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Jim Tørresen (PIRC project manager)

Predictive and Intuitive Robot Companion (PIRC)

IKTPLUSS project 2020-2025

The Research Council of Norway

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Predictive and Intuitive Robot Companion (PIRC)

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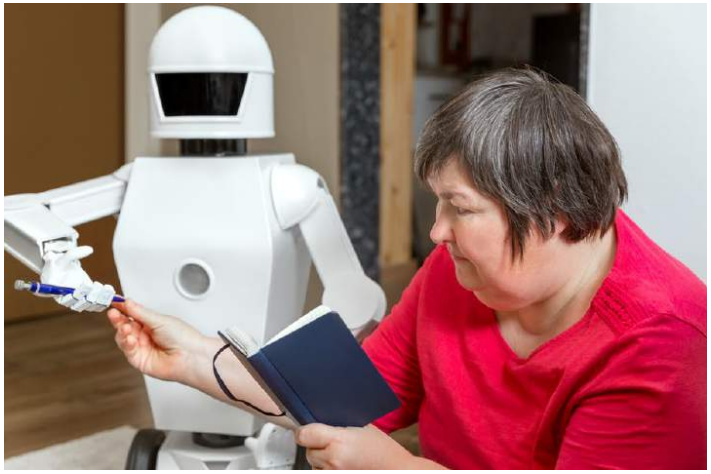
The Research Council of Norway

International Collaboration

COINMAC grant 261645

Funding: *INTPART 2017-2024*

Robots Getting Closer to Human



Time

Human – Robot Interaction
Slow Versus Safe Robot

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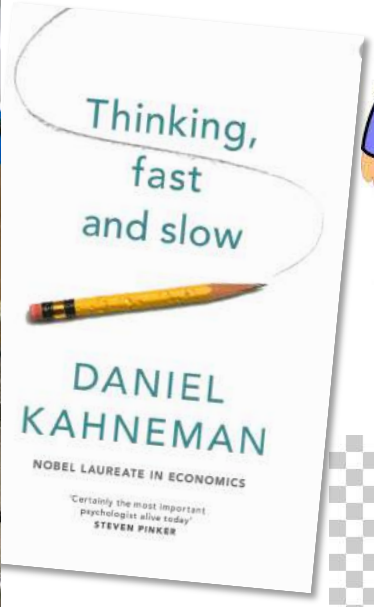
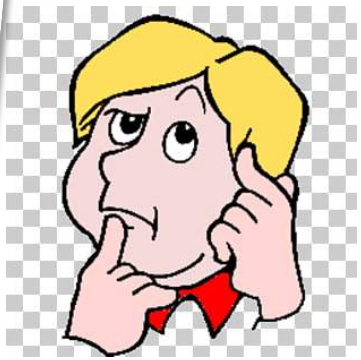
Predictive and Intuitive Robot Companion (PIRC)





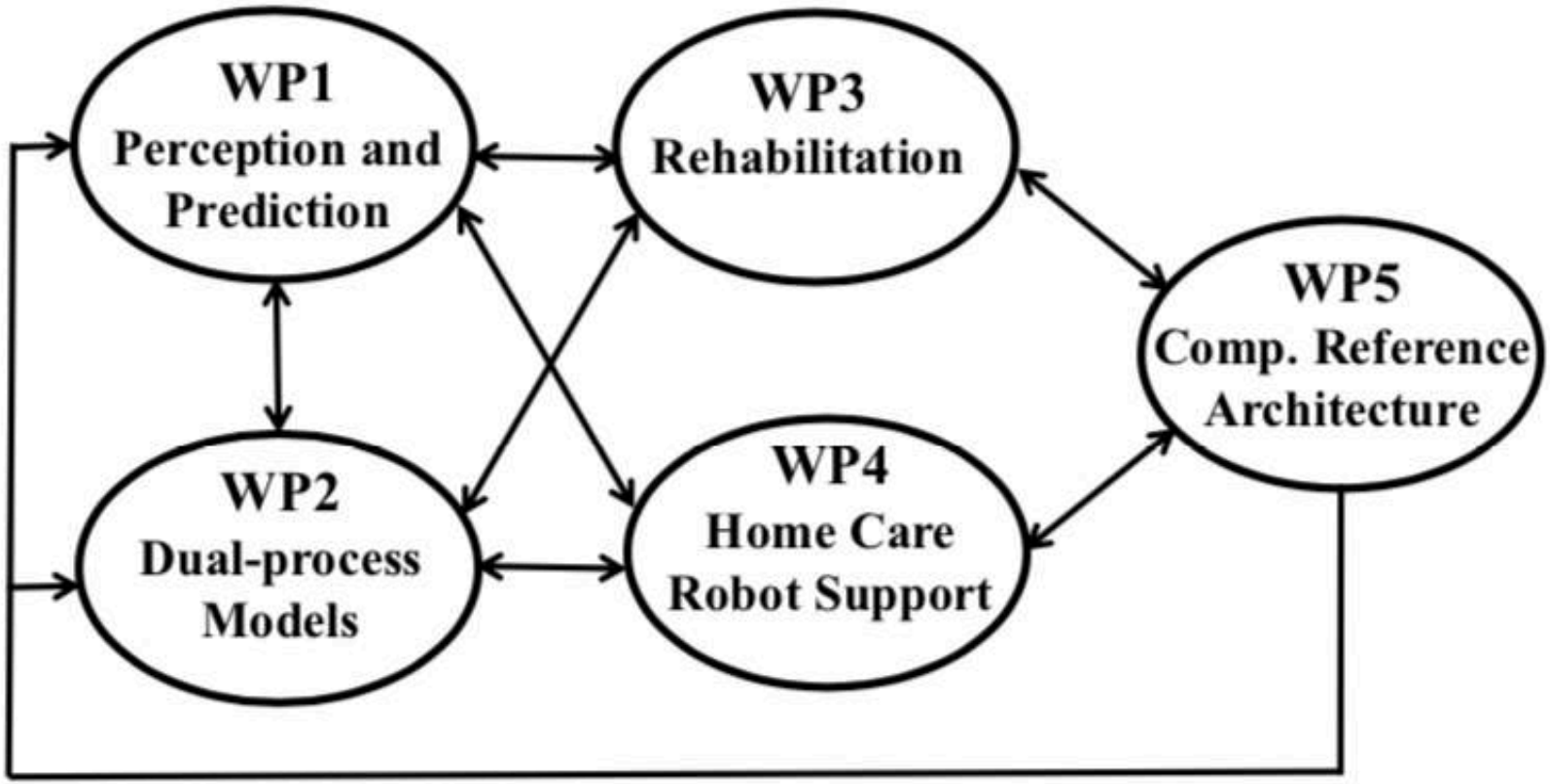
Jim Tørresen @ ROBIN 11 Feb 2021

Main objective

- *Design, implement and evaluate **robots that can learn to predict** and act **using knowledge about human prediction and decision-making mechanisms** and demonstrate how this can be useful in applications with robots for **rehabilitation** and **home care**.*

