Robot Systems Design

The Maersk Mc-Kinney Moller Institute

Course description

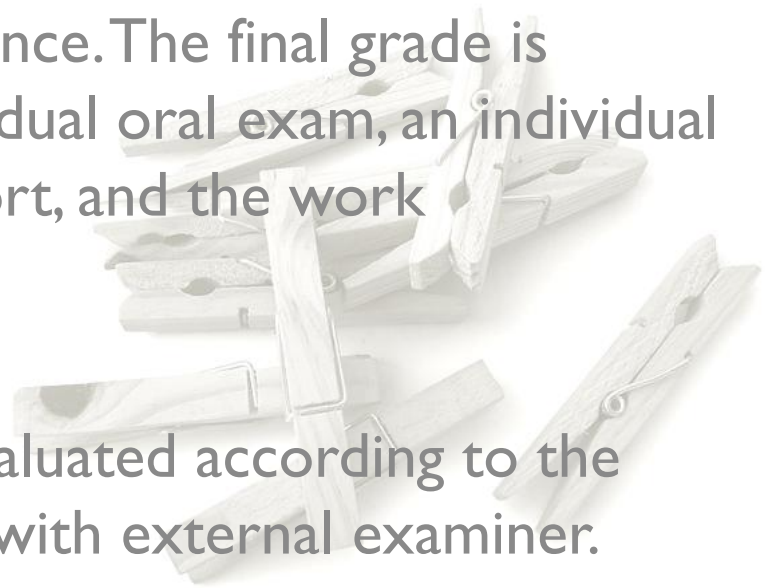
- Objectives and Assessment Criteria:
  - After completing this course, the student is able to:
    - analyze problem and domain to determine best practice, if any.
    - specify and break-down project into prioritized tasks, in a project plan.
    - survey scientific literature, patents and standards related to a concrete problem in robotics and apply the results of the survey in a concrete solution.
    - relate their own solution to available scientific, technical and commercial results in the area.
    - relate their project to the feasibility of implementing the solution in a real-life scenario.
    - show an overall understanding of the technological and architectural challenges by designing, implementing and integrating part of a robotic system with multiple components.
    - show an in-depth understanding of a specific research topic corresponding to the functionality of a subsystem.
- Main Topics:
  - The overall goal of RSD is that all of the participants collaborate on a single project composed of many different subsystems that can be worked on independently and yet must function as a single, complete system at the end of the course. The project should relate to an active research project or be based on internationally published research results, and should lead towards a result of publishable quality.

Course description – cont'd

- Type of course:
  - The course is managed by a teacher with a number of assistants. The teacher defines the project and acts as manager of the project, whereas the assistants are selected to cover the technical expertise required in the project and serve as advisors for each group of students. The technical platform for the project is normally defined before the course starts. The technical platform, the problem domain, and various perspectives on the development of robotic systems are presented in lecture form.
  - Students are divided into groups that are assigned subsystems of the overall project. During the course, students are required to survey scientific papers related to the functionality of the subsystem they have been assigned, study selected papers and present them to each other, and document the relation between the selected papers and subsystem they have been assigned to work on.
  - Students can optionally serve a role as coordinators or architects that mediate the interaction between different groups and the corresponding subsystems.

Course description – cont'd

- Examination requirements:
  - The teacher assistants monitor the work performed by each group and assign an individual grade to each student based on their work performance. The final grade is determined based on an individual oral exam, an individual contribution to a written report, and the work performance.
- Evaluation:
  - Individual oral examination, evaluated according to the Danish 7-point marking scale, with external examiner.



