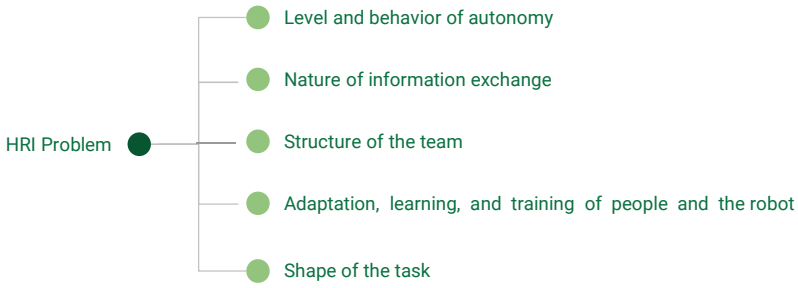
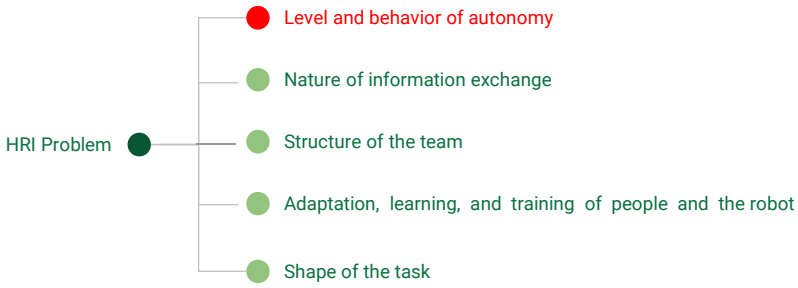
Effective and efficient Human-Robot Interaction in Dynamic Environments

What is Human-Robot Interaction ?

From a designer's perspective



Autonomy



Autonomy

*The extent to which a robot can **sense** the environment, **plan** based on that environment, and **act** upon that environment, with the intent of reaching some **goal** (either given to or created by the robot) without external **control**.*

J. M. Beer, A. D. Fisk, and W. A. Rogers, "Toward a Framework for Levels of Robot Autonomy in Human-Robot Interaction," Journal of Human-Robot Interaction, vol. 3, no. 2, p. 74, Jan. 2014.

Autonomy

Level of Robot Autonomy (LORA)	Function Allocation : Sense	Function Allocation : Plan	Function Allocation : Act
1. Manual Teleoperation	Human	Human	Human
2. Action Support	Human/Robot	Human	Human/Robot
3. Assisted Teleoperation	Human/Robot	Human	Human/Robot
4. Batch Processing	Human/Robot	Human	Robot
5. Decision Support	Human/Robot	Human/Robot	Robot
6. Shared Control with Human Initiative	Human/Robot	Human/Robot	Robot
7. Shared Control with Robot Initiative	Human/Robot	Human/Robot	Robot
8. Supervisory Control	Human/Robot	Robot	Robot
9. Executive Control	Robot	(Human)/Robot	Robot
10. Full Autonomy	Robot	Robot	Robot