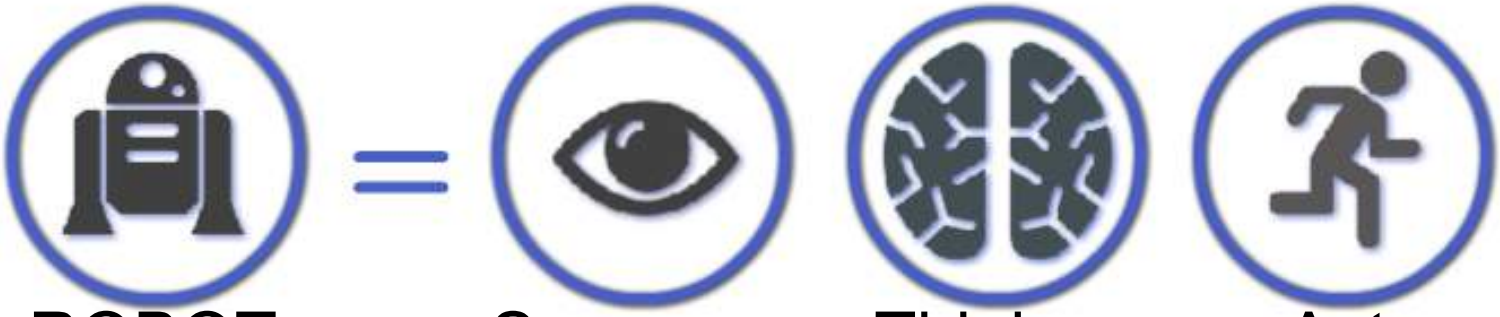
***Research questions**:*

- *RQ1: How can knowledge about **prediction skills** be **integrated into robots** and used to improve how they interact with human users?*
- *RQ2: In what ways will a robot benefit **in interaction with humans by having an adaptive response time** (from quick and instinctive to slower well-reasoned).*
- *RQ3: **Do humans benefit** from a robot that contains adaptive prediction capabilities and adaptivity in its response time?*


WP1
Perception and
Prediction
WP3
Rehabilitation
WP5
Comp. Reference
Architecture
WP2
Dual-process
Models
WP4
Home Care
Robot Support

What is a Robot?

(WP3-4)

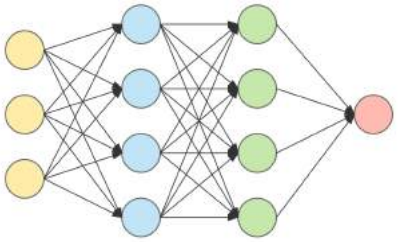


ROBOT = Sense (WP1) Think (WP5) Act (WP2)

