BEHAVIOR BASED CONTROL OF MOBILE ROBOT VIA VOTING TECHNIQUE

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical – Mechatronics & Automatic Control)

Faculty of Electrical Engineering

University Teknologi Malaysia

JUNE 2014

To my beloved mother and father

ACKNOWLEDGEMENT

In preparing this project report, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main project supervisor, Dr Mohd Ridzuan Ahmad, for giving me the trust, encouragement, guidance, critics and friendship for this self-enriching experience.

My fellow postgraduate students should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members.

ABSTRACT

Behavior-based control employs a set of distributed, interacting modules, called *behaviors* that collectively achieve the desired system-level behavior. One typical issue in behavior-based control systems is the formulation of effective mechanisms for coordination of the behaviors' activities in assuring that the mobile robot act in the correct action in accordance to its surroundings environment. This is what is known as action selection Action Selection Problem (ASP). An Action Selection Mechanism (ASM) is basically a mechanism with the main intention of solving the concerns raised in the ASP. There are basically 2 types of ASM mainly Arbitration and Command Fusion. The difference between Arbitration and Command Fusion are Arbitrary ASM allow one or one set of behaviors to take control at any one time.Command Fusion ASMs allow multiple behaviors to contribute to final control of the mobile robot.Voting technique is one of the strategies under the competitive methods used for behavior coordination in mobile robotics. Each behavior developed for a particular mobile robot shall generate a vote for a set of possible robot actions. A typical vote value of zero would normally mean the least desired action and a vote value of one shall mean that the particular action is most desired. These behaviors send votes as a possibility for each action set to achieve the objectives of the behaviors. An arbiter then performs command fusion and selects the most favoured action that is with the highest vote value. This project report will focus on the realization of a behavior based control for a mobile robot using the voting technique.

ABSTRAK

Kawalan berasaskan kelakuan-menggunakan satu modul yang berinteraksi modul. Modul yang dipanggil sebagai kelakuan ini secara kolektif mencapai tingkah laku tahap sistem yang dikehendaki. Salah satu isu yang biasa dalam sistem kawalan berasaskan tingkah laku ialah perumusan mekanisme yang efektif untuk penyelarasan aktiviti-aktiviti tingkah laku dalam usaha memastikan bahawa tindakan robot mudah alih dalam keaadaan yang betul selaras dengan persekitaranya. Ini adalah apa yang dikenali sebagai pemilihan tindakan Masalah Pemilihan Tindakan (ASP). Mekanisme Pemilihan Tindakan (ASM) pada asasnya satu mekanisme dengan tujuan utama menyelesaikan kebimbangan yang dibangkitkan dalam ASP. Secara asasnya terdapat 2 jenis ASM iaitu Timbangtara dan Gabungan Perintah. Perbezaan antara Timbangtara dan Gabungan Perintah adalah Timbang tara sewenang-wenang membenarkan satu atau satu set tingkah laku untuk mengawal pada satu-satu time. Gabungan Perintah membolehkan pelbagai tingkah laku untuk menyumbang kepada kawalan akhir daripada robot mudah alih.Teknik pengundian adalah satu strategi yang digunakan untuk menyelia set kelakuan untuk robot mudah alih. Setiap kelakuan yang dibangunkan didalam sesuatu sistem robot akan berpeluang untuk menjana undian bagi setiap tindakan robot. Pemilihan tindakan yang akan diambil oleh robot mudah alih bergantung kepada nilai undian yang tertinggi. Hanya tindakan yang mendapat undian tertiingi akan dilaksanakan oleh robot mudah alih. Laporan kerja ini memberikan tumpuan kepada perlaksaan algoritma teknik undian bagi satu robot mudah alih.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A mobile robot is an automatic system mounted on a mobile platform and has the capability to move around its environment and perform a specific task. There are several robot control classes which can be employed in programming a mobile robot namely Deliberative, Hybrid, Reactive and Behavior Based robotics.

Behavior-based robotics was developed for situated robots, allowing them to adapt to the dynamics of real-world environments without operating upon abstract representations of reality and at the same time allowing more computational capability. Behavior-based control employs a set of distributed, interacting modules, called behaviors that collectively achieve the desired system-level behavior.

Each behavior receives inputs from sensors and/or other behaviors in the system, and provides outputs to the robot's actuators or to other behaviors. Thus, a behavior-based controller is a structured network of interacting behaviors, with no centralized world representation or focus of control. Instead, individual behaviors and networks of behaviors maintain any state information and models and its environment.

Each behavior can take inputs from the robot's sensors and/or from other modules in the system, and send outputs to the robot's actuators and/or to other modules. Many different behaviors may independently receive input from the same sensors and output action commands to the same actuators. Behaviors are encoded to be relatively simple, and are added to the system incrementally.

Behaviors (or subsets thereof) are executed concurrently, not sequentially, in order to exploit parallelism and speed of computation, as well as the interaction dynamics among behaviors and between behaviors and the environment.