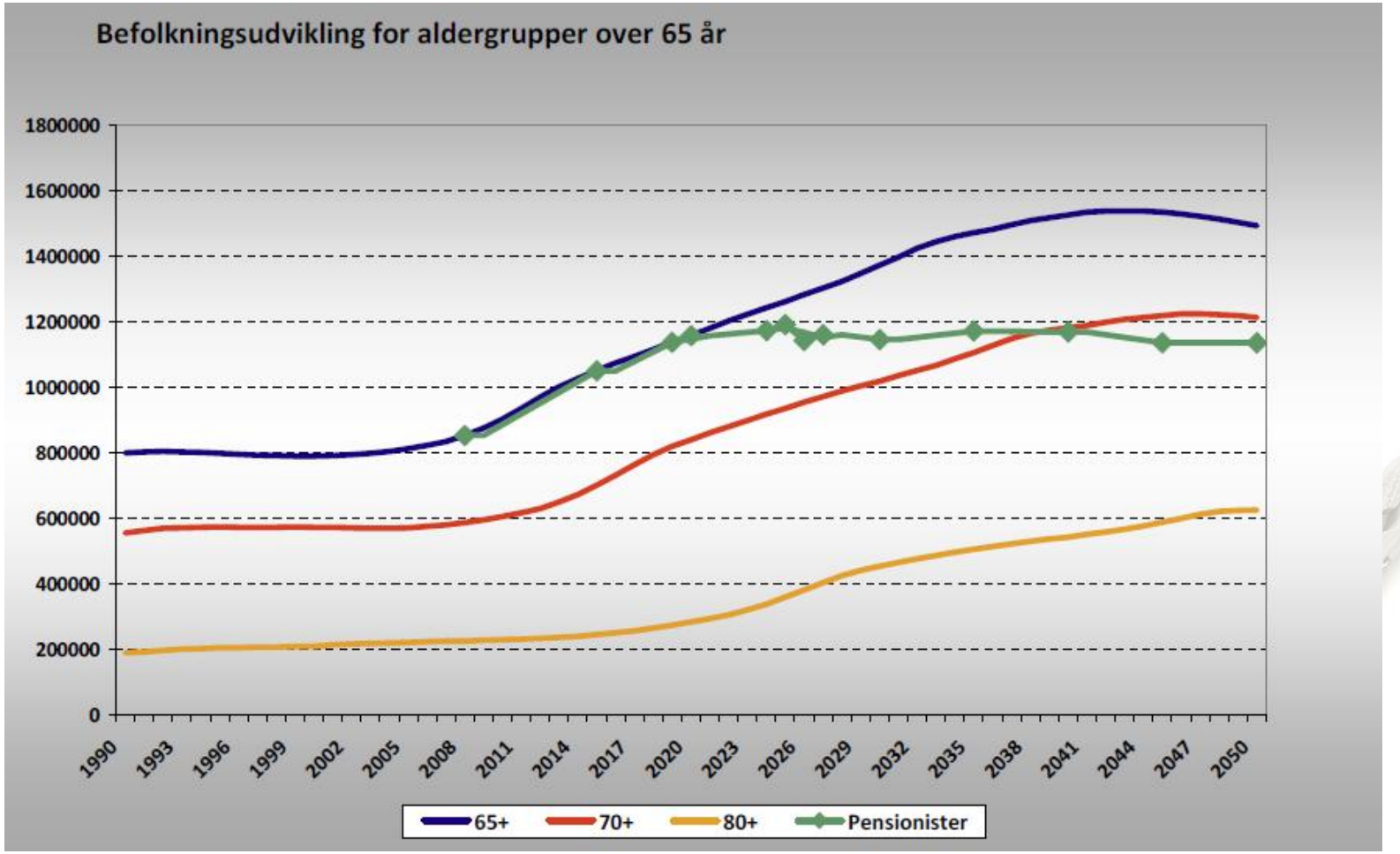
Course outline

- One common project
  - Robotic solution for handling laundry in nursing homes
- Group work
  - Groups of 3-4 students work on sub tasks contributing to the common project
  - Each group appoint one chair to participate in common meeting negotiating interfaces
- Supporting lectures
  - Lectures will provide general knowledge and inspiration for the course
- Supervision
  - The process and the relation to the common project will be supervised by Pedro, Bjørn & Kasper
  - Technology and research matters of each sub project will be supervised by the research groups at MMMI