Sense (WP1) → Sensors

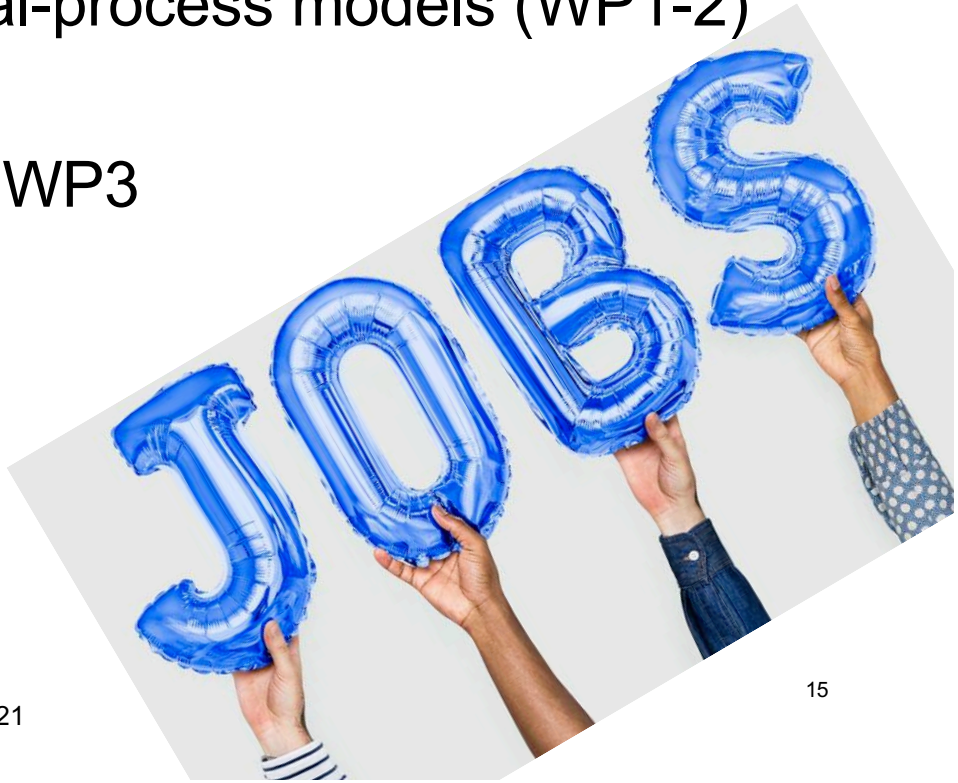
Think (WP5) → Artificial Intelligence

Act (WP2) → Motors + Mechanics

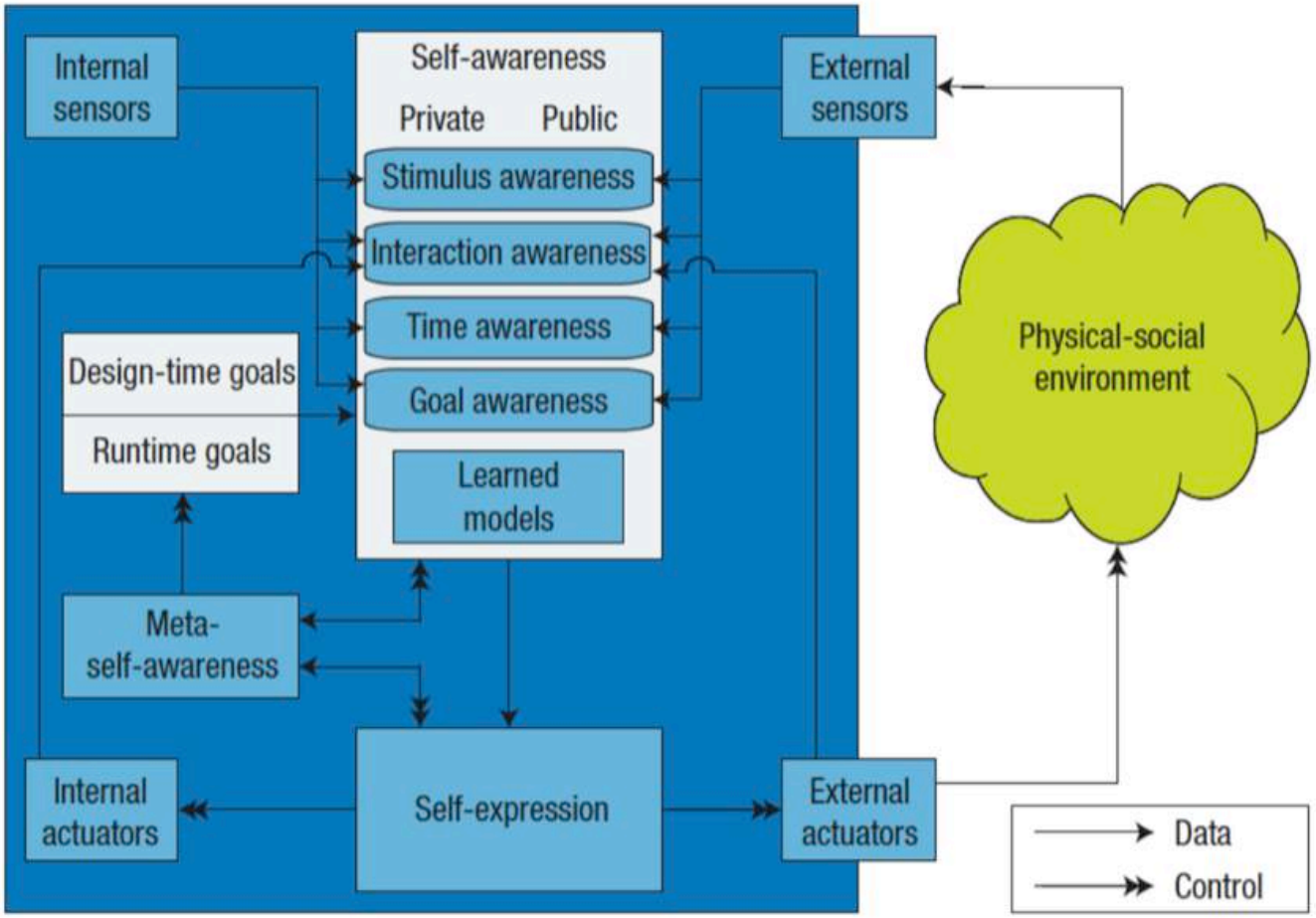


Three researchers (PhDs and "postdocs" starting 2021/2022) to be hired for the project will cover mainly:

- Perception and prediction, and dual-process models (WP1-2)
- Robot for physical rehabilitation in WP3
- Home care robot support in WP4



Reference Architectural Framework



Physical Rehabilitation at Home (WP)

- Proactively improve recommendations and adapt rehabilitation instructions
- Two types of **non-verbal communication** of intentions or mood:

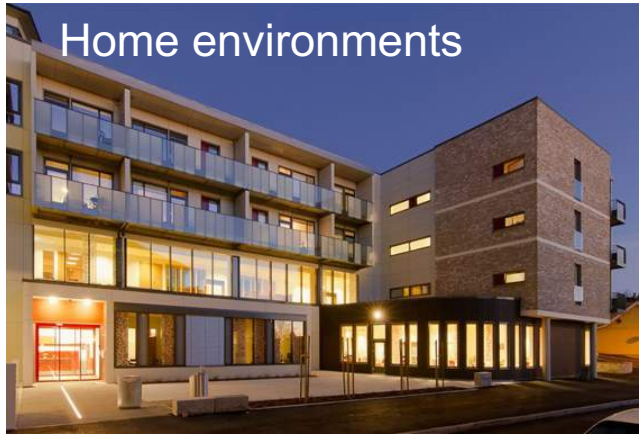
1) **Behaviours or gestures –** communication through motion and actions.

2) **Sound or music** – coming from a robot in a user-adapted form.

- User studies in how different robot behaviour impacts each user with regards to attention, mood etc would be important.

Home Care Robot Support

- Study how some **pre-trained configurations** (WP1-2) can be **combined with intuitive actions** in a new and unseen home.
- Focused on two different tasks: **preparing food in the kitchen** and **interacting with a human** with regards to bringing food etc and returning remains.

