



Faculty of Information and Communication Technology

**TRUST REQUIREMENTS APPROACH FOR ELICITING
REQUIREMENTS AUTONOMOUS CAR**

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**TRUST REQUIREMENTS APPROACH FOR ELICITING REQUIREMENTS
AUTONOMOUS CAR**

HALIMATON SAADIAH BINTI HAKIMI

**A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Information and Communication Technology**


Faculty of Information and Communication Technology

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2020

DECLARATION

I declare that this thesis entitled “Trust Requirements Approach for Eliciting Requirements Autonomous Car” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.


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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.

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Date : 8/6/2020

DEDICATION

I dedicate this thesis to my precious family:

Haji Hakimi Yaacub

&

Mrs Halijah Abdullah

&

I.r Abdul Hatim Hakimi & Wife

&

Mr. Haritah Hakimi

“Your endless Prayers, love and support have gotten me here”

ABSTRACT

A new revolution of the automotive industry is hitting the industry with the need for an autonomous vehicle. This is in line with the Mega Science 3.0 Roadmap 2020-2050, which requires the industry to provide safer and more efficient driver-free driving. However, the acceptance level of the autonomous car is still minimal due to lack of trust in the autonomous technology. In this case, the challenging task for automakers are to gain user acceptance in using these highly technology cars. Although much effort has been made to gain users' acceptance such as improving the safety features of the car, yet there have been very limited works to elicit trustable requirements of the cars before the development of an autonomous car. In this case, eliciting accurate functional requirements is challenging, especially for automotive engineers who are not well with the business process and the vocabulary used in the autonomous domain. Motivated by these problems, the objective of this thesis are three-folds; Firstly, to analyze trust requirements comprising trust attributes and trust properties, secondly to propose a new trust requirements approach in eliciting autonomous requirements, and thirdly to evaluate the usability of the proposed trust requirements approach. This thesis proposes a new automated approach to assist the automotive engineer and client-stakeholders to elicit trust requirements of the autonomous car. For this, we started with an analysis of the significant trust attributes and trust properties of autonomous. Next, we have developed a trust requirements autonomous car (TReAC) pattern library in order to store all the input and significant trust attributes and trust properties of the autonomous car. Then, we embed the TReAC pattern library to the elicitation process to elicit requirements of the autonomous car. Here, an automated tool support called Autocarreq.MEReq is also developed to realize the approach. Finally, a comprehensive evaluation of the approach, through usability test, was conducted. In summary, the finding of the evaluations show that our approach is useful and able eliciting trust requirements at the early stage of autonomous car development. It is believed that the proposed approach could help to increase the acceptance of users towards autonomous car. This is because the developments approach able to elicit and validate the trust level of the car requirements.

