Computer Vision for Autonomous Mobile Robots

Dissertation

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Preface

When starting my thesis and my work in the Middle Size league of RoboCup, I always intended to use RoboCup as an example domain for methods that should later work somewhere else. I am glad that I was able to find an algorithm that was very useful for our soccer robots, but which will also be of great use for other systems. The algorithm is able to efficiently track large homogeneous regions in image sequences.

My second aim was to try to use shape information for robot localization and navigation. Here, I developed a method that is specialized to the RoboCup scenario in that it tries to recognize a palette of features in the very specific RoboCup field lines. However, the way in which detection is performed can be transferred to other scenarios.

It has always been difficult to achieve the balance between a reliable, working system in practice and the aim for inventing new methods. Often, simple methods work better in practice. In the end, I am glad that it was not a balancing act but rather a convergence of the two aspects. All the methods that are proposed in the thesis were used in our final six robots participating at the world championships in Lisbon 2004, where we placed fourth.

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Abstract

This thesis has been written in conjunction to our engagement in the Midsize league of RoboCup where autonomous mobile robots play soccer. In particular, it is about the computer vision system of the robots, which supplies the necessary visual information.

The main contribution is a new image processing technique that allows efficient tracking of large regions. The method yields the precise shape of the regions and it is a base for several other methods, which are described in this thesis.

They comprise a new localization method enabling the robots to determine their precise position by perceiving the white field lines. In particular, they are able to perform real-time recognition of a whole palette of features, including the center circle, T-junctions and corners. If a situation occurs where no feature can be recognized, another new method, the "MATRIX-method", is applied. It uses a pre-computed force field to match the perceived field lines to the corresponding lines in a model.

Overall localization is then performed in a three-level fusion process, which precisely takes into account the different time delays in the system. The approach has been demonstrated to work, playing over 10 games at the world-championship 2004 in Lisbon where the system achieved fourth place.

Although the system was conceived for participation in RoboCup, especially the region tracking method will be of great use for many other applications.
Contents

Preface ......................................................... 1

1 Introduction ........................................... 5
   1.1 Motivation ........................................ 6
   1.2 The Middle Size League ......................... 7
   1.3 The FU-Fighter’s Middle Size Robot ............ 10
   1.4 Localizing the Robot by the Field Lines .... 13
   1.5 Organization of the Thesis ..................... 14

2 Related Work ......................................... 15
   2.1 Navigation Using Laser Range Scanners .... 16
   2.2 Navigation Using GPS and DGPS ............. 18
   2.3 Navigation Using Radar ......................... 20
   2.4 Navigation Using Infrared Proximity Sensors . 21
   2.5 Navigation Using Ultrasonic Sensors ....... 21
   2.6 Navigation by Vision ............................ 22
   2.7 Typical System Architectures in RoboCup .... 29
   2.8 Existing Methods for Field Line Extraction .. 30
      2.8.1 Applying Thresholding and Thinning to Extract the Lines .. 31
      2.8.2 Using the Canny Edge Detector to Extract the Lines ....... 32
      2.8.3 Using the Radial Scan Method to Extract the Lines ....... 37
      2.8.4 Using a Model to Extract the Lines ..................... 38
   2.9 Existing Methods for Robot Self-Localization Using the Field lines .. 40
      2.9.1 Monte Carlo Localization ..................... 40
      2.9.2 Global Localization by Matching Straight Lines .... 44
### 2.9.3 Relative Localization

### 2.10 Methods for Feature Detection

#### 3 A new Algorithm: Tracking Regions

- **3.1 Extending the Region Growing Paradigm**
  - **3.1.1 Region Growing by Pixel Aggregation**
  - **3.1.2 The Key Observation**
  - **3.1.3 Shrinking Regions**
  - **3.1.4 Alternating Shrinking and Growing**
  - **3.1.5 Applicability**
  - **3.1.6 Running Time**
  - **3.1.7 Controlling the Tracking**
  - **3.1.8 Homogeneity Criterion**
  - **3.1.9 Tracking Several Regions**
- **3.2 Boundary Extraction**
- **3.3 Extracting the Field Lines By Tracking Regions**
- **3.4 Results**