There are basically 2 classes for the coordination of behaviors which are cooperative and competitive. Each class has different strategies for realization.For cooperative methods, outputs of each behavior response are combined instead of winner takes all technique.

In competitive method where several behaviors are active, the coordination function can be seen as winner takes all and only 1 single response will be selected. The selection of the winning behavior is done by means of arbitration.

Voting technique is one of the strategies under the competitive methods used for behavior coordination in mobile robotics. Each behavior developed for a particular mobile robot shall generate a vote for a set of possible robot actions. A typical vote value of zero would normally mean the least desired action and a vote value of one shall mean that the particular action is most desired. The behaviors send votes as a possibility for each action set to achieve the objectives of the behaviors. An arbiter then performs command fusion and selects the most favored action that is with the highest vote value.

This project report will focus on the realization of a behavior based control for a mobile robot using the voting technique.

1.2 Problem Statement

In behavior based mobile robots, one issue that needs to be asked is on the coordination of behaviors. What ensues when two or more behaviors are triggered simultaneously with each demanding the mobile robot to take different actions. In resolving conflicts among active behaviors there are many possible ways of resolving conflicts. One alternative that can be employed is by having each behavior to generate votes for each of the possible actions for the mobile robot to execute. As per project scope, the mobile robot discussed in this project report shall be a mobile robot with a task of performing vacum action. There are several assumptions that have to be taken into account in constructing and completing the mobile robot vacum cleaner.

a) Assumptions about the Environment

It is assume that the environment is a closed-off, interior room with a relatively smooth, level surface and with minimum number of furnitures.

b) Assumptions On the mobile robot hardware

The mobile robot built in this project is minimal and may not have all the features as compared to commercial vacum cleaning robot in the market.

c) Assumptions Functional Requirements

The mobile robot vacum cleaner does not vacum materials such as glass water or moist. The vacum unit shall only remove dry materials such as dust, fibre, cigarette smoke from a surface to be cleaned by airflow.

1.3 Project Objectives

There are three project objectives which are to be achieved from this project as briefly explained below:

a) To build minimal hardware and system configuration for the behaviors of the mobile robot.

b) To program the mobile robot controller based on the voting technique algorithm and verify its execution. The Romeo V2 Controller was used to act as the “brain” for the mobile robot. The Romeo V2 controller is programmed by using the Arduino IDE Version 1.0.5 and can be program similar to Arduino Leonardo using the C language. Verification of the program is completed by conducting a series of experiments for each of the behaviors. This is further detailed in Chapter 5 - Future Works of this project report.

c) To analyze the overall performance of the mobile robot and suggest for improvements from the results obtained. Series of experiments were analyzed by statistical means involving average values and non-parametric methods. Suggestions for improvements were made based on the results achieved and are captured in this project report.

1.4 Project Scope

The scope of work for this project shall involve the following:

a) Design of robot behaviors with respect to an application of a mobile robot. The application chosen for this project is a mobile robot vacum cleaner. As mentioned in the project objective, there are 3 behaviors developed for the project namely obstacle avoidance, cliff avoidance and vacum behavior. Identification of the required sensors and actuators are determined at this stage. For vacum behavior, modelling and calculations of vacum capacity etc. is not included.

b) Perform robot programming on the mobile robot vacum cleaner that will simulate the obstacle avoidance, cliff avoidance and vacum behavior. The programming of the mobile robot vacum cleaner shall employ the voting algorithm.

c)Verify the programming for the obstacle avoidance, cliff avoidance and vacum behavior on the mobile robot vacum cleaner by means of non-parametric experiments. Results obtained from these experiments shall be analysed to verify the execution of the program.

1.5 Project Report Organization

This project report starts with chapter 1 on the introduction to the project. A brief description on the problem statements, project objectives and project scope is explained.

Chapter 2 deals with the literature review which basically summarize the arguments of the robot researchers on the subject of behavior based control and particularly the voting algorithm.

Chapter 3 describes the project methodologies taken in completing the project and also provides details on the hardware and software aspects of the mobile robot vacum cleaner as per project scope.

Chapter 4 will further discuss on the results and discussions obtained from the robotic experiments mentioned in chapter 3.

Chapter 5 will discuss on possible future works with regards to the mobile robot vacum cleaner.

REFERENCES

1. Thomas Braunl (2008) Embedded Robotics- Mobile Robot Design and Application: Springer

2. Ulrich Nemzow (2009).Robot Behavior Design Description, analysis and modelling: Springer.

3. Tan Chee Kwong, Shamsudin H.M. Amin, Rosbi Mamat (2002).Using Voting Technique in Mobile Robot Behavior Coordination for goal directed navigation.Jurnal Technologi, Universiti Teknologi Malaysia.

