UiO : Department of informatics
University of Oslo

Research methods

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About me

- Position: Professor at University of Oslo
  - Robotics and Intelligent Systems research group (ROBIN) - IFI
  - RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion
- Education:
  - PhD UiO
  - MSc NTNU
- Research interests:
  - AI, biologically inspired algorithms, robotics, swarms, hardware and embedded systems, music technology

Case: Master’s Thesis project description - TIAGO

Below follows a number of different project description:

1. **Robot sensing:** Multi-modal Sensing for Emergency Monitoring of Older People for Privacy
2. **Robot ethics:** Machine Ethics for Robot Security
3. **Robot control:** Motion Preferences for Home Robot for Safety
4. **Robot control:** Reinforcement learning (RL) for safe human-robot interaction
5. **Robot safety:** Exploring the concept of safety in care robots
6. **Robot design:** An explorative study on Universal Design principles and care robots
7. **Human-robot interaction:** The theoretical and practical challenges with informed consent in AI-based care robots
8. **Human-robot interaction:** The role of sociomorphism (rather than anthropomorphism or zoomorphism) in HRI
9. **Human-robot interaction:** "It takes two to <<TiANGO>>: An investigation on intuitive non-verbal interaction with social robots.
10. Human-Robot Interaction: "Let the robot take care of grandma"

How to do a thesis?

- Project: Do *X* with the robot
- How can we learn something new while doing that?
- How to do it so that it matters for others?

- Research: “a detailed *study of a subject*, especially in order to discover (new) *information* or reach a (new) *understanding*”

Example: robot control

- Project: *Make the robot find the fastest way from X to Y without colliding with humans or obstacles on the way*
- How can we learn something new while doing that?
- How to do it so that it matters for others?

- Compare algorithm A with algorithm B
  - A may be known, state of the art
  - B may be self-developed algorithm
- Test it multiple times
  - The people may move, obstacles change
- Do statistics
  - To say with confidence that there really is a difference

Example: human-robot interaction

- Project: *Make the robot cooperate with a human on a task by handing over objects*

- Design two approaches
- Test with different people
- Multiple options:
  - Measure time to complete a task
  - Surveys – e.g. how did you experience (1..5) and free comments
  - Interview participants

Example: robot design

- Project: *Design a new robot head for use in care homes*

- Involve the potential users of the robot in the process
- Discussions, interviews, observation
- Prototyping, multiple iterations

Example: robot design – engineering approach

- Project: *Design and prototype a new hand mechanism for gripping of some type of objects*

- Simulations and prototyping of new mechanism
- Measure performance properties
  - Gripping accuracy
  - Gripping force
  - Speed

- Compare with existing approach if possible

Example: robot control – theoretical approach

- Project: *Extend the arm and investigate the kinematics and workspace of the robot*

- Use mathematics / mechanics theory to develop precise equations of the robot's movements given the extension
- Use established conventions when formulating the solutions

Did your research project fit into one of these?

Science and research

Science

- (*knowledge* from) the careful study of the *structure and behaviour* of the physical world, especially by watching, measuring, and doing experiments, and the *development of theories to describe the results of these activities*

- Many types of science!

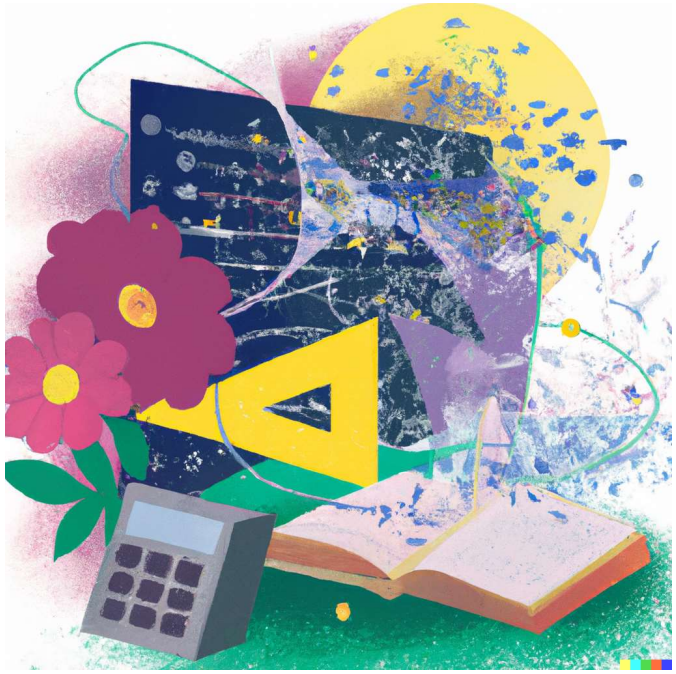
Research

- a detailed *study of a subject*, especially in order to discover (new) *information* or reach a (new) *understanding*

- Many ways to do research!