#### 4 A new Localization Method Using Shape Information

- **4.1 Three Layers for Robot Self-Localization**
- **4.2 The Robot’s System State**
- **4.3 Coordinate Systems and Transformations**
- **4.4 Relationship between Wheel Rotations and the Robot’s Movement**
- **4.5 The Dynamic Model**
- **4.6 Using a Kalman Filter to Fuse the Three Layers**
- **4.7 Fusing Delayed Measurements**
  - **4.7.1 Splitting the Kalman Cycle**
  - **4.7.2 Explicit Representation of Time**
- **4.8 Layer 1: Odometric Information**
- **4.9 The Observation Model**
  - **4.9.1 The Omni-Directional Vision System**
  - **4.9.2 The Distance Function**
  - **4.9.3 Predicting the Location of Objects in the Image**
  - **4.9.4 Transformation of Two-Dimensional Points on the Field**
4.9.5 Transformation of Arbitrary 3D Points ........................................... 101
4.10 Transforming the Contours into World Space .................................. 102
4.11 Modelling the Field Lines ............................................................... 105
4.12 Layer 2: Relative Visual Localization .............................................. 107
  4.12.1 MATRIX: A Force Field Pattern Approach ................................... 107
  4.12.2 Adapting the System Dynamics Approach ................................... 117
4.13 Layer 3: Feature Recognition .......................................................... 130
  4.13.1 Representation of the Line Contours .......................................... 130
  4.13.2 Quality and Quantity of Features .............................................. 132
  4.13.3 Direct Pose Inference by High-Level Features ............................ 134
  4.13.4 Smoothing the Lines ............................................................... 139
  4.13.5 Splitting the Lines ................................................................. 139
  4.13.6 Corner Detection ................................................................. 142
  4.13.7 Classification ........................................................................... 144
  4.13.8 Constructing Arcs and straight lines ........................................... 144
  4.13.9 Grouping Arcs and Detecting the Center Circle ............................ 148
  4.13.10 Refining the Initial Solution of the Circle ................................. 150
  4.13.11 Determining the Principal Directions ...................................... 153
  4.13.12 Discarding Unreliable and Grouping Collinear Lines .................. 153
  4.13.13 Detecting the Corners of the Penalty Area ................................. 157
  4.13.14 Results of the Feature Detection ............................................. 158
4.14 Results of the Overall Localization .................................................. 162

5 Conclusions and Future Work ............................................................. 164
  5.1 Considering the System Dynamics Approach .................................... 165
    5.1.1 Automatic Modeling .............................................................. 165
    5.1.2 Automatic Learning of Feature Detectors .................................. 166
    5.1.3 The Problem of Feature Selection .......................................... 166
  5.2 Top-Down Versus Bottom-Up Methods .......................................... 167
  5.3 Criticizing the Proposed Feature Recognition Approach .................. 168
  5.4 The Problem of Light ................................................................. 171

6 Summary of Contributions ................................................................. 176
### A Pseudo-code of Described Algorithms

- A.1 Thinning .......................................................... 178
- A.2 Smoothing the Line Contours ................................ 178
- A.3 Calculation of a Curvature Measure ......................... 179
- A.4 Extracting Local Maxima in Curvature ....................... 180

### B Source Code of the Region Tracking Algorithm

- B.1 The Homogeneity Criterion .................................... 183
- B.2 The “Don’t touch” Array ...................................... 183
- B.3 Initializing the Region Tracker ................................. 184
- B.4 FU_RegionTracker.h ........................................... 184
- B.5 FU_RegionTracker.cpp ......................................... 186
- B.6 FV2.h ............................................................... 192
- B.7 FV2.cpp ............................................................ 193
- B.8 FU_Contours.h .................................................... 194
- B.9 FU_Contours.cpp ................................................ 195
- B.10 UTIL_HEAP.h .................................................... 197
- B.11 UTIL_TOPFX.h .................................................. 200

### Bibliography

202