Background – the challenge

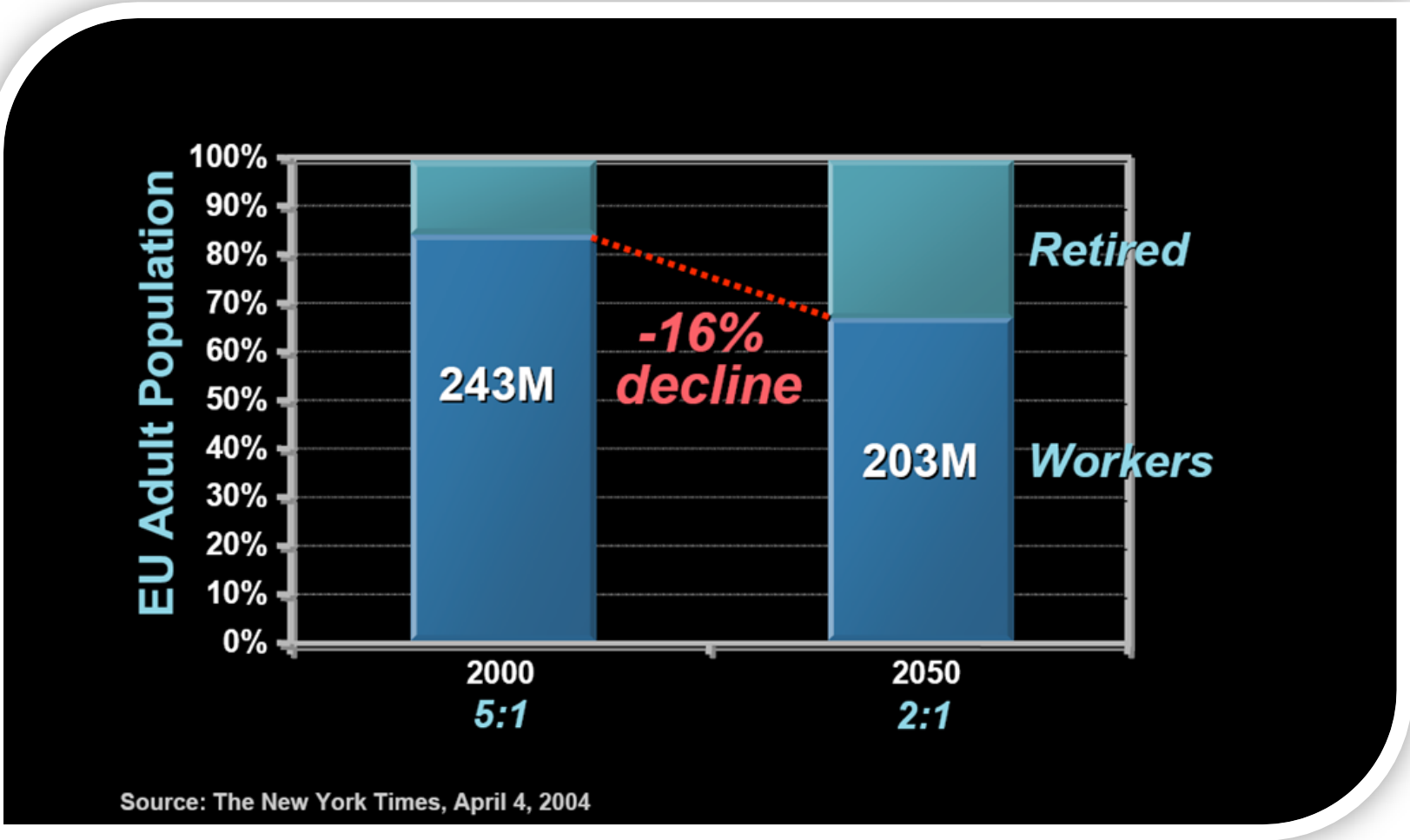
- More elders
  - The demographics development is a huge challenge for the public sector – if the level of services should be maintained
    - The share of elders in the population will double over the next 40 years
    - The work force will decrease by 350,000 people
    - It is hard to recruit new staff for the care sector
  - World wide the average lifetime increase
    - From 48 years in 1955 to 73 years in 2025
  - The fertility coefficient is decreasing
    - From 5 in 1955 to predicted 2.3 in 2025
    - Major difference was in 1995 Italy with 1.2 against Yemen with 7.6
- Chronic diseases
  - Information, supervision/coaching and self-care can be strongly preventive
  - Huge potential
    - 75% of expenses in the health-care sector (71.5 billion DKr) can be related to treatment of chronic and lifestyle diseases
    - 1.5 million Danes have a chronic disease
  - Telemedicine is predicted to half the number of hospitalizations