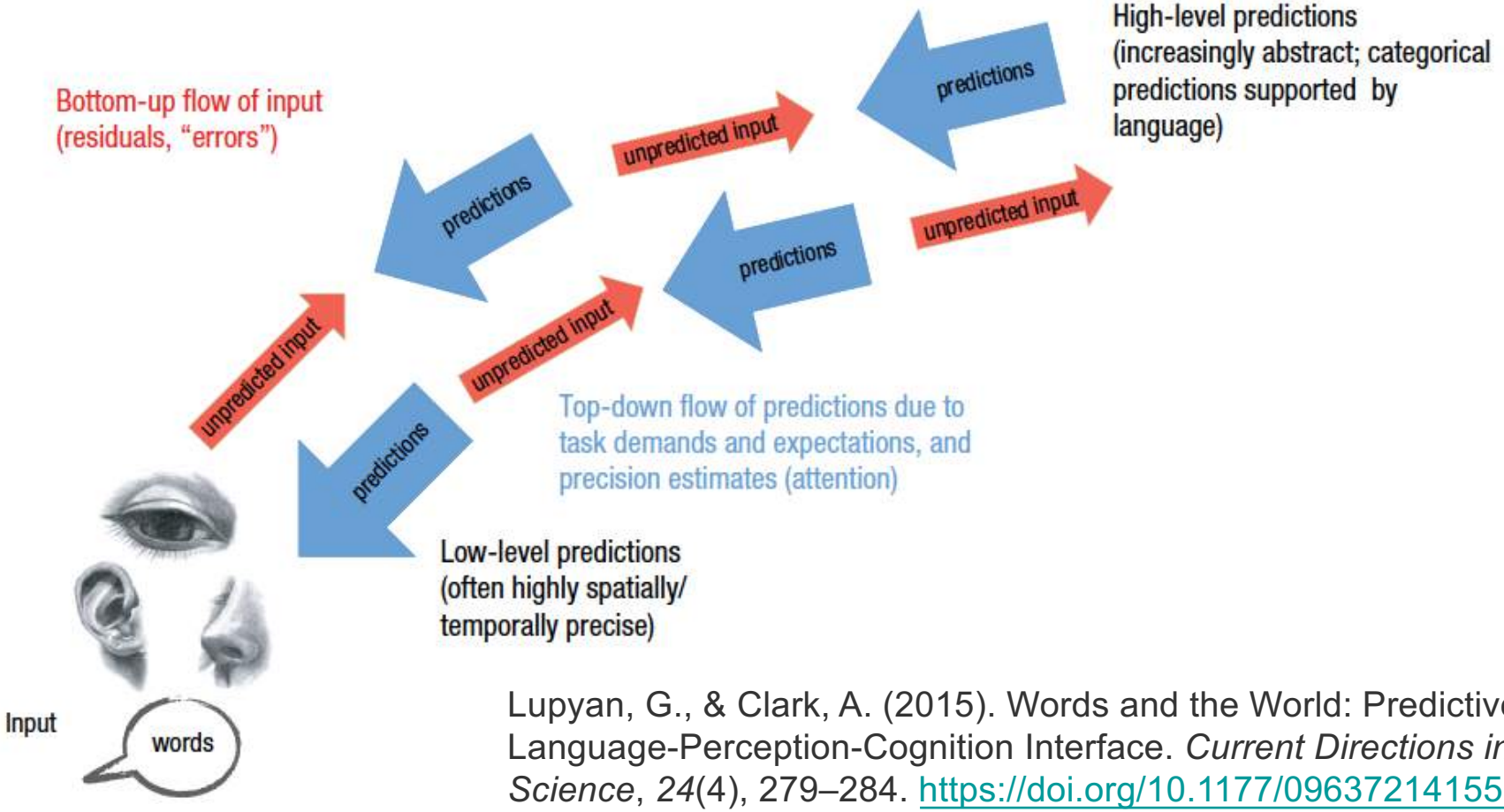


Relevant Robot Companions

Lio - Personal Care Robot (Switzerland)

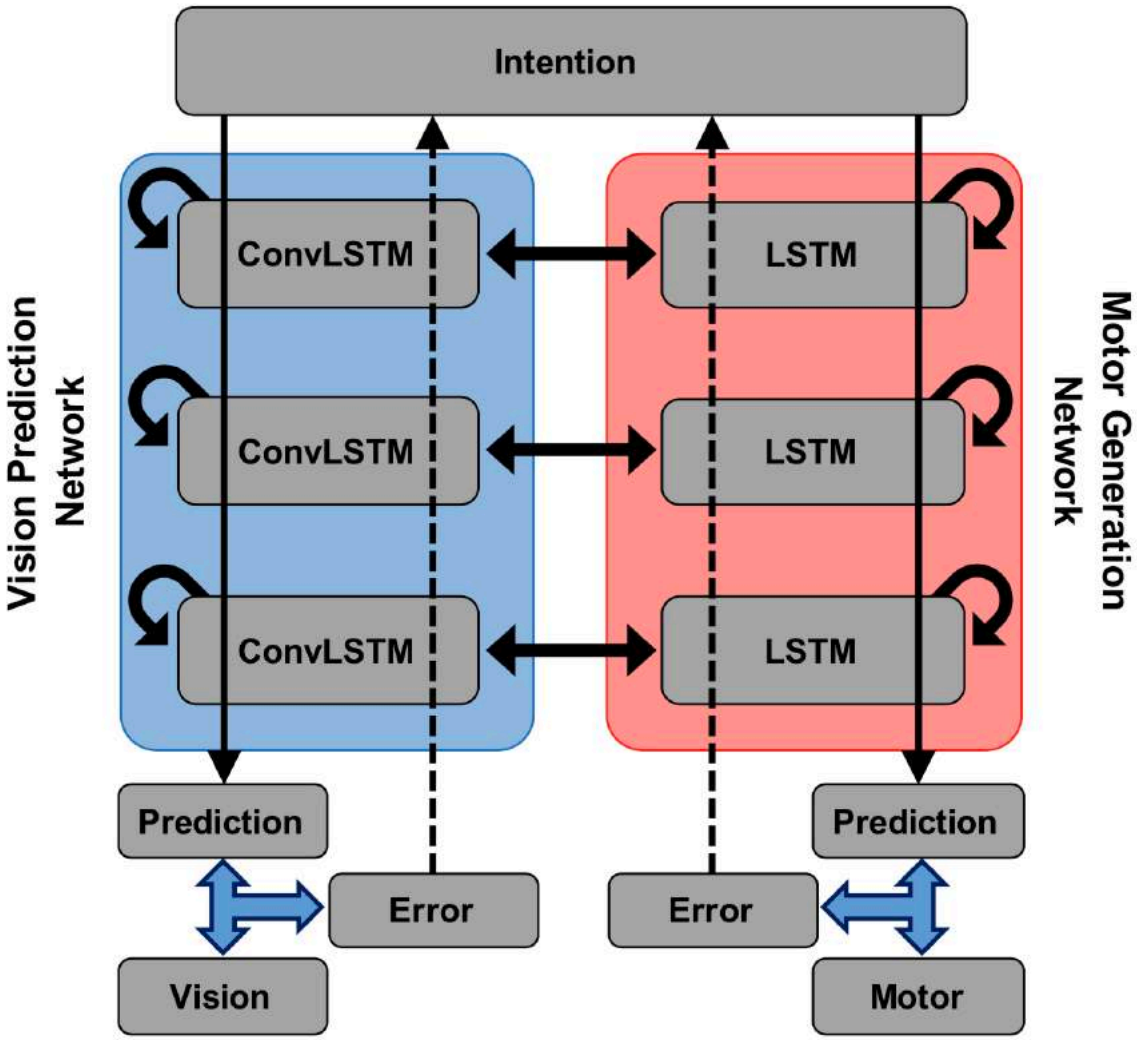
Halodi Eve – Humanoid Robot (Moss, Norway)

Prediction Through Error Correction



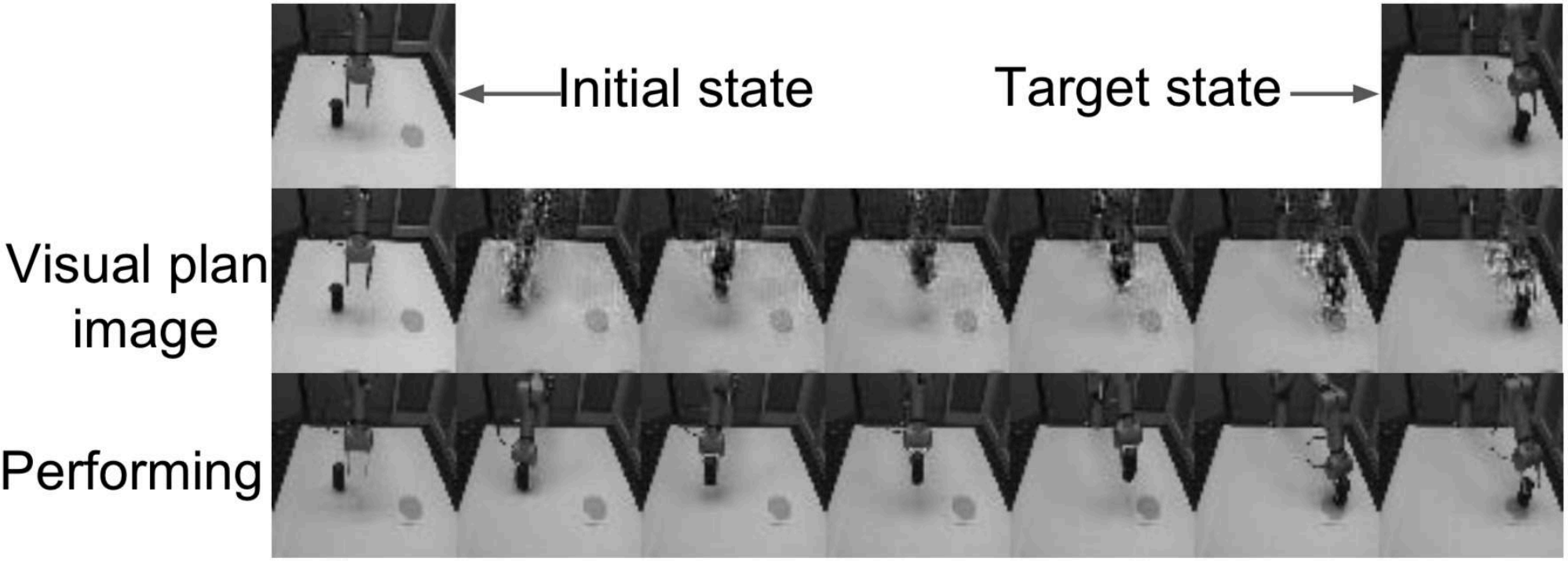
Lupyan, G., & Clark, A. (2015). Words and the World: Predictive Coding and the Language-Perception-Cognition Interface. *Current Directions in Psychological Science*, *24*(4), 279–284. https://doi.org/10.1177/0963721415570732

