Routemark-Based Navigation of a Wheelchair

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Overview

strategic navigation

map

route

tactical navigation

location designator

elementary navigation tactics

basic behaviours

open and enclosed space

landmarks

network of passages

routemarks

Survey knowledge

route knowledge

tactical navigation

basic behaviours

open and enclosed space

landmarks

network of passages

routemarks
State of Our Work

- strategic navigation
- tactical navigation
- elementary navigation tactics
- basic behaviors
- map
- route
- location designator
- open and enclosed space
  - landmarks
- network of passages
  - routemarks
- route-following
- survey knowledge
- route knowledge
- teaching
- basic behaviors
- routemark constellations
The Bremen Autonomous Wheelchair

Vehicle
- 134 cm x 72 cm
- front driving axle
- back steering axle
- on-board PC + 5 microcontrollers

Sensors
- 12 tactile sensors
- 6 infrared sensors
- 8 wide-angle ultrasonic sensors (80°)
- 8 narrow-angle ultrasonic sensors (7°)
- 1 camera on a pan-tilt-head
- odometry
Sensor Control Subsystems

Collision Detection

Steering Restriction

Navigation

- tactile sensors
- ultrasonic sensors
- infrared sensors
Sensor Weaknesses

**Ultrasonic**
- reflections: diagonal, smooth surfaces
- absorption: soft surfaces

**Infrared**
- perceived too late: dark, unreflective surfaces
- perceived too early: mirroring surfaces
Local Obstacle Map

**Properties**
- “short term memory”
- stores local surroundings of the wheelchair
- size 4 x 4 m²
- entries are forgotten after 30 seconds

**Input**
- 6 narrow-angle and 2 wide-angle ultrasonic sensors
- 6 infrared sensors

**Output**
- 4 “virtual sensors”
Basic Behaviors

Behaviors
- wall-centering
- wall-following left/right
- turning into left/right door
- direction-following forward/backward
- stop

Mode of operation
- forward until collision
- then 50 cm back
- again forward
Semi-Local 3D-marks

Preliminary Work

image sequence
→ small (semi-local) image regions
→ normal flow field
→ focus of expansion

Future

→ depth
→ semi-local 3D-structures
→ 3D-marks

Advantages

• efficient (realtime)
• robust against noise
Artificial Routemarks
Properties

- “short term memory”
- stores routemarks in the local surroundings of the wheelchair
- radius 5 m

Symbols

- routemark X
- camera on turning pan-tilt-head
Behaviors
- wall-centering
- wall-following left
- wall-following right
- stop

Routemarks
- routemark X
- routemark constellation

Teaching
Autonomous Switching of Behaviors
Errors

Possible Errors
- all routemarks missing
- behavior performed erroneously

Finishing Erroneous Behaviors
- timeout
- other routemarks found
Backtracking

**Method**
- no inverse behaviors
- instead: recording odometry positions during behavior
- canceling behavior by backtracking recorded positions
- with “direction-following backward” behavior

**Strategy**
- backtracking last segment, searching for routemarks
- repeating last segment
- backtracking last two segments
- repeating last two segments etc.
Summary

The Bremen Autonomous Wheelchair
  • sensor control subsystems

Basic Behaviors
  • local obstacle map

Route marks
  • semi-local 3D-marks
  • artificial route marks
  • local routemark map

Route Navigation
  • teaching
  • autonomous switching of behaviors
  • errors
  • backtracking