The demographic development

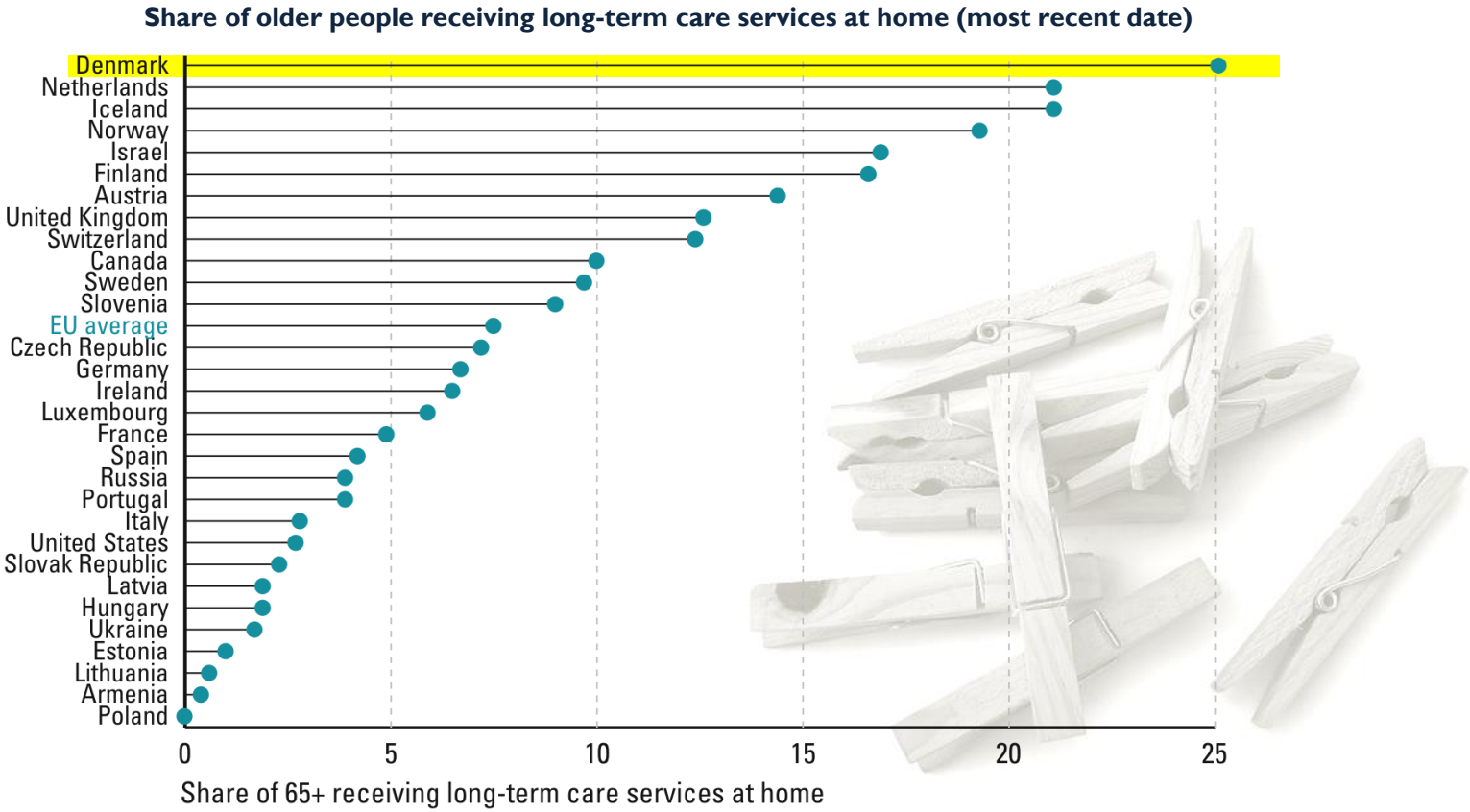


Source: DaneAge Association

Workers vs. Retired



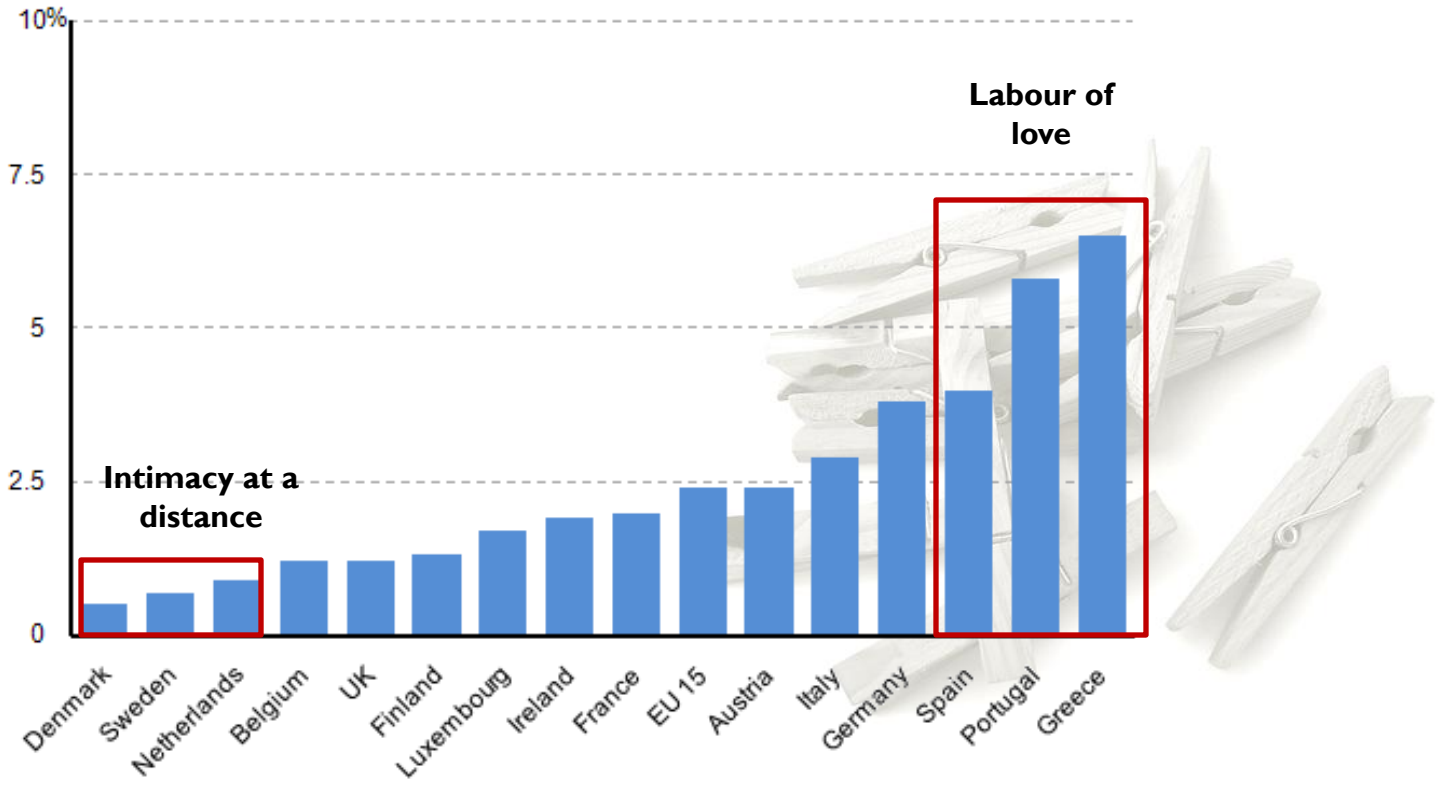
Home care – DK vs. EU



Source: Huber et al. (2009 forthcoming) Own calculations based on OECD, NOSOSCO , WHO, Eurostat and national sources.