Predictive coding type deep recurrent neural network model



Choi, M et al, Predictive Coding for Dynamic Visual Processing: Development of Functional Hierarchy in a Multiple Spatiotemporal Scales RNN Model, arXiv:1803.02578, 2018 - arxiv.org

Predictive coding type deep recurrent neural network model



Choi, M et al, Predictive Coding for Dynamic Visual Processing: Development of Functional Hierarchy in a Multiple Spatiotemporal Scales RNN Model, arXiv:1803.02578, 2018 - arxiv.org

System 1: Fast, automatic, frequent, emotional, stereotypic, unconscious.

- Examples (in order of complexity) of things system 1 can do:
  - determine that an object is at a greater distance than another
  - localize the source of a specific sound
  - display disgust when seeing a gruesome image
  - solve 2+2=?
  - read text on a billboard
  - drive a car on an empty road
  - come up with a good chess move (if you're a chess master)
  - understand simple sentences
  - connect the description 'quiet and structured person with an eye for details' to a specific job

System 2: Slow, effortful, infrequent, logical, calculating, conscious

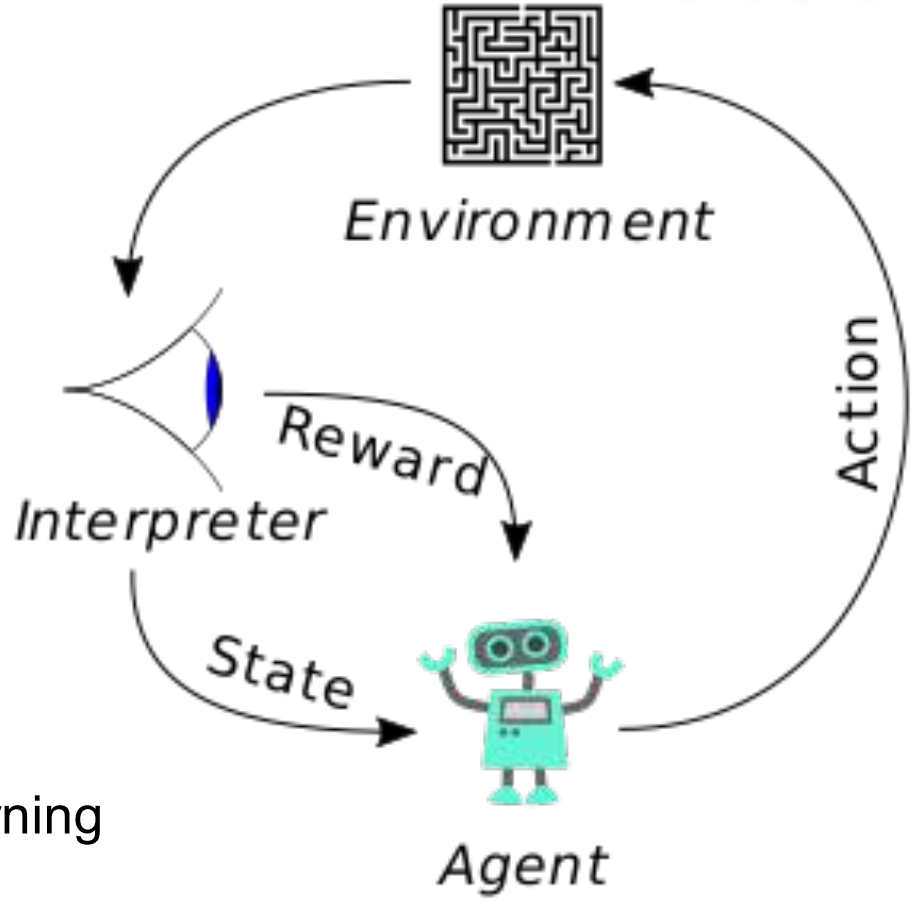
- Examples of things system 2 can do:
  - brace yourself before the start of a sprint
  - direct your attention towards someone at a loud party
  - dig into your memory to recognize a sound
  - sustain a higher than normal walking rate
  - determine the appropriateness of a particular behavior in a social setting
  - count the number of A's in a certain text
  - give someone your phone number
  - park into a tight parking space
  - solve 17 × 24

cs

Where to find:
1. custard cream (dessert or baking goods)
2. pineaple chunks (vegetables, with corn/tacos or dessert

Reinforcement learning (RL)