Branches of science

- Natural science
  - Life science, physical science
- Social science
  - Sociology, anthropology, economics, …
- Formal science
  - Mathematics, theoretical computer science, …
- Applied science
  - Engineering, medicine, computational science, …
- Humanities
  - Languages, philosophy, arts, …
- Interdisciplinary science
  - Cognitive sciences, music technology, …

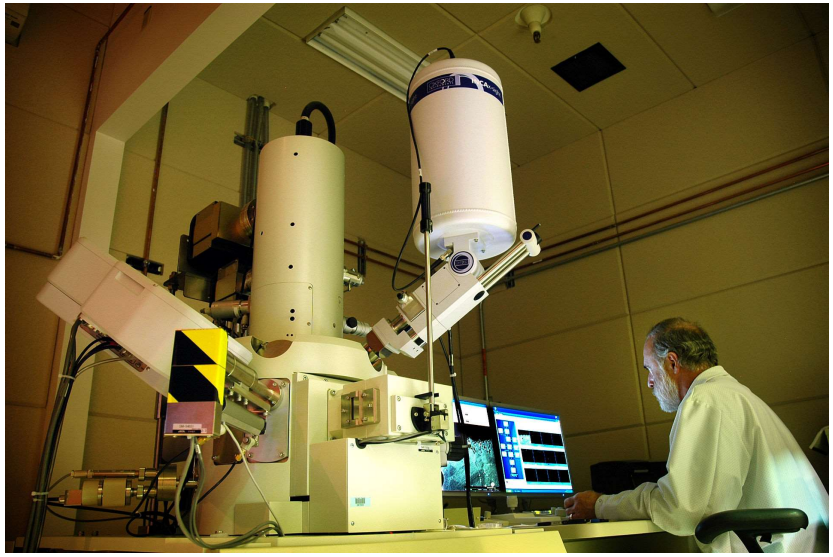


Research methods

- Empirical research / non-empirical research
- Basic research / applied research

- Research in different sciences often use different research methods
  - Some methods are valued higher in some fields

- There is no single “correct” research method in informatics / computer science!

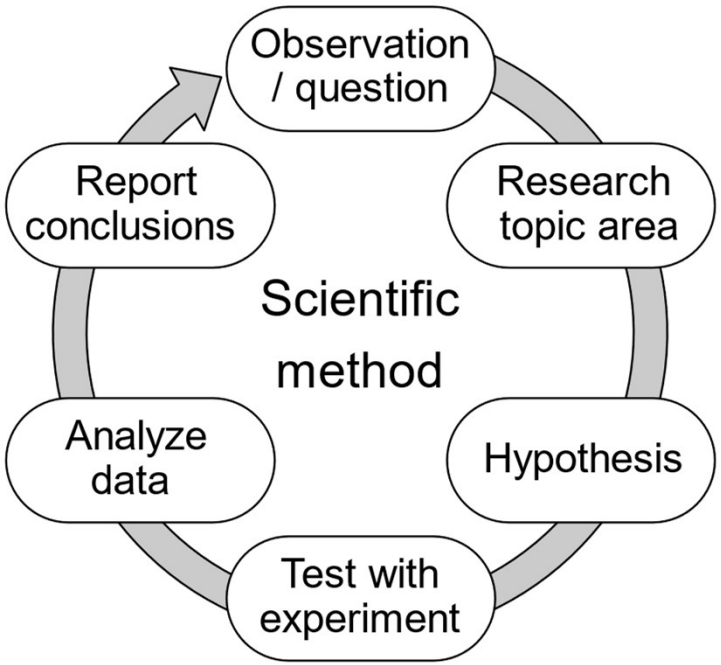


Research method examples

- Natural science
  - Scientific method
- Social science
  - Surveys, interviews, focus groups
- Formal science
  - Prove theorems, develop theories, …
- Applied science
  - Apply other sciences to improve or find new solutions to problems
  - e.g. engineering and medical
- Humanities
  - Interpretation, aesthetic interpretation, speculative reason
- Interdisciplinary science
  - Mix of the above!

