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NEURAL NETWORK BASED IMAGES PROCESSING FOR AUTONOMOUS MINIROBOTS

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Abstract

In many robotics applications such as Navigation, path planning, or exploration, autonomous robots are required to localize themselves in their environment. In this thesis, we present a framework for localization and mapping using a wheeled robot equipped with a single camera. We consider the problem of global localization using vision-based localization as well as odometry method. The goal of global localization is to estimate the self-position of the robot with respect to a priori given map by using motion and perception sensors without using any priori knowledge of the initial self-position.

The work presented here carries out in three stages. First combines a data from the sensors that equipped with the mobile robot, vision sensor and odometry data (robot wheels' count). An image processing algorithm is adapted for detect the environment’s features (landmarks) from the camera sensor. The image processing algorithm is included a color segmentation algorithm, an estimator of segmentation noise, and a camera calibration method.

A color segmentation algorithm is used to detect and extract the color landmarks from the environment. The color segmentation algorithm used the Hue Saturation Value (HSV) color histogram to extract and identify the color landmarks. To reduce the noise that extracted with the landmarks, the morphology opening techniques is used. A neural network based camera calibration method for the global localization of mobile robots using color vision is presented. It is used to reduce the error between the image coordinate and the robot center coordinates. The proposed MultiLayer Perceptron network using the Bayesian learning method successfully finds the relationship between image coordinate without explicitly calculating all the camera parameters, including position, orientation, focal length, and lens distortion.

After adapted the image processing algorithm to extract the landmarks, the relative angle between the landmark and the robot need to be estimated. The odometry data combines with the vision data is used to estimate the necessary inputs (landmark's angles) for geometric method to estimate the robot localization or for building a map.

In the second stage, the vision-based localization is solved through studying the Triangulation methods. Triangulation is based on the measurement of the bearings of the robot relatively to the landmarks placed in the environment. The triangulation algorithms suffer from some restrictions on the landmark positions in the environment and on the angles between the landmarks as seen from the robot. Two solutions to the robot self-localization driver from the triangulation algorithms are developed in this thesis, the Alternative Geometric Triangulation (AGT) algorithm and the modified Geometric

Triangulation (MGGT) algorithm. The AGT algorithm is a new method for robot self-localization and introduced from the landmarks' geometric coordinates and from the environment coordinates. The MGGT algorithm is a modified version of the Geometric Triangulation algorithm. We compare the presented algorithms with the geometric triangulation algorithm. The AGT and MGGT algorithms use three distinguishable landmarks. They work for both counterclockwise and clockwise landmarks labeling. Also, it is not required to consider any restrictions on the angles between the landmarks as seen from the robot. The two algorithms work consistently inside, outside or over the triangle formed by three landmarks.

The third stage, a map-based matching is considered for building and learning a map of the environment features. In most autonomous robotic systems, a map of the environment is an essential component for carrying out specific-application tasks, and must be given a priori or incrementally built from sensor information. Solving the localization problem based on the use of a known map of the environment is done through develop neural networks. A new approach to build a map using self-organizing map is introduced and it's using only local information about the important features (landmarks) in the environment. The output of the neural networks is a trained map when recall, the robot is able to get information about its position. The neural networks can be considered as an intelligence machine that can predicate new cell or location in the environment.

Our approach has been implemented and exhaustively tested in real-time experiments and in a simulation graphic interface program. The results illustrate that the approaches presented in this work can successfully localize the robot in the environment and learn the environment's map.

Contents

Abstract **1**

Contents **7**

List of Figures **11**

List of Tables **17**

1 Introduction **19**

1.1 Autonomous Mobile Robots 19
1.2 Localization and Mapping 20
1.3 Image Processing for Mobile Robot Localization 22
1.4 Calibration of Vision Sensor for Mobile Robot 25
1.5 Neural Network and Map Matching 26
1.6 Contribution of the Work.. 27
1.7 Thesis outline 28

2 Localization Techniques and Sensors **31**

2.1 Introduction.. 31
2.2 Localization Techniques 31
2.2.1 Relative Position 32
2.2.2 Absolute Position 33
2.3 Localization Sensors 35
2.4 Visual Features 39
2.4.1 Natural Landmarks 40
2.4.2 Artificial Landmarks 40

2.5 Odometry Method 41
2.5.1 Draw back for Odometry Method 43
2.5.2 Estimate Landmark's Angle based on Odometry Method 45
2.6 Camera Sensor 48
2.6.1 Camera Geometry 48
2.6.2 Overview of the Camera Distortions 51
2.7 Summery 54

3 Image Processing Algorithms for Feature Extraction 57

3.1 Introduction 57
3.2 The Image Camera and Bayer Filter Pattern 58
3.3 The Demosaicking Algorithms 60
3.3.1 Non-adaptive Algorithms 60
3.3.2 Adaptive Algorithms 63
3.3.3 Bilateral Algorithms 64
3.4 The Landmark Detection 64
3.4.1 Survey on Color Segmentation Methods 65
3.4.2 Color Representation 69
3.4.3 Color Segmentation and Object Extraction 72
3.5 Image Enhancement Techniques and Noise Reduction 73
3.6 Landmark Confidence 76
3.7 Experimental Results 76
3.7.1 Robot Platform 76
3.7.2 Color Segmentation Algorithm 77
3.7.3 Visual Landmark Angle Estimation 80
3.8 Discussion and Conclusions 82

4 Camera Calibration using Neural Networks Techniques 83

4.1 Introduction and Motivation 83
4.2 Control Points 86
4.3 Camera Calibration Methods 89

4.3.1 Explicit Camera Calibration 89
4.3.2 Implicit Camera Calibration 92
4.4 The Implementation of Neural Networks for Camera Calibration 93
4.5 Experimental Results 94
4.6 Conclusions..98