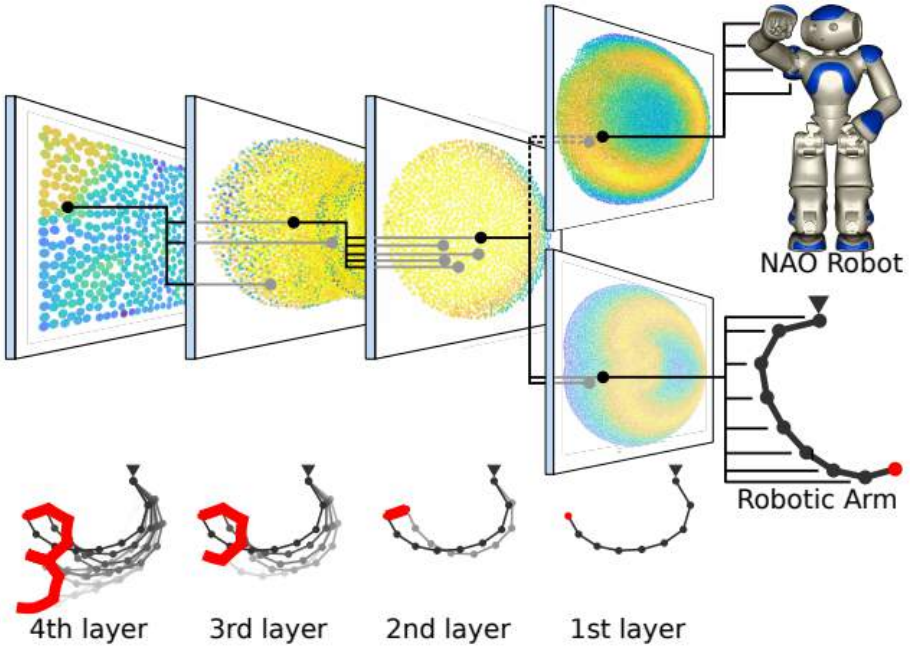
A Reinforcement Learning (RL) scenario: an **agent** takes **actions** in an environment, which is interpreted into a **reward** and a representation of the **state**, which are fed back into the agent.



RL is one of three basic machine learning paradigms, alongside supervised learning and unsupervised learning.

Hierarchical behavioral repertoires

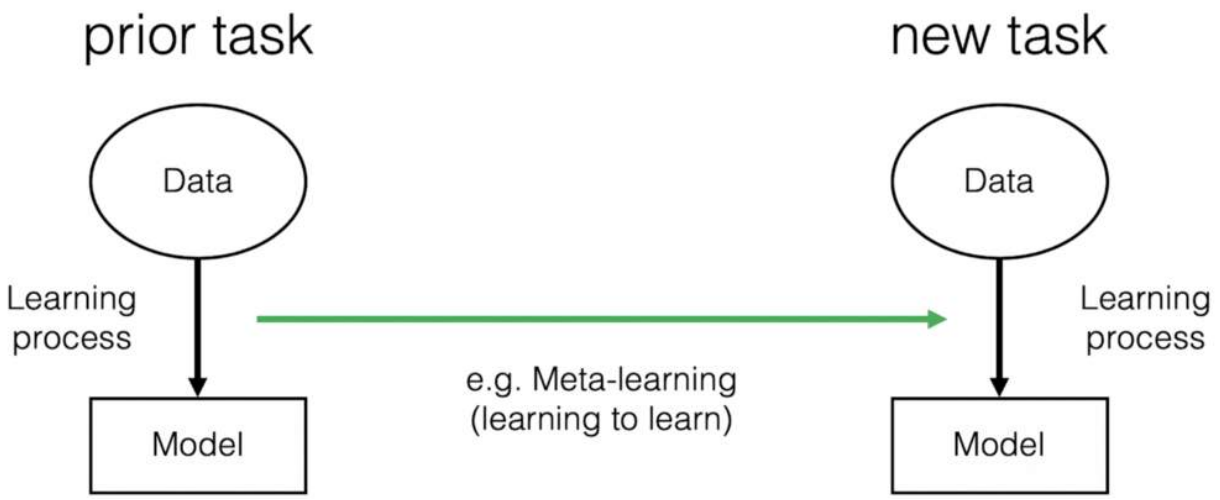
- Reinforcement learning will be relevant for learning a library of standard robot tasks.
- Learned as combinations of more basic behaviours.
- Apply automatic methods for building hierarchies.



A. Cully and Y. Demiris, "Hierarchical behavioral repertoires with unsupervised descriptors," in Proceedings of the Genetic and Evolutionary Computation Conference, Kyoto, Japan, Jul. 2018, pp. 69–76

Catastrophic forgetting

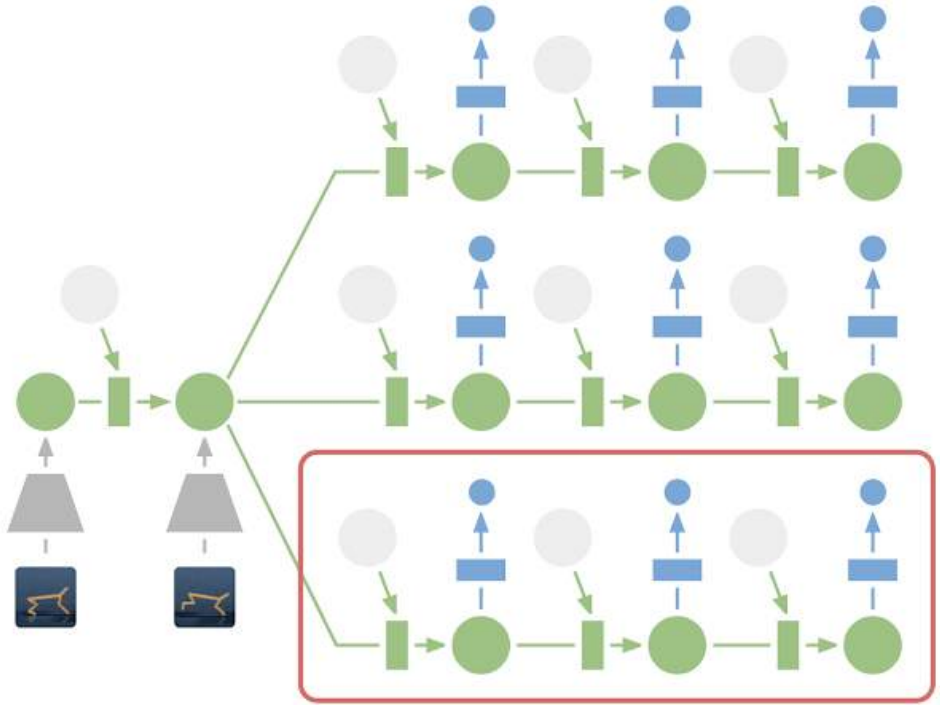
- A challenge in machine learning is learning a new task without reducing the performance of previously mastered tasks.
- When the new task is learned, these important weights might be changed to solve the new problem.
- **Meta-learning**: The network learn a general structure of all tasks it will be exposed to.



