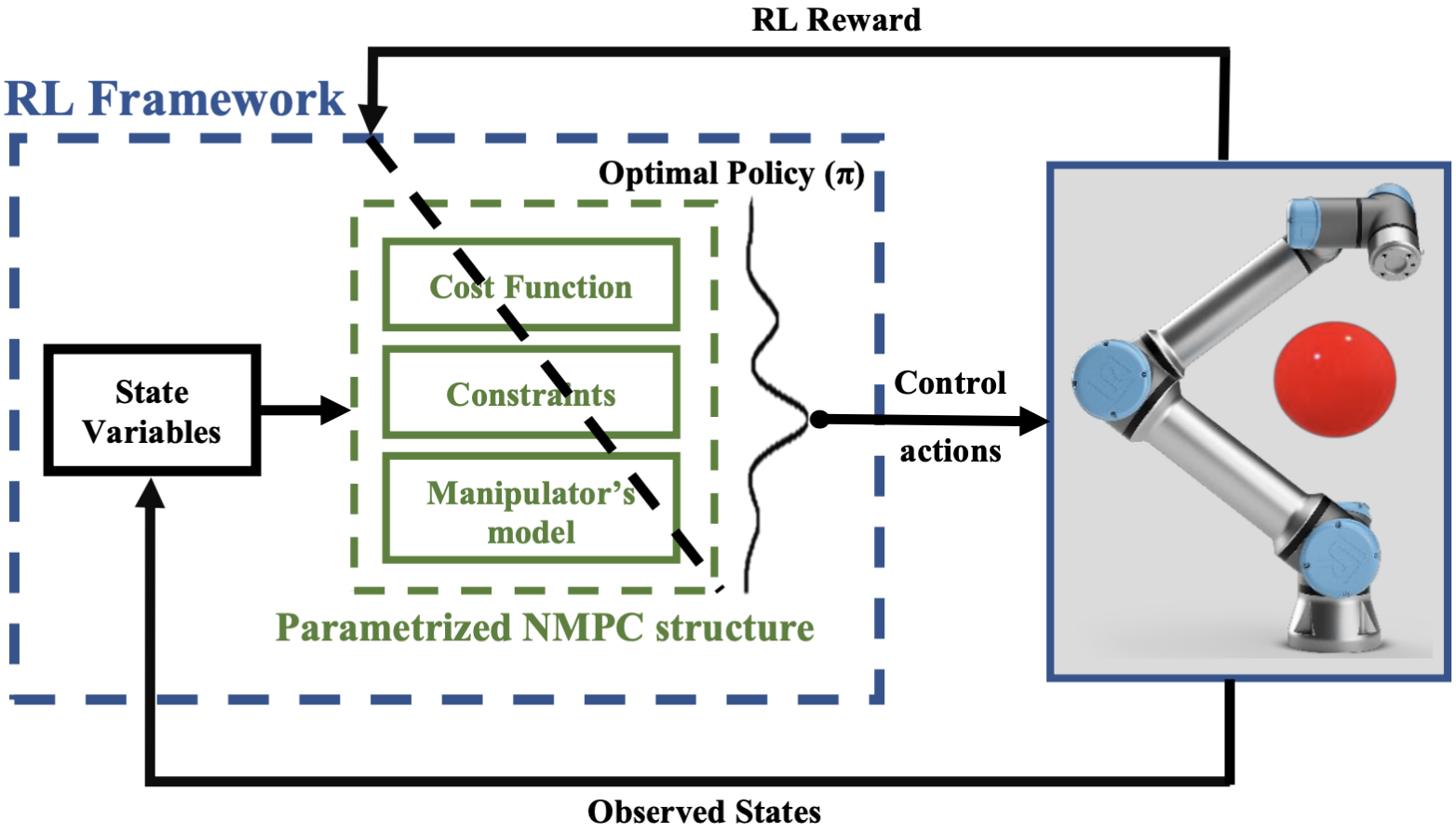
Ethical Concerns: 3. Safety

- Challenge: Robots getting **physically much closer to humans** than what we are used to. => Can hit us unintentionally or hurt us through un-authorized access
- Trade-off between robot size, performance and safety
- Mitigation:
  - Equip robots with **soft material**
  - Provide a self/user-aware adaptable system that can **learn about the user's daily activities** and preferences
  - **Explainable AI/transparent systems** to be able to correct for unwanted or harming behavior