ABSTRAK

Revolusi baru industri automotif memukul industri dengan keperluan kenderaan berautonomi. Ini adalah sejajar dengan Roadmap 2020-2050 Mega Science 3.0, yang memerlukan industri untuk menyediakan pemanduan tanpa pemandu yang lebih selamat dan lebih cekap. Walau bagaimanapun, tahap penerimaan kereta autonomi masih minima kerana kekurangan kepercayaan pada teknologi berautonomi. Dalam kes ini, lebih banyak tugas yang mencabar bagi pembuat kereta adalah untuk mendapatkan penerimaan pengguna menggunakan kereta teknologi tinggi ini. Walaupun banyak usaha telah dibuat untuk mendapatkan penerimaan pengguna seperti meningkatkan ciri keselamatan kereta, namun terdapat kerja yang sangat terhad untuk menangkap dan mencungkil keperluan kepercayaan sebelum membuat kereta berautonomi. Dalam hal ini, mencungkil keperluan fungsi yang tepat adalah mencabar, terutama bagi jurutera automotif yang tidak mahir dengan proses perniagaan dan perbendaharaan kata yang digunakan dalam domain otonom. Motivasi kepada masalah ini, objektif tesis ini terdiri daripada tiga bahagian; yang pertama adalah untuk menganalisis keperluan kepercayaan yang terdiri daripada sifat amanah dan sifat amanah, yang kedua adalah memberi pendekatan kepercayaan yang baru dalam menimbulkan keperluan autonomi, dan yang ketiga adalah menilai kebolehgunaan pendekatan keperluan amanah yang dicadangkan. Tesis ini mencadangkan pendekatan automatik baru untuk membantu Jurutera Automotif dan pihak pelanggan-pemegang kepentingan untuk mendapatkan keperluan kepercayaan kereta autonomi. Untuk ini, kami memulakan dengan menganalisis atribut amanah yang penting dan sifat kepercayaan yang autonomi. Seterusnya, kami telah membangunkan kepercayaan keperluan kereta automotif (TReAC) perpustakaan corak untuk menyimpan semua input dan sifat amanah yang penting dan sifat kepercayaan kereta autonomi. Kemudian, kami memasukkan perpustakaan corak TReAC kepada proses pencungkilan untuk memenuhi keperluan kereta autonomi. Di sini, sokongan alat automatik yang dipanggil Autocarreq.MEReq juga dibangunkan untuk merealisasikan pendekatan tersebut. Akhirnya, penilaian komprehensif mengenai pendekatan melalui ujian kebolehgunaan telah dijalankan. Ringkasnya, dapatan penilaian pendekatan menunjukkan bahawa pendekatan kami berguna dan mampu mencungkil keperluan kepercayaan pada peringkat awal dalam pembangunan kereta autonomi. Dengan ini yakin, bahawa pendekatan yang dicadangkan ini dapat membantu meningkatkan penerimaan pengguna terhadap kereta autonomi. Ini adalah kerana pendekatan pembangunan dapat mampu mencungkilkan dan mengesahkan tahap kepercayaan terhadap keperluan kereta.

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TABLE OF CONTENTS

	PAGE
DECLARATION	
DEDICATION	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	x
LIST OF APPENDICES	xii
LIST OF ABBREVIATIONS	xiii
LIST OF PUBLICATIONS	xiv
 CHAPTER	
1. INTRODUCTION	1
1.1 Introduction	1
1.2 Research background	2
1.2.1 Requirements engineering	3
1.2.2 Trust requirements	4
1.2.3 Autonomous car	5
1.2.3.1 Levels of autonomous driving	7
1.3 Problem statement	9
1.4 Research questions	11
1.5 Research objectives	11
1.6 Significant of the study	12
1.7 Organization of thesis	12
1.8 Summary	14
 2. LITERATURE REVIEW	15
2.1 Introduction	15
2.2 Conducting systematic literature review	15
2.2.1 Planning the systematic literature review	16
2.2.1.1 Research question	16
2.2.1.2 Formulation and validation of review protocol	18
2.2.2 Conducting the review	23
2.2.2.1 Identifying relevant literature	23
2.2.2.2 Data extraction and quality assessments	23
2.2.2.3 Reporting the review	24
2.2.3 The review result	24
2.2.3.1 Quality assurances	25
2.2.3.2 Quality extraction	27
2.3 Related research	32
2.3.1 Definition trust requirements	32
2.3.2 Related works on trust requirements engineering	38
2.3.2.1 Trust requirements elicitation	38

