Metamorphic Testing Applied on Baidu Apollo Autonomous Driving System

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Zhichao He
20032295

Supervised by Dr. Dave Towey

School of Computer Science University of Nottingham Ningbo China

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Abstract

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Chapter 1

Introduction

This chapter introduces the background information of autonomous vehicles as well as the basic concepts of metamorphic testing and fuzz testing. The motivation, aims and objectives of the project are then described. Finally, the outline of the dissertation is given.

1.1 Background

1.1.1 Autonomous Vehicles and Baidu Apollo

Give background information, history, technologies and applications of autonomous vehicles. Introduce Baidu Apollo system in details, especially in the level of software.

1.1.2 Oracle Problem and Metamorphic Testing

Describe the definitions of Oracle problem, MT and MR. Give simple examples here. Explain why this approach is suitable for autonomous driving.

1.1.3 Fuzz Testing

Explain the concepts of fuzz and fuzz testing. Give examples and explain the reason of using this technique.

1.2 Motivation

Provide real life problems or accidents of autonomous driving systems

1.3 Aims and Objectives

Explain the overall intention of the project and specific steps that will be taken to achieve the intention.

1.4 Dissertation Outline

Summarize the chapter and give the outline of the rest of the dissertation

Chapter 2

Related Work

This chapter gives two (or more) related researches of autonomous vehicle testing and the methodologies and results of these researches. New thoughts in my project and better approaches than existing work in the same field are introduced.

2.1 Metamorphic Fuzz Testing on Autonomous Vehicles

Apart from methodology and results, explain the advantages of the project. Give extra information about potential drawback and how to avoid or optimise it.

2.2 Metamorphic Testing of Driverless Cars

Same as previous section...

2.3 Innovative MRs and Improvements

Introduce different thoughts, design, new MRs and testing approaches that is better than the existing experiments.

Chapter 3

Methodology

This chapter presents the basic testing methods applied in my project, including MT and Fuzz testing, and it also shows the combination of the two methods. The software level modules of Apollo and its internal Robotic Operating System are introduced. Finally, the mechanism of data extraction and analysis in presented.

3.1 MR and MT

Introduce how to apply MT to my project of testing, and how it is used to detect MR violations. Give some NEW MRs that support testing. Specify what makes a good MR. Give some example of poor MRs?

3.2 Fuzz Testing

Introduce how fuzz testing is used in test case generation in my project. Discuss how fuzz parameters (refresh frequency, approach to define obstacle generation region, density of obstacles in testing region) influences the testing results. Specify what is a good fuzzing.

3.3 MFT: The Combination of MT and Fuzzing

Describe how the two methods are combined and generate a more appropriate approach for testing Baidu Apollo software. State why this is suitable for autonomous driving testing.

3.4 Apollo Software Modules

Outline the primary modules in Apollo software that is highly relative to my testing. For example, prediction, perception, planning, control and routing. Discuss how these modules interact with each other and how data is transmitted and stored.

3.5 Robot Operating System

Describe the background information of ROS, including file system, computational graph and ROS nodes, ROS topics and ROS messages, and testing script writing in Python.

3.6 Data Extraction and Analysis

Show how key information (obstacle information, collision information, vehicle information) in the driving simulation can be extracted and how these data can be use to analysis the collision rate and evaluate MRs and fuzz functions.

Chapter 4

Design & Implementation

This chapter covers the design of the automatic testing in this project. It then specifies the Apollo installation details and Dreamview Simulation Environment GUI.

Design containing a comprehensive description of the design chosen, how it addresses the problem, and why it is designed the way it is Implementation containing a comprehensive description of the implementation of your software, including the language(s) and platform chosen, problems encountered, any changes made to the design as a result of the implementation, etc.

4.1 Design of Automatic Testing

Introduce the first and second stages of the test, and accordingly fuzzing and MT steps.

4.1.1 Fuzzing

Describe how the obstacles are randomly generated in the scene and how is the information of obstacles and collisions are monitored and obtained.

4.1.2 MR Generation and MT Implementation

Present the MRs used and how MT is applied to generated follow-up cases. Explain in detail how the source test cases were restored and how follow-up ones are developed based on source ones and the MRs.

4.1.3 Test Script Explanation

Introduce the programming language (Python) used to write the scripts. Give details of related libraries used in the script and how the data is stored in and read from files.

4.2 Apollo Installation and Dreamview Simulation Environment

Introduce the procedures of Apollo installation, building and debug. Describe the GUI and usage of Dreamview. State the supporting OS, platform and related issues encountered.

4.2.1 Building Apollo on Ubuntu 18.04

Explain that Apollo is only supported in Ubuntu OS (Because it need ROS which can only run on Linux). Specify how Apollo is build on Ubuntu 18.04.

4.2.2 Docker Environment

Introduce the concepts of Docker and how it is used to provide a running environment of Apollo. Give some instructions or problems encountered.

4.2.3 Problems Encountered

Provide details of technical problems encountered in building Apollo, using Dreamview and running test scripts.

Chapter 5

Results and Analysis

This chapter presents the different testing results of several round of simulations. The results are analysed and the MRs and fuzz function are evaluated.

5.1 Testing Results

Based on a certain amount of experiments, summarize the testing results in a table. Critical information includes candidate failure rates and genuine failure rates. Determine the seriousness of the problem according to the genuine failure rate. Give some reasoning and analysis about the season of the failure.

5.2 MR/MT Evaluation

Based on the results, reflect on how well the MRs are used to undercover problems in Apollo system. Discuss how can the MRs be improved to perform better.

5.3 Fuzz Function Evaluation

Based on the results, reflect on how well the fuzz function is implemented to generate effective test cases to the simulation environment in Apollo system. Discuss how the fuzz function is improved during the testing process and how it can be improved in the future.

5.4 Summary of MFT on Apollo

Summarize the effectiveness of MFT applied on Apollo autonomous driving systems. Discuss the possibility of testing other self driving software using MFT.

Chapter 6

Summary & Reflections

This chapter includes a discussion of results in a wider context (considering other work). It also covers the project management details and contributions and reflections of the project.

6.1 Project management

Cover the tasks as a part of the work plan and progress as well as how time and resources are managed.

6.2 Contributions and reflections

Provide the details of achievements and contributions including innovation, creativity and novelty (if there is any) as well as a personal reflection on the plan and experience of the project (a critical appraisal of how the project went).

References