Farzan Majeed Noori, Michael Riegler, Md Zia Uddin, and Jim Torresen. 2020. Human Activity Recognition from Multiple Sensors Data Using Multi-fusion Representations and CNNs. ACM Trans. Multimedia Comput. Commun. Appl. 16, 2, Article 45 (June 2020),

Motion Planning and Obstacle Avoidance Using Non-lin. Model Predictive Control-based Reinforcement Learning

- Controller can effectively control the end-effector's pose in such a way as to avoid any collisions
- NMPC parameters are tuned using a learning strategy according to the RL reward



A. Baselizadeh, W. Khaksar and J. Torresen, "Motion Planning and Obstacle Avoidance for Robot Manipulators Using Model Predictive Control-based Reinforcement Learning," *2022 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, Prague, Czech Republic, 2022, pp. 1584-1591, doi: 10.1109/SMC53654.2022.9945504

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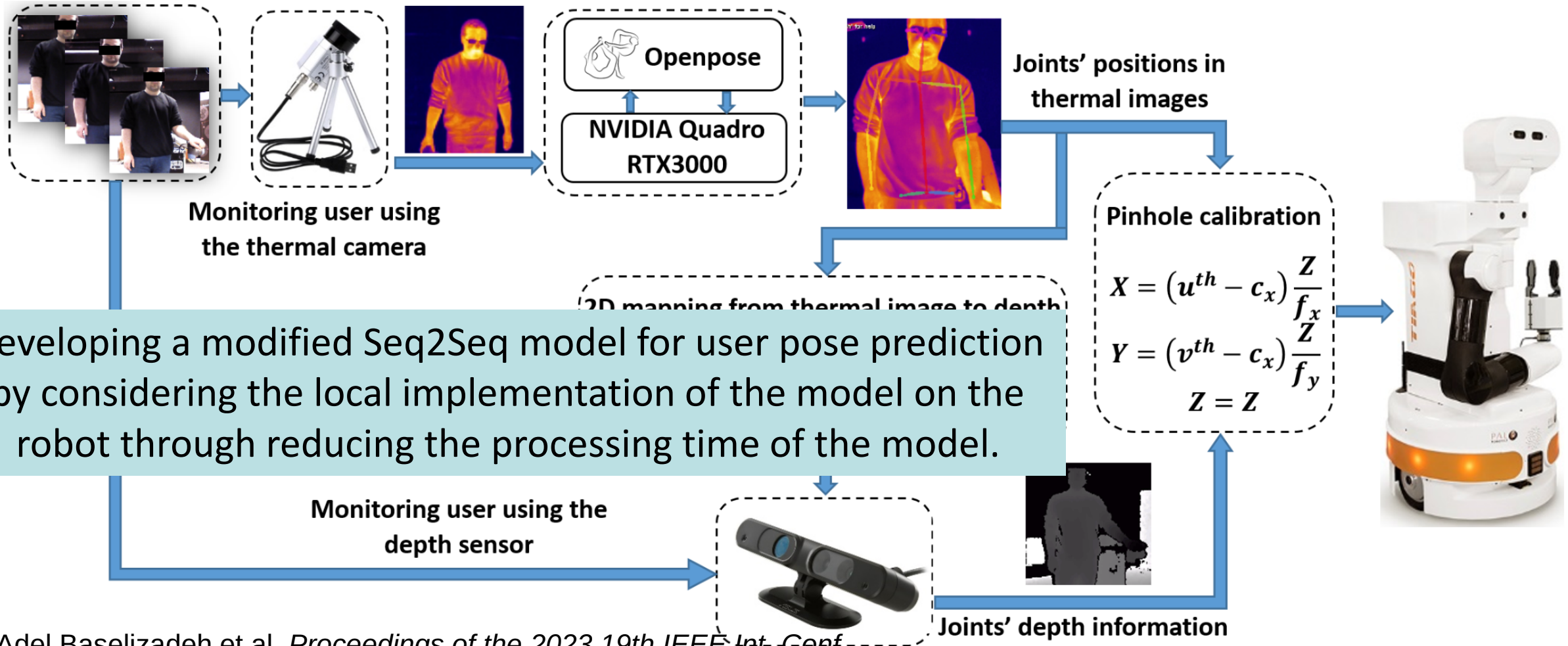
University of Oslo

Privacy-Preserving User Pose Prediction for Safe and Efficient Human-Robot Interaction



Developing a modified Seq2Seq model for user pose prediction by considering the local implementation of the model on the robot through reducing the processing time of the model.