2.3.2.2	Approaches/frameworks/models in requirements elicitation	39
2.3.2.3	Tool used in requirements elicitation	50
2.3.2.4	Trust requirements attributes	54
2.4	Theoretical framework	62
2.5	Conceptual model	64
2.6	Summary	66
3.	RESEARCH METHODOLOGY	67
3.1	Introduction	67
3.2	Research design	67
3.3	Phase I: The planning and analysis	69
3.3.1	Literature review	70
3.3.2	Conducting survey	71
3.3.2.1	Variable and hypothesis: design	72
3.3.2.2	Population and sampling	75
3.3.2.3	Procedure of data collection	78
3.3.2.4	Validity and reliability of the study	80
3.4	Phase II: The development approach	84
3.5	Phase III: Evaluation and testing	85
3.5.1	Usability test	86
3.5.1.1	Study I: Student	87
3.5.1.2	Study II: Expert	90
3.6	Summary	92
4.	DESIGN AND DEVELOPMENT OF TRUST REQUIREMENTS APPROACH	93
4.1	Introduction	93
4.2	Determination of trust requirements attributes and properties	95
4.2.1	Demographic background	96
4.2.2	Reliability analysis	99
4.2.3	Descriptive statistics of research variables	100
4.2.4	Partial Least Squares analysis (PLS) assessing (PLS-SEM) path modelling results	102
4.2.4.1	Evaluating the reflective measurement model	103
4.2.4.2	Assessing PLS-SEM results	105
4.2.4.3	Fornell-Lacker criterion	115
4.2.4.4	Internal consistency (composite reliability) for all model	116
4.2.4.5	Multicollinearity analysis	117
4.2.4.6	Construct model direct relations	118
4.2.4.7	Summary of all research hypothesis	126
4.2.5	Model of trust requirements for autonomous car (TReAC Model)	130
4.3	Trust requirements autonomous car pattern library	132
4.4	Automated tool: Autocarreqs.Mereq	136
4.4.1	Overview of trust requirements approach	136
4.4.2	Tool architectures	140
4.4.2.1	High level architecture	142

4.4.3	Usage example	144
4.5	Summary	148
5.	RESULT AND DISCUSSION	149
5.1	Introduction	149
5.2	Usability test	150
5.3	Survey: Usability test I	151
5.3.1	Cronbach alpha	152
5.3.2	Survey result	153
5.3.2.1	Background information	153
5.3.2.2	Usability results	155
5.3.2.3	Participants feedback	157
5.4	Usability test with the experts	161
5.5	Threat of validity	165
5.6	Summary	166
6.	CONCLUSION AND FUTURE WORK	167
6.1	Introduction	167
6.2	Summary of research objectives	167
6.2.1	Research objective 1	168
6.2.2	Research objective 2	169
6.2.3	Research objective 3	170
6.3	Research contributions	171
6.4	Limitations	171
6.5	Future work	172
6.6	Summary	173
	REFERENCES	174
	APPENDICES	191

LIST OF TABLES

TABLE	TITLE	PAGE
1.1	The five levels of autonomous driving (NHTSA, 2016)	8
2.1	Summary of PICOC	17
2.2	Research questions	17
2.3	Digital database library	18
2.4	Search term	19
2.5	Inclusion and exclusion criteria	20
2.6	Quality assessments	21
2.7	Question scores	21
2.8	Data extraction	22
2.9	Number of paper study for quality assessment	24
2.10	Quality assurances	25
2.11	Quality extractions	27
2.12	Digital library of paper study	29
2.13	Types of paper study	30
2.14	Definition of trust	32
2.15	Previous methods, approaches, model and tools	52
2.16	Trust attributes metrics	57
3.1	Questionnaire design	73

3.2	The five-point likert scale	74
3.3	Number of persons engaged in managerial, professional and executive (Department of Statistics Malaysia, 2016)	75
3.4	Determining sample size from a given population (Krejcie and Morgan, 1970)	77
3.5	Cronbach's alpha coefficient (George and Mallery, 2003)	83
3.6	Pilot study Cronbach Alpha coefficient	83
3.7	Two usability tests	86
4.1	Demographic Analysis	96
4.2	Cronbach's alpha coefficient scale (George and Mallery, 2003)	99
4.3	Measurement model results for Cronbach' Alpha	100
4.4	Mean scores (Salleh et al., 2012)	100
4.5	Descriptive statistics of research variables	101
4.6	Reliability and validity test	106
4.7	Measurement model results for safety	107
4.8	Measurement model results for security	108
4.9	Measurement model results for experience	109
4.10	Measurement model results for integrity	110
4.11	Measurement model results for privacy	111
4.12	Measurement model results for performance	112
4.13	Measurement model results for trust	113
4.14	Discriminant validity (Fornell-Lacker criterion)	115
4.15	Measurement model results for composite reliability	116

