The Bremen Autonomous Wheelchair – A Versatile and Safe Mobility Assistant

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Contents

Safe Wheelchair
  • System Architecture
  • Sonar Measurements

Drive Assistant
  • Cooperative Obstacle Avoidance
  • Basic Behaviors

Route Navigation
  • Self-Localization
  • Route Assistant
  • Route Following

Summary and Outlook
Safety in Robotics

Industrial robotics

Service robotics

Rehabilitation robotics

Increasing safety demands
The Wheelchair “Rolland”

Technical Information
- Meyra Model “Genius 1.522”
- 84 cm/s maximum speed
- Communication via two serial ports

Sensory Equipment
- Internal sensors (speed/steering angle)
- 27 ultrasonic sensors (Nomadic)

On-Board Computer
- Industry-PC (Pentium 233)
- QNX (real-time operating system)
Problem: Safe Driving Is Complex

- Rear swings out
- Accidents caused by user’s disease (e.g. spasms)

Idea

Drive command from joystick

Sensor data of the surroundings

SAM

Safe motor command
Safe Wheelchair – System Architecture

- Real-time applications
- Asynchronous applications
- Network
- Sense & Act Module (SAM)
- Wheelchair

32 ms
Sonar Sensors in Mobile Robots

**Pros**
- Small
- Cheap
- Good Range Resolution

**Cons**
- Low Angular Resolution
- Specular Reflections
- Cross-Talks
- Blindness in immediate surrounding area
Static Fire Sequence
Static Fire Sequence during Motion
Safe Wheelchair – Local Obstacle Map

**Occupyancy of Cell**
- Never Measured
- Empty
- Obstacle Supposed
- Obstacle Confirmed

**Danger of Collision!**
Safe Wheelchair – Measuring on Demand

Searching
• Only relevant area
• Up to the closest obstacle already known

Sensor Selection (per Side)
• Fire sensor that looks towards the cell that has not been measured for the longest time
• If this is more than one sensor, fire the one not been used for the longest time

Obstacle Detection
• If an obstacle is detected first, force a re-measurement
Safe Wheelchair – Dynamic Fire Sequence
Cooperative Obstacle Avoidance

Full User Control
- No relevant Obstacles

Braking
- Obstacle detected, but not avoiding it

Avoiding
- Obstacle detected, avoiding it

Recovering Rotation
- No relevant obstacles, user did not intervene
Obstacle Avoidance – Speed

maximum right

impossible to avoid
can be avoided even with high speed

maximum left
Obstacle Avoidance – Direction
Obstacle Avoidance – Demonstration
Basic Behaviors

Methods
- Local Obstacle Map
- Virtual Sensors

Behaviors
- Forwards and Backwards
  - Corridor-following
  - Wall-following left/right
- Only Forwards
  - Turning into the left/right door
- Automatic
  - Turning round
- Miscellaneous
  - Stop
Drive Assistant – Demonstration

- Turning Round
- Avoidance
- Smooth Acceleration
- Stopping in Time
Navigation
Self-Localization in Routes

224cm, 75°, 799cm, -83°, 880cm, -87°, 260cm
Matching Generalized Tracks

224cm, 75°, 799cm, -83°, 880cm, -87°, 260cm

250cm, 85°, 750cm, -91°, 440cm

In the third segment, 440 cm from the previous corner

The tracks are incompatible
Compensating for Deviations

306cm, 45°, 150cm, 83°, 224cm

290cm, 130°, 520cm
Route Assistant
Route Following – Demonstration
Summary and Outlook

- Standard Wheelchair
  - Basic Behaviors
  - Drive Assistant
  - No Self-Localization

- Route Assistant
  - Route Following
  - Route Assistant Light
  - Self-Localization in Routes

- Self-Localization in Maps
  - Autonomou ous Navigation
  - Navigation Assistant
  - Navigation Assistant Light

Increasing Autonomy