Adel Baselizadeh et al, *Proceedings of the 2023 19th IEEE Int. Conf. on Automation Science and Engineering (CASE)*

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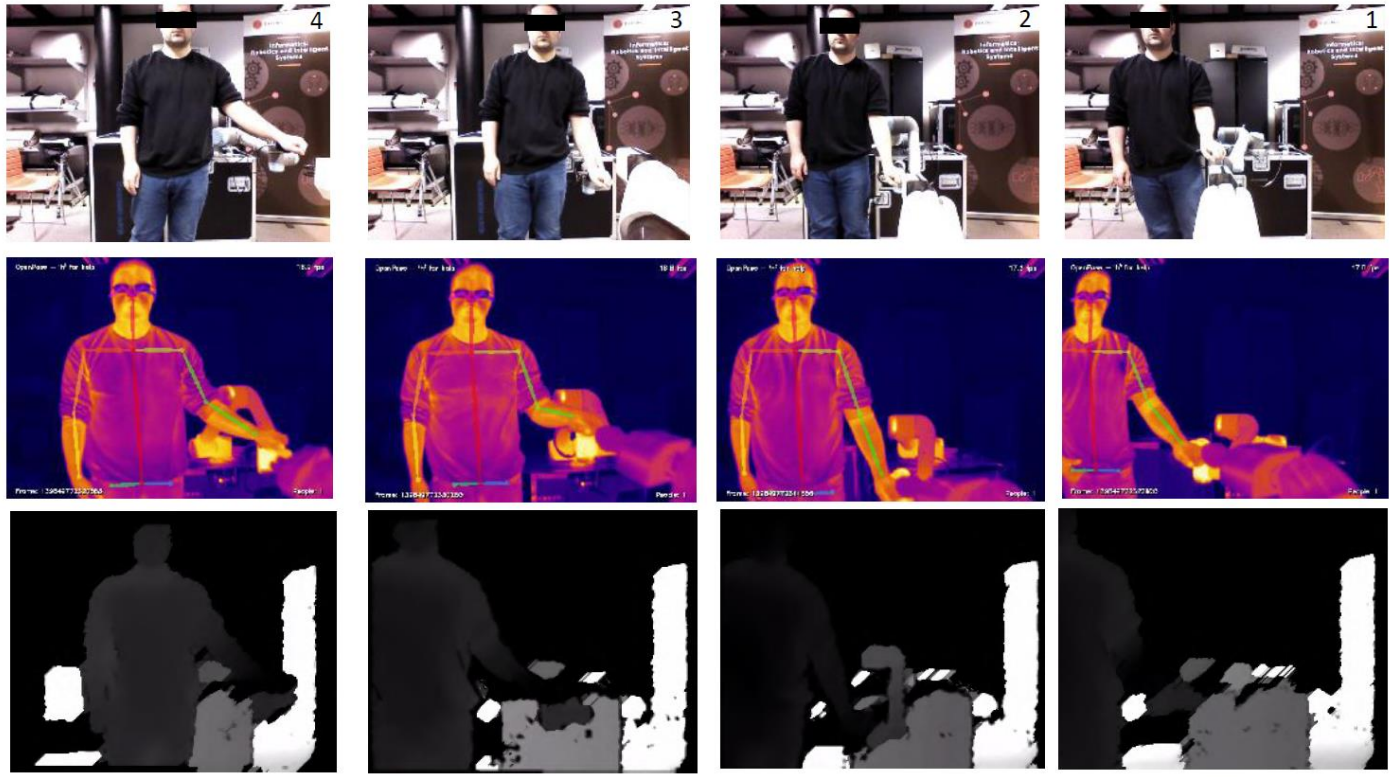
Privacy-Preserving User Pose Prediction for Safe and Efficient Human-Robot Interaction

- User moved their hand in front of the robot (supported by a UR-5 arm for repeatable trajectories).
- The robot's end-effector was programmed to detect the user hand and follow it.
- Once the current and once the predicted user's hand positions were sent to the robot as the desired trajectories to follow.