In DK the challenge is even harder!

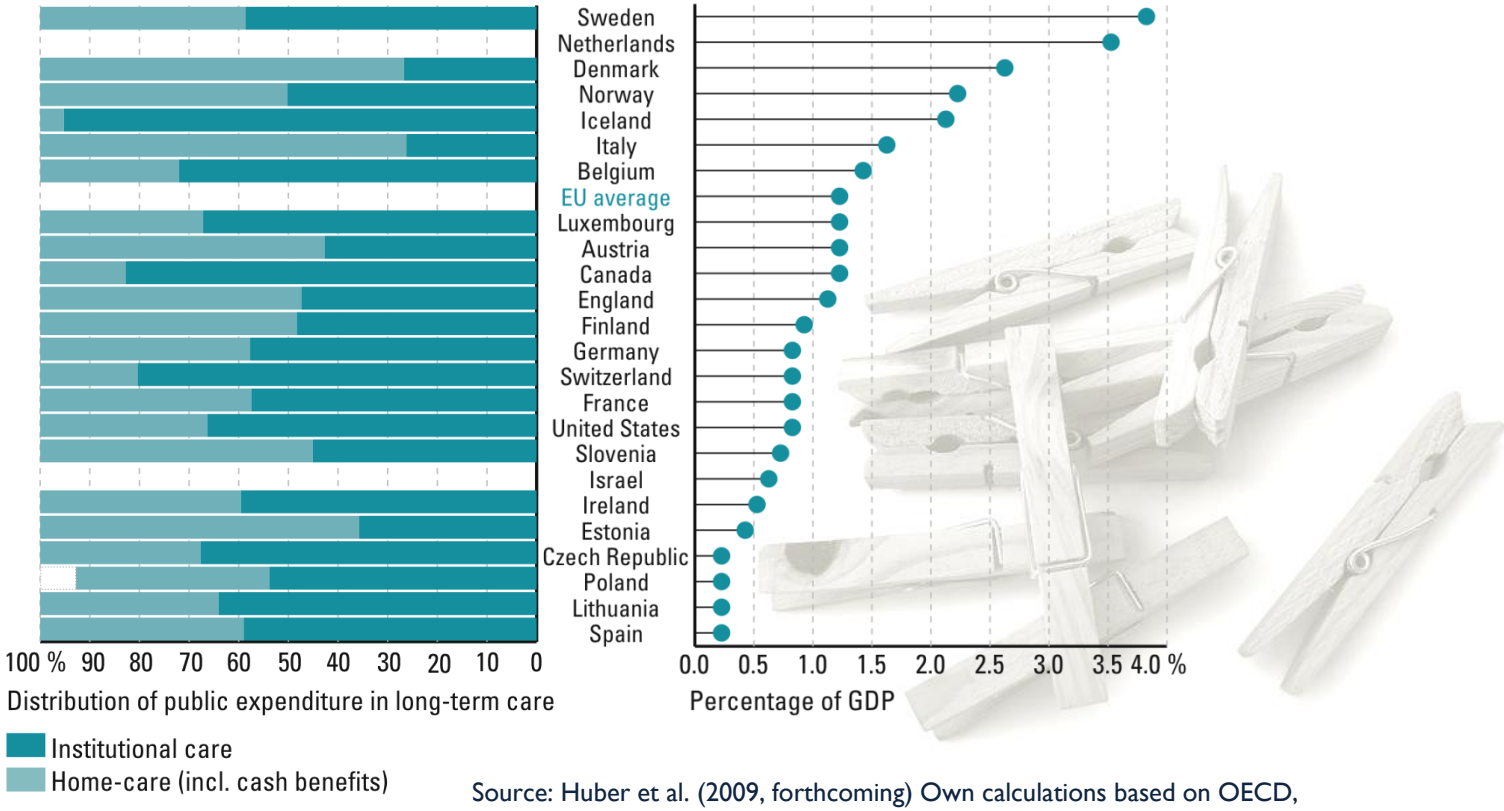
Percentage of the population aged 15+ providing informal care to a co-resident relative aged 60+ (1999)



Source: Huber et al. (2009, forthcoming) Own calculations based on Walker (1999).

Economy

Public expenditure on long-term care and its distribution between home and institutional care (most recent date)



Source: Huber et al. (2009, forthcoming) Own calculations based on OECD, NOSOSCO , Eurostat and national sources.

