Robotic Wheelchair Adapted for Cognitive Disabled Children: Artificial Intelligence and Human Machine Interface

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Overview

Robotic wheelchair

Children with motor and cognitive disabilities
Introduction

- **Objective**: technical (robotics) and psychosocial (wheelchairs)
- **Users**: people with motor and cognitive problems
- **Multidisciplinary team**: engineers, psychologist, medical people, educators, etc.
Introduction

- **Objective**: technical (robotics) and psychosocial (wheelchairs)
- **Users**: people with motor and cognitive problems
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- **Related work**:
  - Oriented to robot motion
    - [Bourhis2001, Lankenau01, Prassler01, …]
  - Oriented to Human-Machine interface
    - [Kuno03, Mazo01, Martens01, Yanko98, …]
  - Intersection … people with cognitive diseases?
Talk overview

Subsystems:
1. Wheelchair
2. Navigation system
3. Human machine interface
4. Work with the user
Wheelchair

- Sensors
  - SICK Laser (proximity)
    - 180° degrees of visibility
    - 8m range and 0.5° resolution
  - Odometry

- Processing system
  - Two PC’s Pentium IV 800MHz
    - VxWorks (control)
    - Windows (high level) ...

- Actuators:
  - Differential-drive vehicle

- Ethernet radio
Talk overview

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  1. Wheelchair
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Autonomous motion system (application)

Type of motion

User autonomy

Autonomous
Supervised
Without supervision

Intelligence of the system
Autonomous motion system (application)

Type of motion

User autonomy

- Autonomous
- Supervised
- Without supervision

Cognitive possibilities

Javier Minguez
Zaragoza, CEDI – 2007
Autonomous motion system (reach)

GLOBAL SENSOR–BASED MOTION SYSTEM

MODELLING

- Global Model
- Local Model

PLANNING

- Global Planning
- Local Planning

Reaction

Obstacle Avoidance

Sensory perception

Action (motion)

Sensors | Controller

LOCAL SENSOR–BASED MOTION SYSTEM

ROBOT
Autonomous motion system (reach)
Autonomous motion system (reach)

GLOBAL SENSOR–BASED MOTION SYSTEM

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- Global Model
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Obstacle Avoidance

REACTION
- Sensory perception
- Action (motion)

Sensors | Controller

LOCAL SENSOR–BASED MOTION SYSTEM

ROBOT
Objective: move the vehicle to a given LOCAL goal location while avoiding the collisions with the obstacles gathered by the sensors.

Premise: Motion in real scenarios.
- Unknown, dynamic, dense, complex and cluttered.

Difficulties:
- Model the scenario dynamics
- Constrained visibility of the sensor.
- Trap situations
- Comfortable navigation
  - no oscillations, shaking behaviors, etc.
Autonomous motion system (current state)

- **Functionalities:**
  - Modeling the scenario.
    - Map construction
      - Laser projection [Minguez01]
    - Localize the vehicle
      - MbICP [Minguez06]
  - Planning
    - Tactical planning
      - D*Lite [Koeing03]
    - Obstacle avoidance
      - ND [Minguez04,05]
  - **Integration** [Minguez05]
    - Tactical planning
    - Errors management in modules
    - Error management in communication
    - Synchronous integration (temporal constraints)
Motion in realistic scenarios
Talk overview

**Subsystems:**

1. Wheelchair
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Order recognition

- 3 types of users:
  1. With possibilities of motion of the extremities (tactile screen)
  2. With reduced possibility of control of the body (push button)
  3. Without movement possibility but with reasonable speech (voice interface)
User feedback

- Visual and auditory feedback
Shared control (user interpretation of motion)

- To convert the user orders into orders for the motion system.

- Two types of modes:

  **Global mode**
  - “Fire and forget”
  - It requires spatial cognition
  - It does not require continuous attention

  **Local mode**
  - “Steering wheel” (direction of motion)
  - It does not require spatial cognition
  - It requires continuous attention
Integration architecture

[Diagram showing a goal, polar grid, obstacles, turn left, turn right, stop, go, and a map with labels like 'Obstacle Free', 'Tactical Planning', and 'Reactive Motion'.]
Talk overview

- **Subsystems:**
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  3. Human machine interfaz
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Children

- **Child 1 (female 16 years old):** cerebral paralysis due to hipoxicoisquemic encephalopathy. Moderate mental deficiency given the Wechsler Intelligence Scale (oral I.Q.: 70; manipulative I.Q.: 47; and general I.Q.: 55).

- **Child 2 (male 14 years old):** Cerebral ischemia in central lobes and motor aphasia. Moderate mental deficiency given the Wechsler Intelligence Scale (oral I.Q.: 66; manipulative I.Q.: 57; and general I.Q.: 55).

- **Child 3 (male 16 years old):** Tetraparesy due to encephalopathy with spastic diplegia and Nistasmus due to cerebral paralysis. Moderate mental deficiency given qualitative observations for DSM-IV2 parameters.

- **Child 4 (male 11 years old):** Cerebral paralysis with maturity deficiency and reduced visual capabilities. Moderate mental deficiency in the W. I. Scale (oral I.Q.: 80; manip. and general I.Q. not available due to his visual and motor limitations).

- **Child 5 (female 20 years old):** Cerebral paralysis in the form of spastic tetraparesy. Severe mental deficiency given qualitative observations for DSM-IV parameters. The global development is equivalent to 50 months given the Battelle Developmental Inventory Screening Test.
Previous work

- Development of GAMES.
  - Cognitive stimulation
  - Learning the interface

- Learning includes
  - Relation of the orders - computer.
  - Relation of the computer – environment.
  - Relation of the orders - computer – environment.

Demo game
Experience

- University of Zaragoza (Children 2 and 3 with voice interface and both types of motion).
- Protocol (usage + interview + circuit).
Experience

- School for Children with special needs (Children 1-5 with tactile and push button and global strategy).
- Protocol (usage + interview and circuit)
Navigation system

- 4.55 hours of operation (driving)
- 1255 meters
- 500 missions
- 10 collisions (4 incorrect operation and 6 inevitable)
- Detection of more than 2000 mobile objects
Voice recognition system

- The grammar was not very intuitive
- The performance was not very good (cocktail party problem and speech problems)
- Very well adapted for the children.

**Tactile screen**

**Commands histogram**

**Motion profiles**
Conclusions

- **Subsystems:**
  1. Wheelchair
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Aplicaciones de asistencia al movimiento:
Supervisión y Control

Future work
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