13.8 % improvement in the robot reaction time was obtained

Adel Baselizadeh et al, *Proceedings of the 2023 19th IEEE Int. Conf. on Automation Science and Engineering (CASE)*

Ethical Challenges Raised by Care Robots

Analysing state-of-the-art projects on the integration of robots within the home- and healthcare services for the independent living elderly.

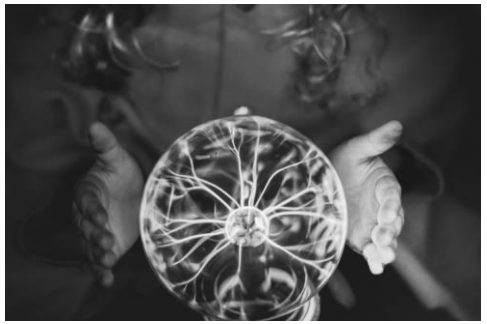
1. Lack of Legal Framework and Harmonized Standards Regulating AI and Robots
2. Decreased Human Contact
3. The Elderly Felt Objectified and Lost Control
4. Elderly Perceived That Their Privacy is Lost
5. The Elderly Felt Deception and Infantilization
6. The Elderly's Concern on Who is Responsible

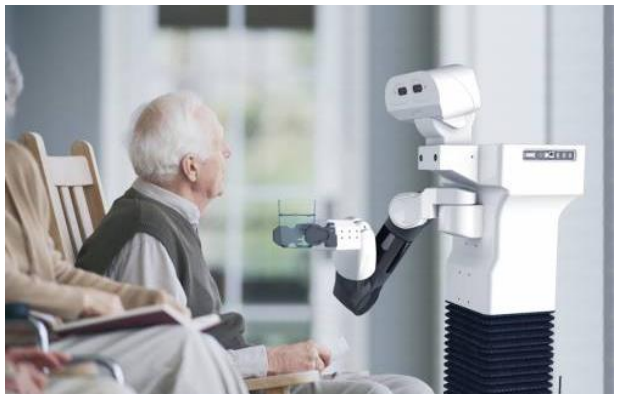
Diana Saplacan, Weria Khaksar, and Jim Torresen, On Ethical Challenges Raised by Care Robots: A Review of the Existing Regulatory, Theoretical-, and Research Gaps, *2021 IEEE Int. Conf. on Advanced Robotics and Its Social Impacts (ARSO)* July 8-10, 2021

UiO : Department of Informatics
University of Oslo

Predictive and Intuitive Robot Companion (PIRC) (2020-2027)

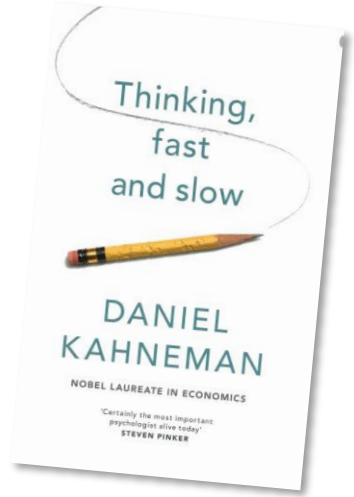
Research Council of Norway grant 312333





Goal: Build **models** that **forecast** future events and **respond dynamically by psychology-inspired computing**:

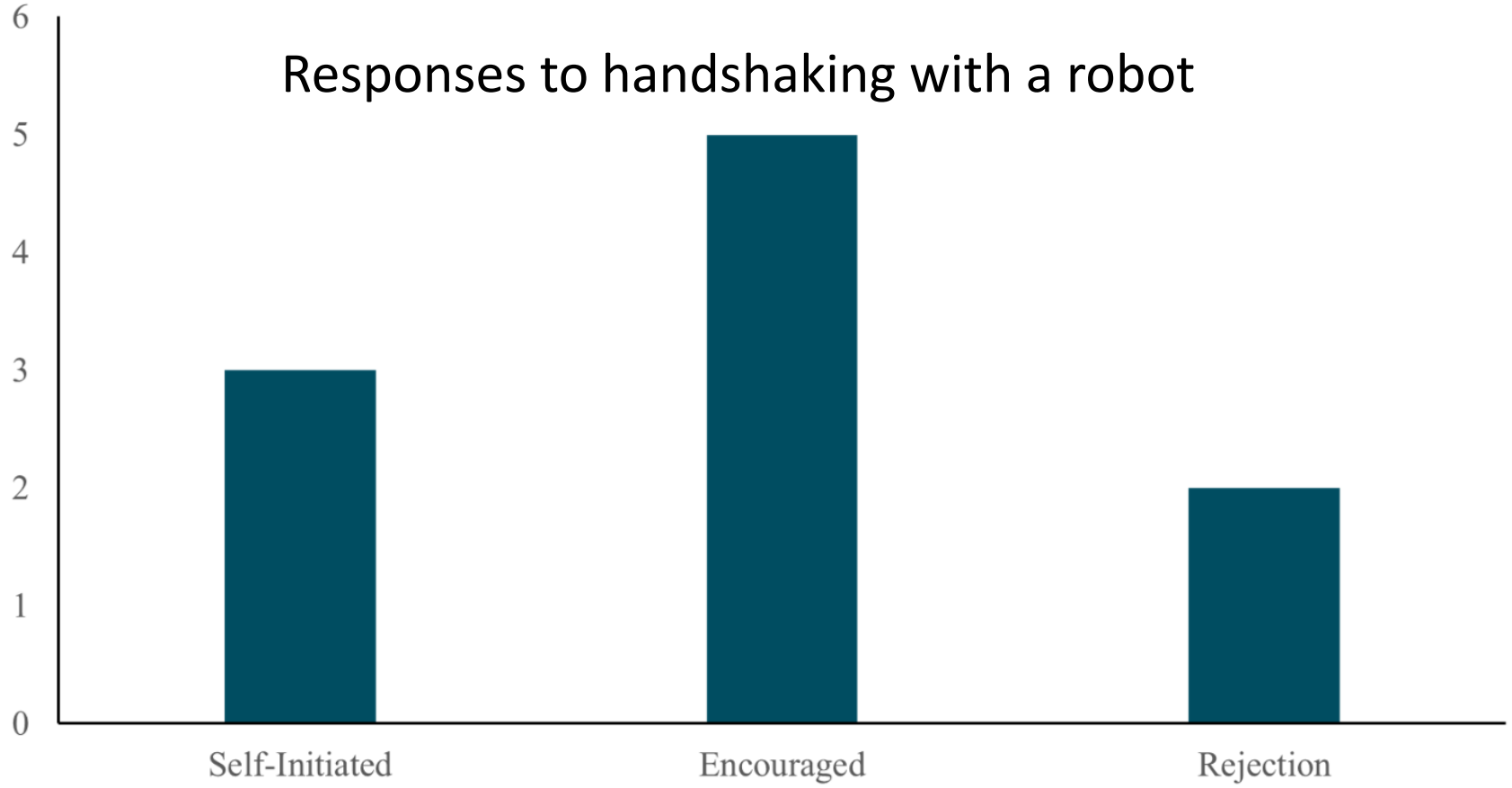
- Apply recent models of **human prediction** to perception-action loops of future intelligent robot companions.
- Include mechanisms for **adaptive response time** from quick and intuitive to slower and well-reasoned
- **Applications**: Physical rehabilitation and home care robot support.



Funding: *IKTPLUSS, Research Council of Norway*

The Research Council of Norway

To Shake or Not to Shake: Intuitive Reactions of Senior Adults to a Robot Handshake



Proceedings of the 32nd IEEE International Conference on Robot & Human Interactive Communication (RO-MAN) 2023 by Marieke van Otterdijk et al

We should focus as least as much on improved quality of life as reducing the cost by the technology being developed

Questions or Comments?

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www.jimtoer.no