Scientific method

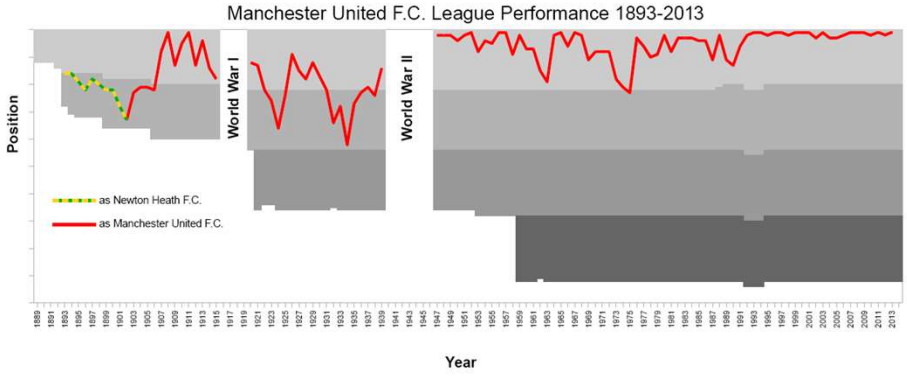
- Aim: Objectively explain events of nature in a reproducible way
- Standard in natural sciences
- Also works in many informatics topics



Quantitative and qualitative

- Quantitative and qualitative approach
  - **Quantitative**: working with numerical data and statistical analysis
  - **Qualitative**: working with more non-quantitative, subjective data, and interpretations
  - Go more into depth about these tomorrow

- Empirical and non-empirical
  - Empirical: collecting data
  - Non-empirical: using existing knowledge to gain new insights



Theorem: $2 = 1$.

Proof.

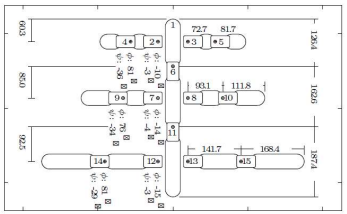
Let $a \neq 0$, and let	$b = a$
Multiply both sides by b:	$b^2 = ab$
Subtract a^2 from both sides:	$b^2 - a^2 = ab - a^2$
Factor:	$(b + a)(b - a) = a(b - a)$
Divide by $b - a$:	$b + a = a$
Now, as $a = b$, we have	$a + a = a$
Simplify:	$2a = a$
As $a \neq 0$, divide by a:	$2 = 1$

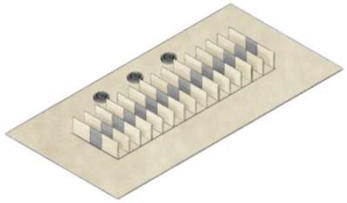
Quantitative or qualitative?

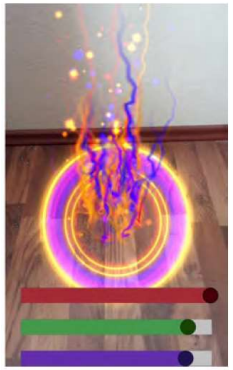
How to choose a research method?

- Depends on the field
  - Some methods are more valued in some fields
  - Traditions can be hard to break
  - Check with literature on the subject
- Depends on your research goals / questions
  - E.g. showing that some software is fast is different from showing that software is user-friendly
- Depends on your resource situation
  - E.g. if you only have access to a few sessions with a small group of people, it may be hard to use quantitative methods
- **Discuss with your supervisor!**
- Once you have chosen, study the dos and don’ts of that method