4. H.R. Everett (1995).Sensors For Mobile Robot – Theory and Application. A.K Peters Limited.

5. Joseph L. Jones(2004).Robot Programming - A Practical Guide to Behavior Based Robotics.Mc Graw Hill

6. Roland Siegwart Illah R. Nourbakhsh (2004).Introduction to Autonomous Mobile RobotsThe MIT Press

7. Ronald C. Arkin (1998).Behavior-Based Robotics.The MIT Press

8. Julio K Rosenblatt (1997).DAMN – Distributed Architecture For Mobile Navigation. Carnegie Melon University

9. Jeremy Blum (2013).Exploring Arduino- Tools and Techniques For Engineering Wizardry. Wiley

10. Thomas J Palmer, Michael Good Rich (2002).Satisficing anytime action Search for Behavior Based Voting.(Proceedings of 2002 IEEE International Conference on Robotics)

11. John Piccirillo, The Art and Science of Selecting Robot Motors Electrical and Computer Engineering University of Alabama in Huntsville

12. Efficient Training For Artificial Neural Network For Autonomous Navigation IEEE Transactions On Instrumentation And Measurement, Vol. 52, No. 4,

13. Behavior-Based Neuro-Fuzzy Controller for Mobile Robot Navigation

14. D. Floreano, J. Godjevac, A. Martinoli, F. Mondada Andj-D. Nicoud, Design, Control, And Applications Of Autonomous Mobile Robots, Micro-Computing Laboratory Swiss Federal Institute Of Technology In Lausanne

15. Keith L. Doty And Reid R. Harrison, Sweep Strategies For A Sensory-Driven, Behavior-Based Vacum Cleaning Agent Machine Intelligence Laboratory University Of Florida.

16. Hyunjin Chang, Taeseok Jin Coordination of Command Fusion for Obstacle Avoidance Control of Mobile Robot Dept. of Mechatronics Engineering, Dongseo University Korea

17. Liu, Kuotsan1A Technical Analysis of Autonomous Floor Cleaning Robots Based on US Granted Patent Graduate Institute of Patent National Taiwan University of Science and Technology

18. K. S. SENTHILKUMAR , A Study of Behavior-based and Role-based Autonomous Multi-Robot Exploration and Coverage Systems Department of Mathematics and Computer Science Papua New Guinea University of Technology International Journal of Latest Research In Engineering and Computing (IJLREC) Volume 1, Issue 1 Page No.12-20, September-October 2013

19. Min-Chie Chiu The Design and Application of a Robotic Vacum Cleaner Department of Automatic Control Engineering Chungchou Institute of Technology.

20. Xi Li and Byung-Jae Choi Design of Obstacle Avoidance System for Mobile Robot using Fuzzy Logic Systems International Journal of Smart Home Vol. 7, No. 3, May, 2013 School of Electronic Engineering, Daegu University

21. Bram Hendriks,Bernt Meerbeek, Stella Boess (2010)Robot Vacum Cleaner Personality and Behavior, Springer

22. Iwan R. Ulrich Francesco Mondada J.-D. Nicoud, Autonomous vacum cleaner Laboratory of Microcomputing (LAMI) Swiss Federal Institute of Technology Lausanne, Switzerland

23. P. Baroni, G. Guida, S. Mussi, And A. Vetturi, A Distributed Architecture For Control Of Autonomous Mobile Robots Università Di Brescia, Dipartimento Di Elettronica Per L'automazioneVia Branze 38, I-25123 Brescia, Italy

24. David Jung, Gordon Cheng And Alexander Zelinsky, Robot Cleaning: An Application Of Distributed Planning And Real-Time Vision Robotic Systems Laboratory, Department Of Systems Engineering Research School Of Information Sciences And Engineering, The Australian National University

25. Christopher J. Harper, Alan F.T. Winfield, A Methodology For Provably Stable Behavior-Based Intelligent Control Intelligent Autonomous Systems Laboratory, University Of The West Of England, Bristol, UK

26. Anis Fatmi, Amur Al Yahmadi, Lazhar Khriji, and Nouri Masmoudi, A Fuzzy Logic Based Navigation of a Mobile Robot World Academy of Science, Engineering and Technology

27. Ricardo F. M. Garcia, Jonathan D. Hiller, Hod Lipson A vacum-based bonding mechanism for modular robotics ICRA 2010 Workshop Modular Robots

28. Yoichiro Endo ,Design And Implementation Of A High Speed Mobile Robot for Testing A Neural Network Crash Avoidance System Department Of Mechanical And Aerospace Engineering Case Western Reserve University.

29. Julio K. Rosenblatt Charles E. Thorpe,Combining Multiple Goals in a Behavior-Based ArchitectureRobotics Institute Carnegie Mellon University

30. S. Parasuraman, V. Ganapathy, Bijan Shirin Zadeh Behavior Based Mobile Robot Navigation Technique Using Ai System: Experimental investigation On Active Media Pioneer Robot, IIUM Engineering Journal, Vol. 6, No. 2, 2005