Problem: We will help your moms! But how?

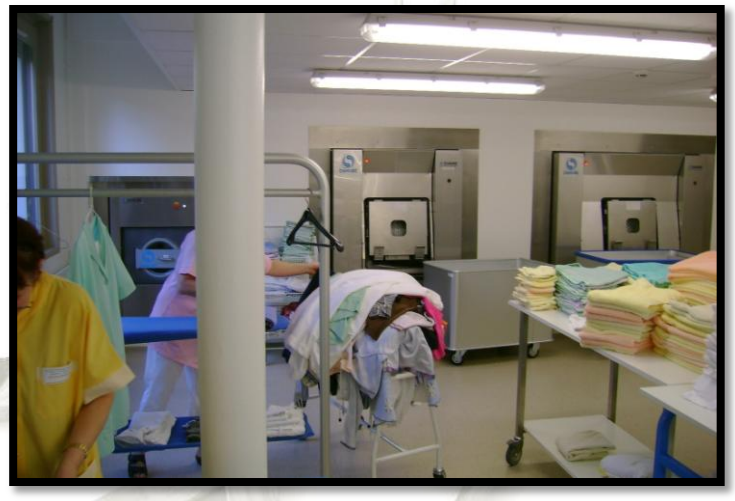
- You will be laundry experts

Problem intro: Moving into a nursing home

- Most elders will have their clothes and linned washed in a central laundry room
  - It an optional service, typically costing 50-200 Dkr per month
  - Rent and wash of lined is also an optional service, ~ 30-100 Dkr extra per month
  - Otherwise relatives or other should take care of the task
- The clothes must be tagged
  - Usually by a number on small labels that are sewed into the clothes if possible
- Conditions
  - Almost all nursing homes will only handle clothes that can be machine washed
    - Silk and wool must be handled by others
  - Some places all clothes will be washed at 60 degrees
  - You can only expect 1-2 machine loads to be washed every 14 days
    - So you need underwear for 14 days
- What's covered by the laundry service (typically)
  - Your laundry will be sorted
  - Brought the laundry room
  - Washed in a washing machine
  - Dried in a tumbler or hanged
  - Folded
  - Brought back and put in your closet

Problem statement

- In Danish nursing homes, the laundry is most often handle at a central place (a laundry room), which raises challenges in
  - Logistics
    - Get the laundry back and forth between the apartment and the laundry room
    - Collecting and pickup the laundry in each apartment
    - Bring it back and put in closets
  - Sorting and separating
    - Different recipes for different kind of clothes, e.g. sort by color
    - Everybody have their own clothes, so it must be sorted after wash
  - Tagging
    - To identify owner, cloth must be tagged. Traditional techniques include
      - Sewing in small labels
      - Ironing labels into the cloth – work for some type of cloth, but not all

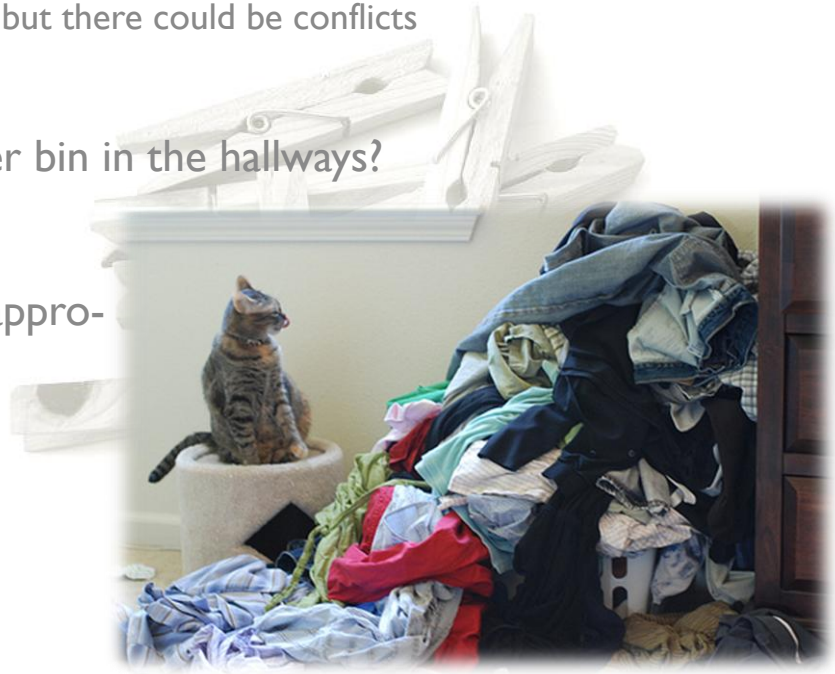


Common project: Robotic laundry

- Each group will work on a sub task of the laundry process
- The common solution should be able to
  - Pickup laundry in or at the apartments
  - Bring it to a central place – the environment should match a typical nursing home
  - Sort it based on based on washing recipes (and tags)
  - After washing it should be sorted again based on tags
  - It should be brought back to the right apartments
- Groups should have 3-4 members
  - One team member of each group must be responsible of discussing interfaces with other groups