Example theses

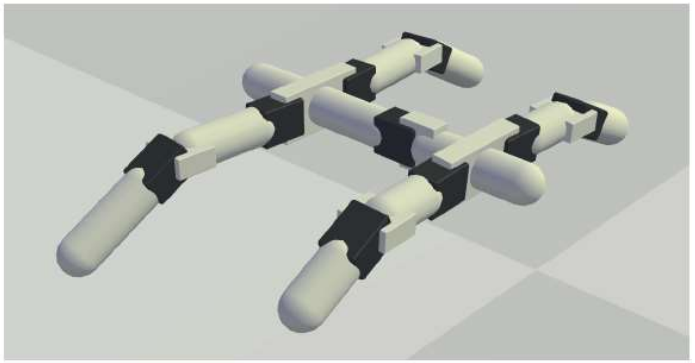




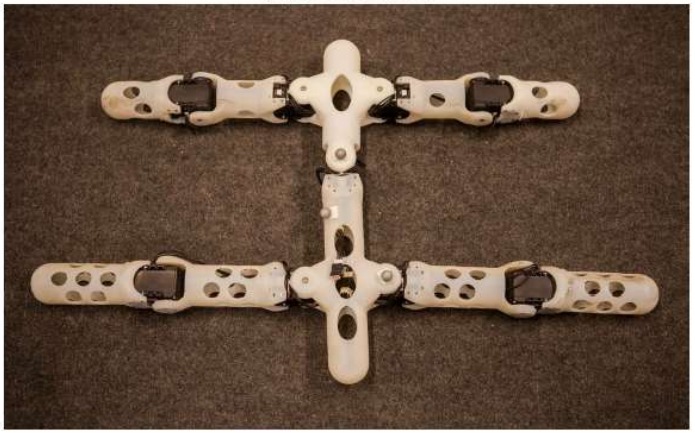


Thesis: Lifetime learning in evolutionary robotics

- Algorithm investigation combining global + local search in simulated and real robots
- Develop variants of algorithms, compare performance
- Run algorithm experiments in simulation and test on real-world robot
- Performance: forward movement speed
  - Measured in simulator
  - Measured using motion capture system



(a) In simulation

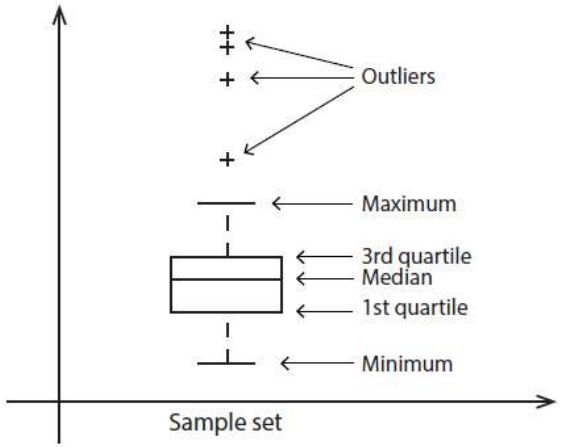


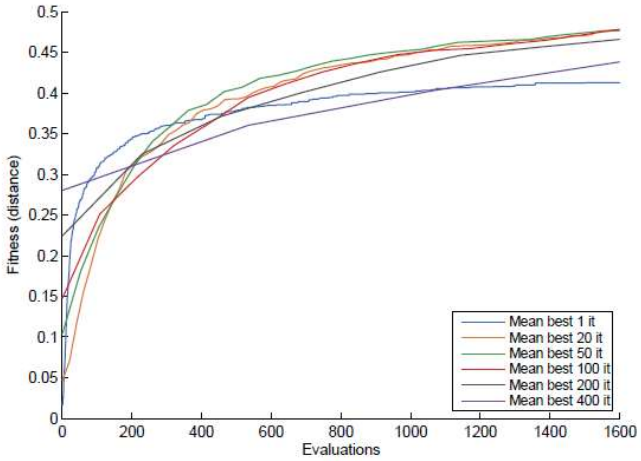
(b) The physical robot

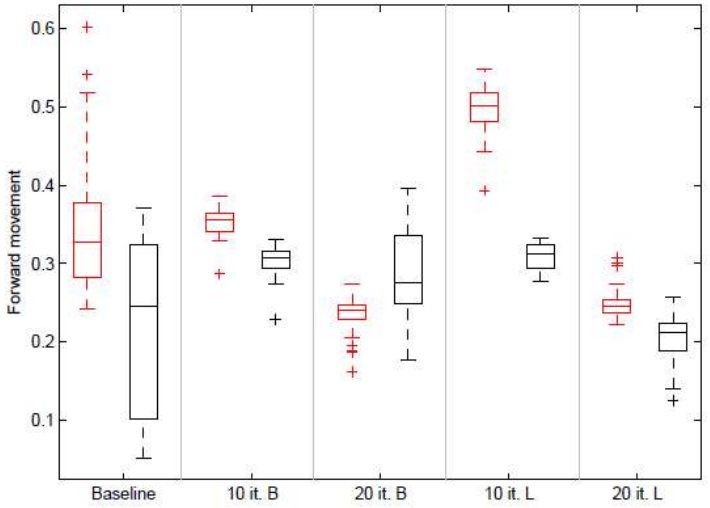
Else-Line Malene Ruud - Lifetime learning in evolutionary robotics

Analysis of results

- Baseline algorithm compared to variants
- Simulation vs. reality
- Multiple “samples” of both simulated and real robot experiments → statistics
  - 30 runs of the algorithms, 30 evaluations of the final results
  - Statistically significant differences?



