Ensuring Safe Obstacle Avoidance in a Shared-Control System

Thomas Röfer, Axel Lankenau

Bremen Institute of Safe Systems
TZI, FB3, University of Bremen
Germany
Outline

The Bremen Autonomous Wheelchair
  • Experimental Platform in Spatial Cognition Research
  • Development of Safe Embedded Systems
  • Real World Application to Support Handicapped Persons

Sonar Sensors in Mobile Robots
  • Pros and Cons of Sonar Sensors
  • Standard Firing Strategies Fail
  • A New Dynamic Firing Strategy

Safe Obstacle Avoidance in a Shared-Control System
  • The Wheelchair’s System Architecture
  • Various Control Modes
  • Avoiding Obstacles and Steering Back to the Original Orientation

Future Work
The Bremen Autonomous Wheelchair

LEAF = Start_FaultTree -> (Corruption_Sig -> CONSUME_CORR
{} End_FaultTree -> LEAF)

C o m m u n .
E r r o r

C o r r u p t  D a t a
n o t
d e t e c t e d

S i m u l a t e d
E n v i r o n m e n t
+ E U C

S a f e t y  M e c h a n i s m s

D e t e c t  C o r r u p t

D a t a co r r u p t e d
C o r r u p t  D a t a
C o r r u p t  D a t a ?

G e n e r a t e  D a t a

224 cm, 75°, 799 cm, -83°, 880 cm, -87°, 260 cm
Sonar Sensors in Mobile Robots

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

**Cons**
- Low Angular Resolution
- Specular Reflections
- Cross-Talks
“Static” Sonar Measurements
Measurements on Demand
Provide Uniform Spatial Coverage

Age of Measurement

Occupancy of Cell
- Never Measured
- Empty
- Obstacle Supposed
- Obstacle Confirmed

Danger of Collision!
Safe Wheelchair – System Architecture

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

32 ms
Various Modes of the Wheelchair

- Operator Control
- Speed Controller
- Obstacle Avoidance
- Automatic Behavior

Operator → Shared Control → System
A “Multi-Mode” Scenario: The Driving Assistant
Obstacle Avoidance – Basic Idea
Obstacle Avoidance – Details

- Obstacle
  - yes
  - left/right
    - Avoid Direction
      - yes
      - Intervention
        - yes
        - Set New Command
Orientation Assistant

- **Orientation Assistant**
- **Obstacle Avoidance**
- **Speed Controller**
- **Stopping in Time**
Orientation Assistant

Orientation Assistant

Obstacle Avoidance

Speed Controller

Stopping in Time
Future Work

Obstacle Avoidance
  • Intensity of Intervention Depending on Sensor Resolution

Driving Assistant
  • Integration of Additional Skills
    – Docking to a Table
    – Shunting
  • Extension of the Man-Machine-Interface
    – Speech Recognition
    – Shared-Control

Orientation Assistant
  • Steering Back to the Original Path