https://mc.ai/a-beginners-guide-to-meta-learning-2

Deep Planning Network – PlaNet

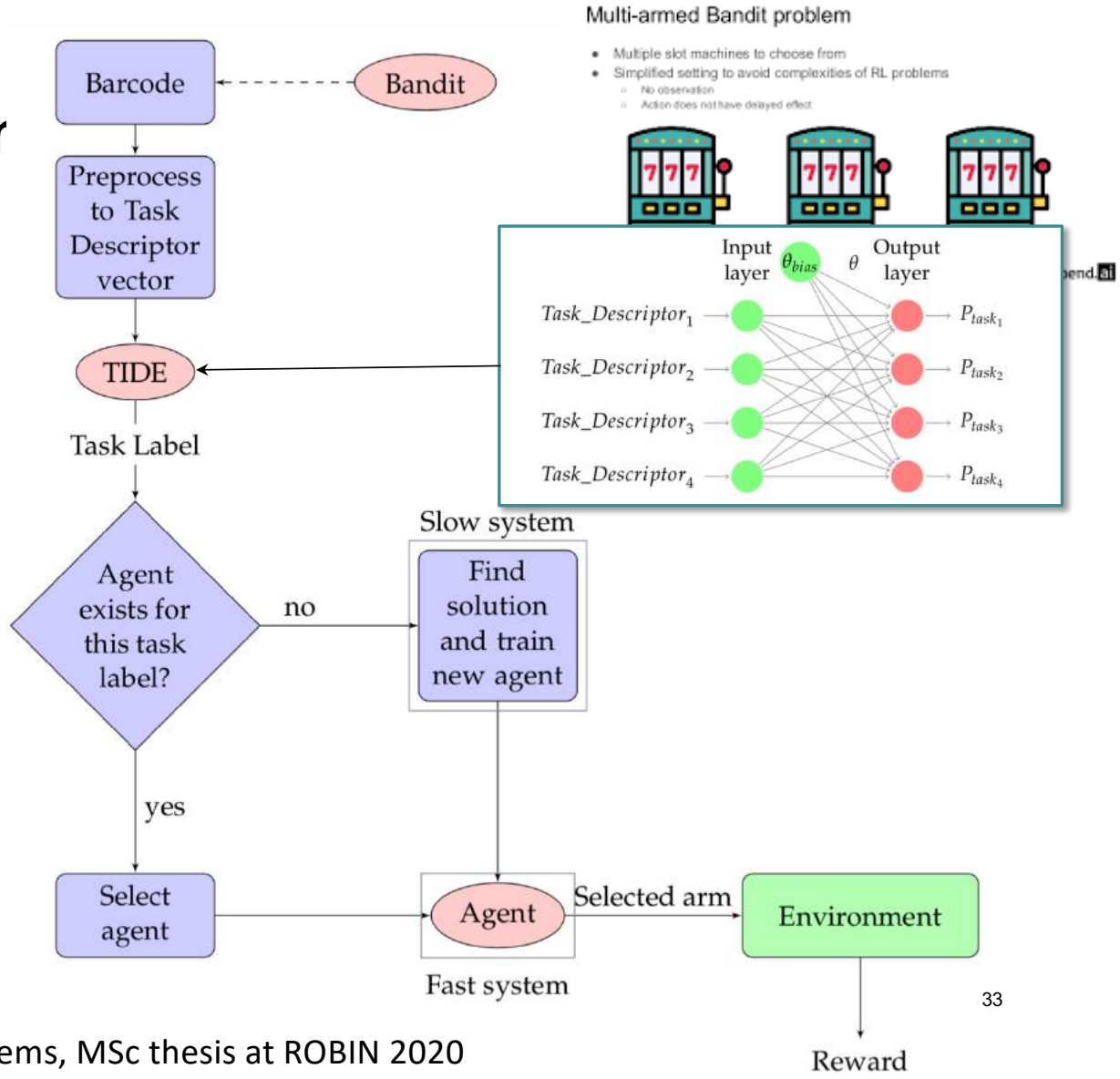
- Mitigating the catastrophic forgetting problem.
- Planning based algorithms, like PlaNet, **learns** stochastic and deterministic **kinematics of the world**, creating a model of the world and use this to plan ahead. This planning allows the algorithm to find better solutions with far less data.
- Knowledge is reused when learning new tasks to achieve high performance more effectively.



Hafner, Danijar, Timothy Lillicrap, Ian Fischer, Ruben Villegas, David Ha, Honglak Lee, and James Davidson. 2019. "Learning Latent Dynamics for Planning from Pixels." In *International Conference on Machine Learning*, 2555–65.

TIDE: Task Identification During Encounters

- Seen a task before?
  - **Yes**: Apply earlier trained behaviour.
  - **No**: find a behaviour to the task, associate it with the task identifier and store it for future use.
- TIDE performs well when the task descriptors have some structure, giving similar tasks similar task descriptors.



Peter Norstein, Thinking fast and slow in intelligent systems, MSc thesis at ROBIN 2020

A ball throwing robot example

Two main robot control parts: One is the **Decision-Making Center** and the other is the **Motion Control Center**.