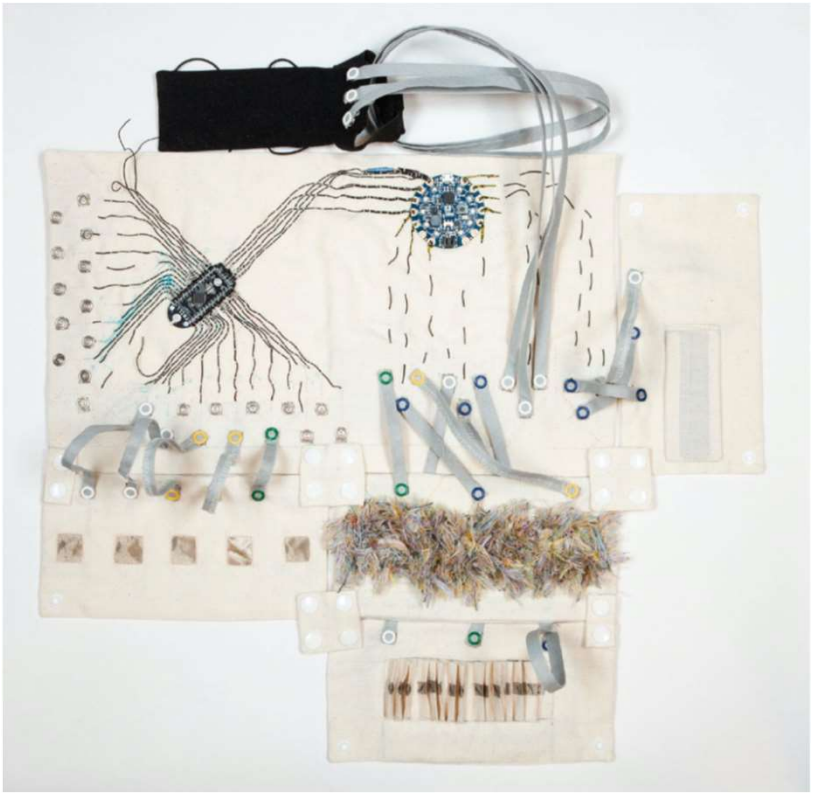




[Else-Line Malene Ruud - Lifetime learning in evolutionary robotics]

Thesis: Textile controllers for computer music

- How do users interact with digital textiles in a creative context?
- Prototypes – integrating electronics in textiles
- *Case study* – 2 DJs
  - To get detailed knowledge about the participants' experiences
  - Practical session
- *Semi-structured interviews*
  - Before and after practical session
- Analysis: *thematic analysis* approach
  - Identify themes in the gathered data



Nanette Lindrupsen - Exploring Textile Controllers for Computer Music

Thesis: Augmented reality visualization of muscle activity

- Exploring AR to enhance live musical performance
- Prototype system with muscle armband and AR visualization
- Interactive participatory experience with 20 participants
  - cancelled due to the pandemic
- Online survey – 37 participants
  - Ranking, scoring, free text
  - Analysis: quantitative + some qualitative
  - Statistics w. hypothesis testing

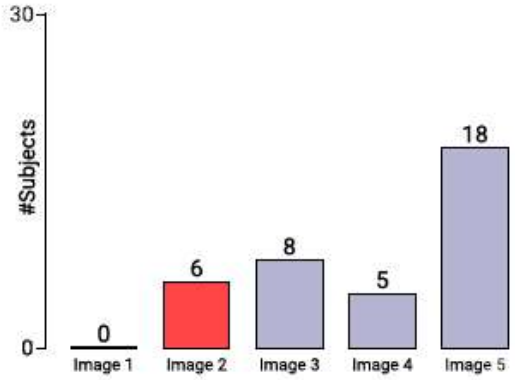


Figure 5.10: Task 4 *(Fingers spread)* distribution of votes. The red bar indicated the correct image.

[Nikolai René Berg - Real-Time Visualization of Muscle Activity using Augmented Reality and Motion Capture]

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Questions