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Human-robot Interaction

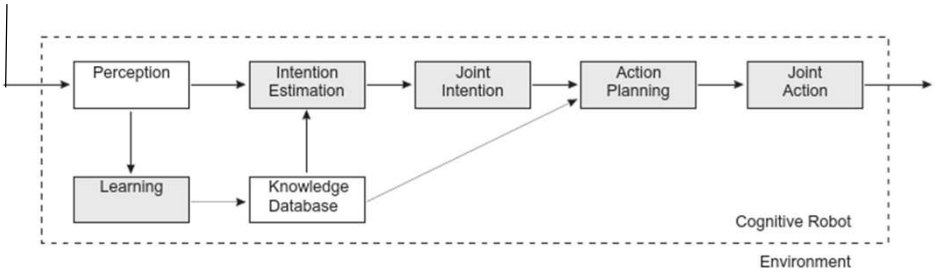
Our AIM

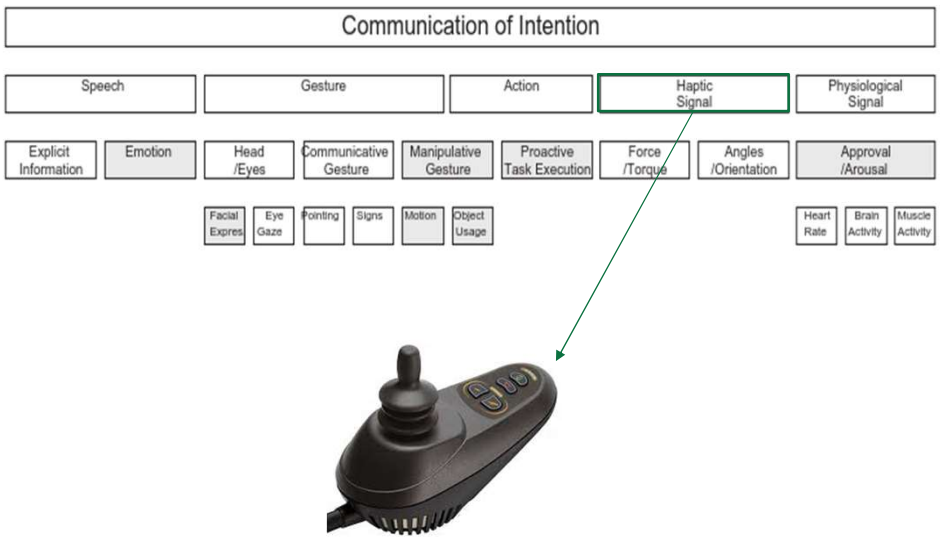
Human-robot Collaboration

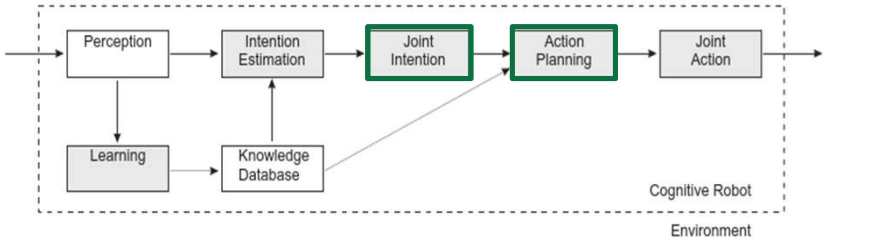
Human-robot Collaboration

HRC is an interdisciplinary research area comprising classical robotics, cognitive sciences, and psychology

Different cognitive architectures used in HRC have different sequences but the main mechanisms are basically the same.







Why is planning difficult?

- Environment is not constant
- Imperfect or insufficient sensors
- Partial observability of the environment
- Intention is not constant over time

Effective HRC?

Optimum utilization robotic resources

Efficient HRC?

The robot knows whether and when to take initiative during joint human-robot task execution.

Human-Robot Collaboration in Assisting people in mobility

Goal of assistive Robotics : Assist the human in a task, not to replace him.

Systems

- take care of the navigation task taking the user where he wants to, without interacting with him after the goal has been set
- automatically override the user when a danger is detected or switch to autonomous navigation if the user decides so

Preferred : shared control navigation system with assisted teleoperation

Why ? The feeling of control that the user gets, perceived self-efficacy and personal control , ability to provide the amount of help needed, adapted to user's needs and changing conditions

Solutions

1. The user provides the input direction via the wheelchair's joystick, while the robot calculates the trajectory using a potential field approach (PFA). These two are combined after weighting the robot output by local efficiency at every time instant.
2. A heuristic estimator for short-term intention inference based on the immediately observable environment around the PMD and user input. A deterministic model is built from demonstration data, capable of generalizing to novel settings from limited training samples.
3. A continuous approach to short-term intention inference which naturally combines intention estimation and demonstration-stylized pathing. A Convolutional Neural Network and a Gaussian Process based approach each parse demonstration data in a decoupled fashion to generate probabilistic feasible traversal maps.
4. Real-time local path planning for mobile robots which considers both the surrounding environment and user intentions. Reinforcement learning based optimization schemes are used to fuse local occupancy maps with inferred intention data for the rapid generation of viable robot paths.
5. **A LSTM based Convolutional Neural Network trained on user input and sensory data to generate motor commands to the PMD to navigate to the intended direction in a local window surrounding the PMD.**

Implementation

Powered Wheelchairs

To be assessed as a 'non-road' vehicle, a motorised wheelchair means a wheelchair that:

- is designed to be used by a single person
- is self-propelled
- is not capable of exceeding 10km/h on level ground
- if not propelled solely by one or more electric motors, has an unladen mass of 40kg or more.

Human-robot Interaction (HRI) : A research area that deals with designing robotic systems to co-exist with humans.

Autonomy is HRI : The extent to which a robot can sense the environment, plan based on that environment, and act upon that environment, with the intent of reaching some goal (either given to or created by the robot) without external control.

Human-robot Collaboration (HRC) : HRC is an interdisciplinary research area comprising classical robotics, cognitive sciences, and psychology

- **Effective HRC** : Optimum utilization robotic resources
- **Efficient HRC** : The robot knows whether and when to take initiative during joint human-robot task execution.

Human-Robot Collaboration in Assisting people in mobility : shared control navigation system with assisted teleoperation

Our current solution : A LSTM based Convolutional Neural Network trained on user input and sensory data to generate motor commands to the PMD to navigate to the intended direction in a local window surrounding the PMD.

THANK YOU

QUESTIONS?