Training goal: shoot the ball into the basket from any angle

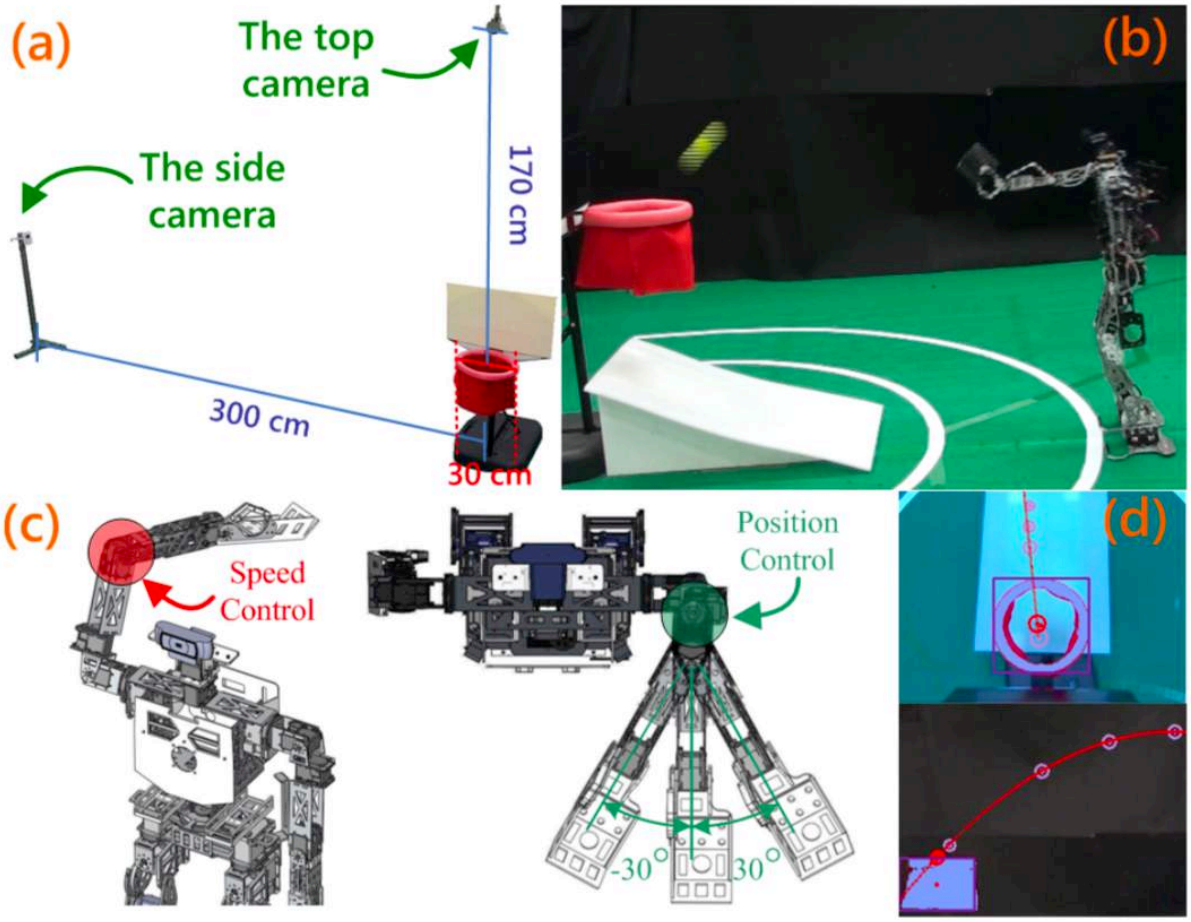


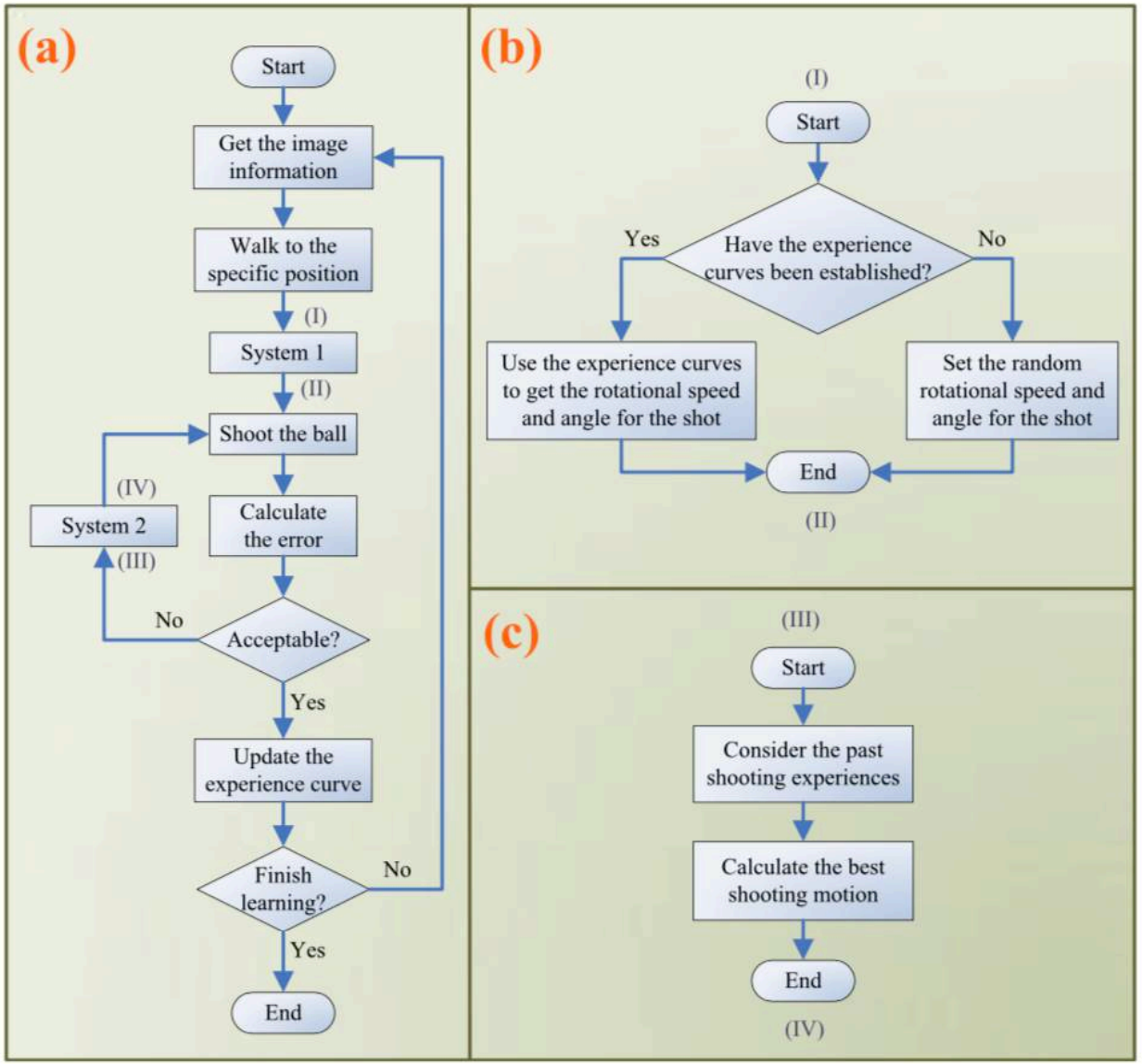
FIGURE 3. Learning environment and control systems of David Junior.

T. S. Li et al. 'Robots That Think Fast and Slow: An Example of Throwing the Ball Into the Basket'. In: *IEEE Access* 4 (2016), pp. 5052–5064. DOI: 10.1109/ACCESS. 2016.2601167.

A ball throwing robot example

Fast system (system 1): a linear combination of polynomials of distances from the basket to determine the rotational speed and angle for shooting the ball into the basket

Slow system (system 2): more complicated hand-crafted set of equations with a memory-buffer.



T. S. Li et al. 'Robots That Think Fast and Slow: An Example of Throwing the Ball Into the Basket'. In: *IEEE Access* 4 (2016), pp. 5052–5064. DOI: 10.1109/ACCESS. 2016.2601167.

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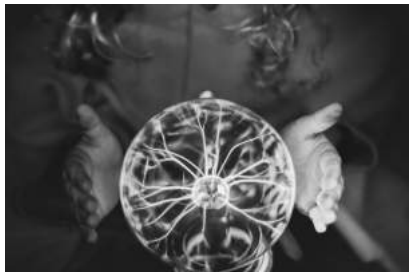
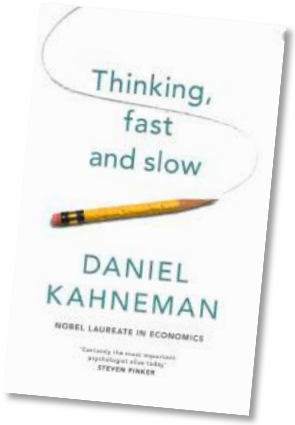
Research Council of Norway grant 312333



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*

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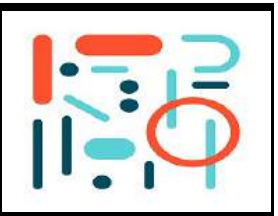

We should focus as least as much on improved human experience as making great technology

Questions or Comments?

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www.jimtoer.no