Subtask 1: Picking-up laundry

- Task description
  - The dirty laundry in apartment of each elder, must be transported to the laundry room.
  - Should the laundry be picked up in each room?
    - From a laundry basket
      - Time might not be an important issue – but there could be conflicts
    - When staff/elder want the robot to be there
      - Time/scheduling will be very important
  - Should the laundry be picked up from larger bin in the hallways?
    - Staff have to carry it to the bin in the hallways
- Challenges
  - Consult with nursing homes for the most appropriate solution to the problem
  - Some robotic construction must take it "on board" the robot
- Technologies available
  - ??
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)



Subtask 2: Bring to laundry room

- Task description
  - When the robot has collected the dirty laundry – it should be moved to the laundry room
  - The robot must use existing hallways, door, elevator to get to the laundry room
    - Usually located in the basement – or in larger nursing homes in another building
- Challenges
  - The robot should move around in the environment of a nursing home
    - It may have some a priori knowledge of the environment, but
      - there will be furniture and other static obstacles
      - there will be elder and staff moving around not to interfere with
  - Close collaboration with subtask 3
- Technologies available
  - ??
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

Subtask 3: Positioning of laundry robot

- Task description
  - To assist robot movements in the nursing home positioning of the robot is required.
  - Should be handled as a separate task but assisting subtask 2
- Challenges
  - Determine appropriate positioning technology
    - Vision, radio-based (triangulation), etc.
    - Precision level locally and globally – sensor fusion ?
  - Should other moving objects be tagged and located?
  - Close collaboration with subtask 2
- Technologies available
  - ??
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

Subtask 4: Drop-off and sorting robot

- Task description
  - When robot arrives at laundry room it should unload the dirty clothes.
  - Either it should be able to tilt the container, or a robot arm either on the robot or in the laundry room should take it of the robot.
  - The clothes should be pre-sorted according to washing recipes – that will require a robot arm
- Challenges
  - The robot should arrive at the right place in the laundry room
  - Dirty laundry should be sorted by a robot arm based on criteria set and controlled by group of sub task 5
    - Either during unloading or from a pile of laundry
  - Close collaboration with subtask 5
- Technologies available
  - ??
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

Subtask 5: Sorting criteria

- Task description
  - Everybody knows that washing black and white together is a bad idea, but there are a lot more criteria to consider, to prepare a wash
    - Appropriate colors for joint was
    - Washing conditions – e.g. temperature, centrifugation, spinning speed, drying
  - The appropriate amount of laundry should be prepared in piles or containers, which correspond to the load size of a washing machine
  - When elders move in their clothes will be tagged (subtask 6), but the washing recipes of each item should also be registered
    - That task should be simple for the staff
- Challenges
  - Together with group of subtask 6 create an easy an appropriate interface for registering clothes and washing recipes
  - Control criteria for the robot arm in subtask 4
  - Close collaboration with subtask 4 and 6
  - Perhaps some "untagged" clothes should be put in washing bags?
- Technologies available
  - ??
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

Subtask 6: Tagging clothes

- Task description
  - When elders move in their clothes will be tagged, so the owner can be identified
    - That task should be simple for the staff
  - Today is used small labels that are sewed or ironed to the clothes
- Challenges
  - Together with group of subtask 5 create an easy an appropriate interface for registering clothes and washing recipes
  - Determine an appropriate tag-technology, and provide "readers" for subtask 7 (and subtask 5/6)
  - Close collaboration with subtask 5 and 7
- Technologies available
  - RFID tags seems to be the most appropriate technology
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

Subtask 7: Post-sorting

- Task description
  - All elders need their own clothes and lined back
    - Ownership is determine by tags of subtask 6
  - So after washing and drying the clothes should be post-sorting to containers of each elder, that the laundry robot should bring back to the apartment of the elders
- Challenges
  - Sort the clothes based on the tags
    - Eventually assisted by assumptions and pre-knowledge of the just washed clothes and subtask 5
  - Prepare for load in containers to robot and load onto robot
  - Close collaboration with subtask 6
- Technologies available
  - ??
- Supervision support
  - ??
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

