Simultaneous Localisation and Mapping on a Model Off-Road Vehicle

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Overview

- Background
  - ⋆ Problems and Objectives
  - ⋆ Related Work

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- Proposal

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  - ⋆ Related Work
- Proposal
- Schedule and Work plan

Problem

- Robocup Rescue

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- Autonomous Navigation

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- Robocup Rescue
- Autonomous Navigation
- Lack of radio communication in disaster sites

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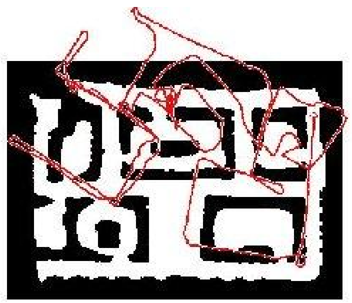

Odometry error (Thrun, 2002)

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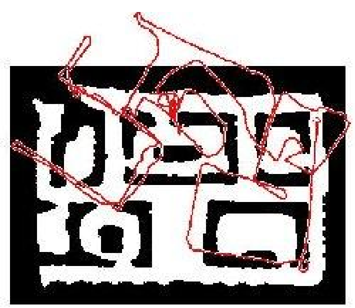


Odometry error (Thrun, 2002)

- Simultaneous Localisation and Mapping (SLAM)

What is SLAM?

robot mapping rocks (Montemerlo et-al)

Literature review

- Challenges
- Approaches
- Related Work

Challenges

- Errors arising from measurement noise
- The high dimensionality of the data obtained
- The correspondence, or data association problem
- A changing environment
- The Robotic Exploration problem

Approaches

- SLAM with Laser Range Finders
  - ⋆ Need distinctive features (Laser beacons, pronounced contours)
  - ⋆ Know exact distance to feature
  - ⋆ Wide field of view

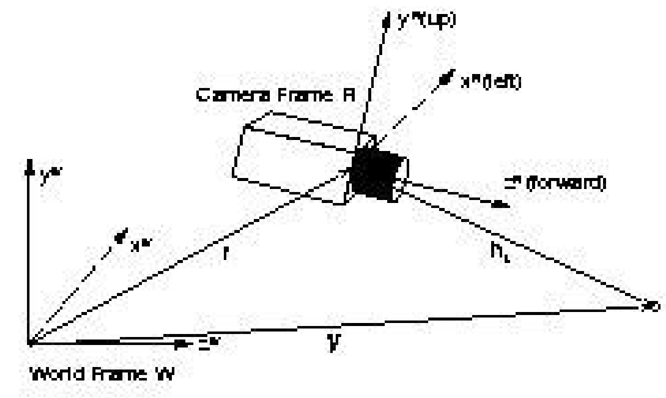
Approaches

- SLAM using a Camera
  - ⋆ Find distinctive features
  - ⋆ Try to work out how far they are
  - ⋆ Be able to recognise a feature seen before
  - ⋆ Far more limited field of view

SLAM Using a Camera

- Sparse map of features representing landmarks built
- Stores estimated state and covariance of system using an EKF
- State Vector for camera comprises of:
  - ⋆ Position Vector
  - ⋆ Orientation Quaternion
  - ⋆ Velocity Vector
  - ⋆ Angular Velocity Vector relative to a fixed world frame