5 Development of new Analytic model for Robot Localization . 101

5.1 Introduction...101
5.2 Triangulation Method 102
5.2.1 The Related Work... 103
5.2.2 The Geometric Triangulation Algorithm............................ 104
5.2.3 Restrictions of the Triangulation algorithms 107
5.2.4 The Generalized Geometric Triangulation Algorithm 108
5.3 An Alternative Geometric Triangulation Algorithm 112
5.4 Modified Generalized Geometric Triangulation Algorithm...119
5.5 Experimental Results 125
5.5.1 Real-time Exterminate.. 125
5.5.2 Simulation Exterminate for robot position 129
5.5.3 Simulation Exterminate for robot orientation..................... 130
5.5.4 Simulation Exterminate for noisy landmark angles 133
5.6 Discussion and Conclusions 134

6 Estimating Robot Position using Self-Organizing Network ... 139

6.1 Introduction...139
6.2 Map Based Positioning 140
6.2.1 Map Building.. 140
6.2.1.1 Occupancy Grid..141
6.2.1.2 Feature Maps 141
6.2.1.3 Topological Maps...142
2.1.4 Hybrid Topological-Metric Maps 144

6.2.2 Map Matching 144
6.3 The Self-Organizing Feature Maps Network 144
6.4 Map-based position using SOFM 148
6.4.1 Environment Setup 148
6.4.2 SOFM Architecture 149
6.5 Experiment Results 149
6.6 Discussion and Conclusions 152

7 Conclusions and Future Work 153

7.1 Conclusions 153
7.2 Future work 155

Appendix A: Publications 159

Appendix B: Robot Platform 161

A.1 Khepera II 161
A.2 Camera module (TC5740) 162
A.3 FPGA information processing module 164

Appendix C: Approaches To Avoid Overfitting Problems 167

Bibliography 169

Glossary 193

List of Figures

Figure 1.1: Localization system block diagram.................................23

Figure 2.1: Khepera with the camera module in the test environment...46

Figure 2.2: The moving equation when the robot is rotating. 47

Figure 2.3: The angle between two facing direction of the robot 47

Figure 2.4: Geometric calculation of change in facing direction, θ is the angle of movement, D_0 and D_1 are the arc lengths of the respective motors, and R is the distance between the two differential drive wheels and equals 52.5mm...48

Figure 2.5: Abstract camera model – box with a small hole in it (Pinhole camera)...49

Figure 2.6: The geometry of a pinhole camera..................................50

Figure 2.7: The geometry of a pinhole camera as seen from Y_1 the axis...50

Figure 2.8: Perspective projection of a square. 52

Figure 2.9: Radial distortion: a) barrel, b) pincushion. 52

Figure 2.10: Radial (d_r) and tangential (d_t) components of non-linear lens distortions. An ideal point is moved into distorted position. 53

Figure 2.11: an overview of distortions caused by a real camera.......53

Figure 3.1: The Bayer Color Filter Array pattern...............................59

Figure 3.2: The nearest neighbor interpolation. 61

Figure 3.3: The bilinear interpolation algorithm................................ 62

Figure 3.4: An HSV color wheel. 71

Figure 3.5: A different structuring elements, (a) is a [3 5] rectangle structuring element, (b) is a square structuring element, (c) is a [7 7] diamond structuring element, and (d) is a disk-shaped structuring element. R represents the number of the neighborhood.................... 75

Figure 3.6: Khepera minirobot II equipped with FPGA module and 2D color CMOS camera module, and a typical image with 640 x 480 pixels from the camera module... 77

Figure 3.7: Flow chart of the landmark detection............................. 78

Figure 3.8: (a) A gray-scale Bayer image, which is acquired by a single-sensor digital camera. (b) A full color image. 79

Figure 3.9: The Hue H Component (a), the S Component, and the V Component of HSV color space................................. 80

Figure 3.10: (a) Binary image after applied histogram threshold. (b): The image is eroded and dilated (morphology method). Most noise is removed. The centre of the landmark is calculated... 80

Figure 3.11: The visual landmarks angle errors................................ 81

Figure 4.1: Variants of control points: (a) centers of gravity of circles and (b) squares, (c) intersections of lines in rectangular and (d) triangular, (e) corners of squares, and (f) chessboard. The control points are marked as dots... 86

Figure 4.2: Improper threshold value of lines: (a) threshold value causes corrupted and non-continuous lines, (b) threshold value leads to lines spanning multiple pixels.. 87

Figure 4.3: Improper threshold value of squares. 87

Figure 4.4: Differences between centers of gravity of an object (+) and its perspective projection (x): a) square, b) circle. ... 88

Figure 4.5: The camera geometry used in Tsai's two stage model with perspective projection and radial lens distortion. 90

Figure 4.6: The imaging geometry. 92

Figure 4.7: Neural network model for camera calibration. 94

Figure 4.8: The performance of the camera calibration on the measured landmark angles. 98

Figure 5.1: The robot's position is the intersection of two circles. Each one of the two circle passes through the robot and two landmarks. 103

Figure 5.2: Geometric Triangulation. 106

Figure 5.3: robot can not localize itself on the circumference that contains the three landmarks. 107

Figure 5.4: Generalized Geometric Triangulation. 109

Figure 5.5: In (a), the landmarks are labelled in counterclockwise fashion, and in (b), the landmarks are labelled in clockwise fashion. 111

Figure 5.6: The landmarks labelled in clockwise fashion. 111

Figure 5.7: An Alternative Triangulation Algorithm to estimate robot's position R by handling three Landmarks. 111

Figure 5.8: Divisions of the plane according to the value of θ_1 and θ_2. 118

Figure 5.9: Divisions of the plane according to the position of the third landmark L_3 relative to the positions of