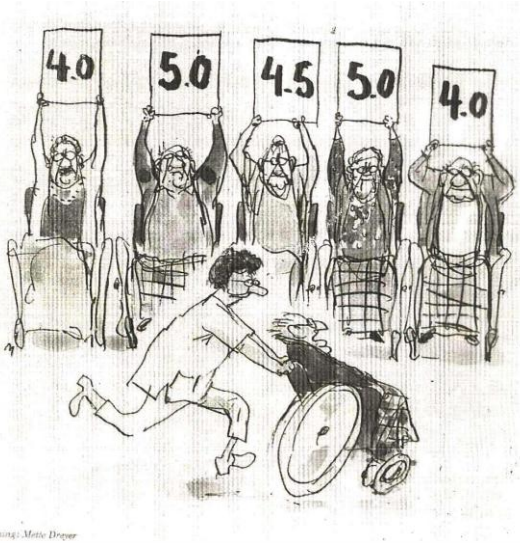
Subtask 8: Simulator

- Task description
  - In order to optimized elements of the robotic laundry handling process it would be a strong tool to have a simulated tasks where advanced tasks can be tested before put into hardware.
- Challenges
  - Build a simulator in software that covers all aspects of the robotic handling process
- Technologies available
  - Agent-based software technologies
  - AI??
- Supervision support
  - ??
  - Software-team (Kasper, Bjørn, Pedro, and Shabbir)
  - RSD general supervisors (Kasper, Bjørn, and Pedro)

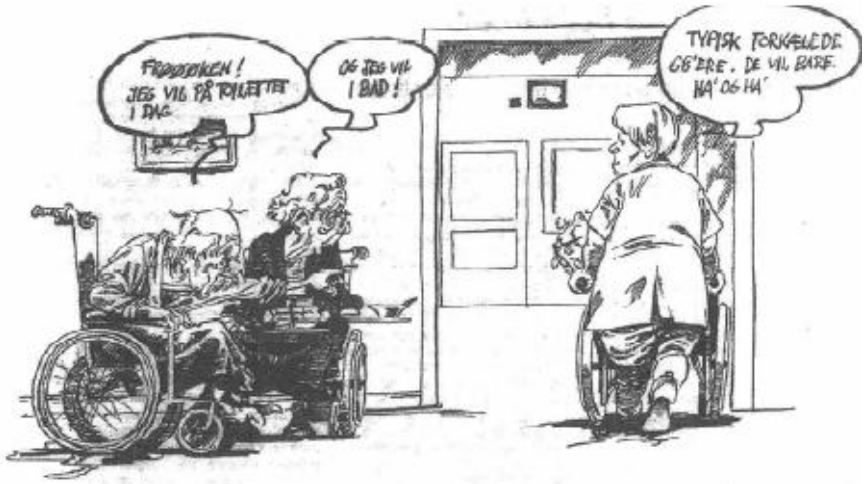
Subtask 9 (optional): Hang/dry the clothes

- Perhaps this is too complicated??

Perhaps a robotic solution could do it better?



Forholdene på plejehjemmene er igen kommet i søgelyset.



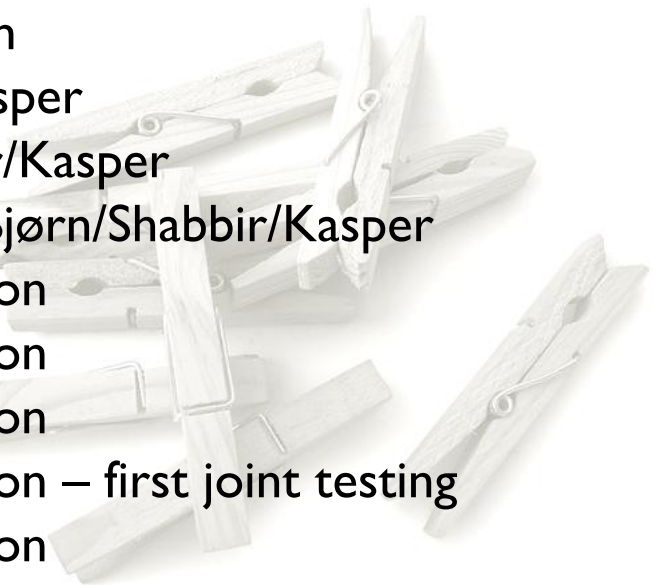
Det forventes, at 68-generationen vil kræve ind i hidtil uhørt omfang, når de bliver pensionister.

Course outline

- Hours scheduled every Wednesday 8:15 - 12:00 throughout the semester
  - All lectures and joint meeting will be places in these slots
- Extra supervision will be arranged on more individual basis
  - But all should participate in joint work each Wednesday
- The subtasks of the previous slides frame the project
- During first weeks of innovation process and agreements we will define and negotiate extent of each subtask.

Draft: General lectures and schedule

- 3/2: Introduction to RDS
- 10/2: Innovation process and framing subtasks
- 17/2: Vision control by Norbert Kruger
- 24/2: Robot motion control by Henrik Gordon
- 3/3: Interfacing robots by Anders Sørensen
- 10/3: Positioning technologies by Pedro/Kasper
- 17/3: Tagging technologies by Bjørn/Shabbir/Kasper
- 7/4: Agent-based software simulation by Bjørn/Shabbir/Kasper
- 14/4: Hands-on project work and supervision
- 21/4: Hands-on project work and supervision
- 28/4: Hands-on project work and supervision
- 5/5: Hands-on project work and supervision – first joint testing
- 12/5: Hands-on project work and supervision
- 19/5: Report aspects and hands-on project work
- 26/5: Finalizing the project and final testing




Any questions?