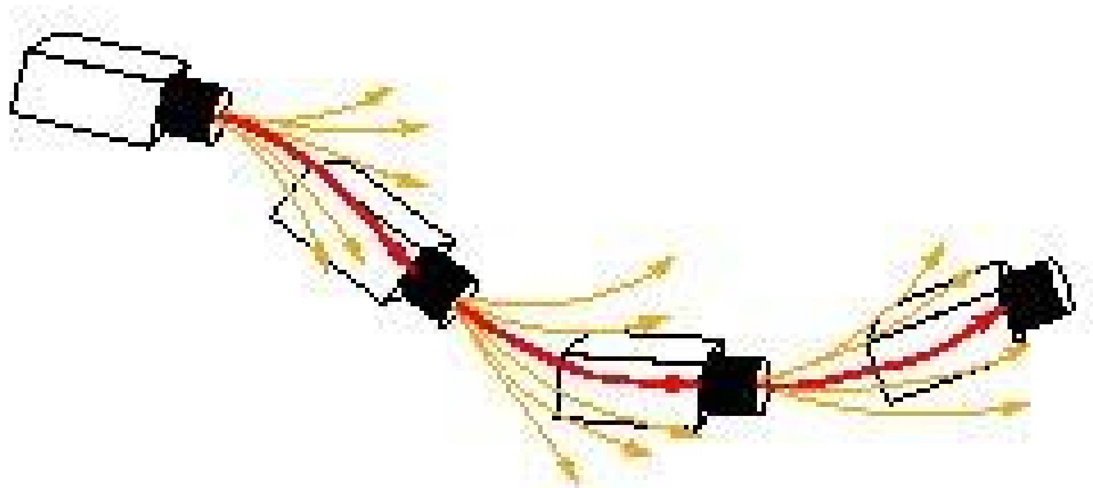
SLAM Using a Camera



Frames in camera geometry (Davison et-al 2004)

SLAM Using a Camera

- Feature states are 3D position vectors
- The EKF models motion of an essentially smooth character



Visualisation of the "constant velocity" model for smooth motion (Davison et-al 2004)

Related Work

- An Autonomous Robotic System for Mapping Abandoned Mines
  - ⋆ Ferguson et-al – CMU
  - ⋆ Groundhog robot equipped with laser range finders
  - ⋆ Maps abandoned mines unreachable by humans
  - ⋆ Uses local maps, and scan matching to minimise residual error
  - ⋆ Uses A* search for its corridor following algorithm

The Groundhog

Related Work

- SLAM using active vision
- wearable active vision
  - ⋆ Interactions between hand and wearable camera
  - ⋆ Using a wide-angle camera
- movie

The Truck

4x4 Monster Pickup TXT-1 Truck

- Stereo Megapixel Camera
- Inertial Measurement Unit
- Infrared Camera
- 850MHz P4 CPU (to be upgraded to 1.6GHz Pentium M)

Proposal

- Implement Visual SLAM on the Monster Truck

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- Implement mapping code using SLAM
- Build a map of the area
- Get the truck moving autonomously in the Robocup arena

Proposal

- First do it on a simulator
- Once everything is in place, move on to the real hardware

Which Simulator?

- Gazebo

Which Simulator?

- Gazebo
  - Part of player-stage
  - Provides a way to model 3D environments
  - Can be used interchangeably with stage without need for code modification

Which Simulator?

- USAR Simulator

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- USAR Simulator
  - Simulates the Urban Search and Rescue arenas in Robocup Rescue
    - Simulates Robots
    - Simulates Sensors
      - Proprioceptive sensors (battery state), Preceptive sensors (camera), position estimation sensors (rotation, velocity)

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  - Uses the Unreal Tournament 2003 game engine
  - Use a controller like Pyro to interact with the game-bot interface

The USAR Simulator

Simulated Orange Arena

Work Plan

Stage 1 – Literature Review

- A study of SLAM implementations
- A survey of available simulators
  - ⋆ 2 Weeks – Done

Stage 2 – Familiarisation with the Simulator

- Installation of Unreal Tournament 2003
- Installation of USARSim and Pyro
- Familiarisation with the above packages
- Familiarisation with UT2003 Editor
- Experimenting with the above
  - ⋆ 3 Weeks – Mostly Done

Stage 3 – Simulating the Truck

- Learning to use UT2003 Editor
- Learning to use the Karma Physics Engine
- Building Truck Body
- Building any extra sensors
- Testing
  - ⋆ 1 Week

Stage 4 – Developing a Brain

- Writing an AI to do SLAM
  - Localise itself
  - Draw a map
- Deciphering sensor readings
- Processing the camera and IMU data
- Testing
  - 3 Weeks

Stage 5 – Optimising SLAM algorithm

- Trying out a few different arenas
- Optimising algorithm by improving things like image processing, etc
  - ⋆ 1.5 Weeks

Stage 6 – Exploration

- To move autonomously, it has to know how
- Initial SLAM implementation would rely on joystick control by human
- By the end of this stage, the robot should be able to move around by itself
  - ⋆ 1.5 Weeks

Stage 7 – Testing

- Testing and Debugging
- Measuring different optimisations
  - ⋆ 1 Week

Stage 8 – Porting to Hardware

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  - 2 Weeks

Stage 9 – Write-up

- Write up
- Editing and Proof-reading
  - ⋆ 1 Week (ongoing)

Questions?