4.16	Multicollinearity analysis (VIF value)	117
4.17	Construct model direct relationships	119
4.18	Summary results for “safety” hypotheses 1	120
4.19	Summary results for “security” hypotheses 2	121
4.20	Summary results for “experience” hypotheses 3	122
4.21	Summary results for “integrity” hypotheses 4	123
4.22	Summary results for “privacy” hypotheses 5	124
4.23	Summary results for “performance” hypotheses 6	125
4.24	Summary of hypothesis	126
5.1	Reliability test of the questionnaire	152
5.2	Proficiency level of using the Autocarreq.Mereq tool and experience with any other tool	154
5.3	Frequency of respondent’s feedback based on themes	158
5.4	Background information for the participants	162
5.5	Frequency of respondent’s feedback based on themes (expert)	163

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Three phases of systematic literature review	16
2.2	Selection process	19
2.3	Theoretical framework	63
2.4	Trust requirements model for autonomous car (TReAC Model)	65
2.5	Relationship one TA to many TP	65
3.1	The research design	68
3.2	Structure of planning and analysis phase	69
3.3	The systematic literature review protocol	70
3.4	Flow of quantitative approach	71
3.5	Formula determining sample size	77
3.6	Structure of development workable prototype	84
3.7	Structure of evaluation and testing	85
4.1	The overview of trust requirements approach	94
4.2	Factor loading for research constructs and their indicators	104
4.3	TReAC model	117
4.4	Overview of structure TReAC Model	131
4.5	The relationship between trust attributes and trust	133

	properties	
4.6	Example of trust attributes related to trust properties	134
4.7	Overview of structure TReAC library	135
4.8	The overview of trust requirements approach	137
4.9	Rule to calculate trustworthy level (%) of trust requirements	138
4.10	The MVC design pattern	140
4.11	Basic layout of multi-tier architecture	141
4.12	The high-level architecture of Autocarreq.MEReq	142
4.13	Insert and upload requirements specification	144
4.14	Verify trust and generated matching keywords	145
4.15	Trust score	146
4.16	Insert and edit suggestion trustworthy attributes	147
5.1	Structure of evaluation and testing	150
5.2	Percentage of user acceptance for novice requirements engineer	155
5.3	Percentage of participants' feedback	157

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Variable measurement instrument	191
B	SPSS output	197
C	Survey on determination of trust attributes and trust properties based on user perspective	204
D	Appointment letter	211
E	Survey questionnaire with student requirements engineering	212
F	Survey questionnaire with expert	214
G	Open-ended feedback	217
H	Expert feedback and comments	220

LIST OF ABBREVIATIONS

AC	-	Autonomous Car
ACC	-	Automated Cruise Control
CACC	-	Cooperative Adaptive Cruise Control
ECO	-	Economic
EXP	-	Experience
INT	-	Integrity
NHTSA	-	The National Highway Traffic Safety Administration
NIST	-	National Institute of Standards and Technology
NKRA	-	National Key Research Area
PER	-	Performance
PRI	-	Privacy
RE	-	Requirement Engineer
SAF	-	Safety
SEC	-	Security
SDLC	-	System Development Life Cycle
TRU	-	Trust
TA	-	Trust Attribute
TP	-	Trust Property
TReAC	-	Trust Requirement Model of Autonomous Car

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3. Hakimi, H., Kamalrudin, M., Sidek, S. and Akmal, S., 2018. Determining the Trust Requirements Attribute in Automotive Industry. *International Journal of Pure and Applied Mathematics (IJPAM)*, 119(18), pp. 487-508.

Conference

1. Hakimi, H., Kamalrudin, M., Sidek, S. and Akmal, S., 2018. The Trust Requirement Model for Develop Acceptable of Autonomous Car. *Journal of Electrical and Electronic Engineering*, 6(2), pp. 59-64.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Eliciting requirements has become crucial in any product development as they contribute significantly to the satisfaction of the needs of client-stakeholders. Requirements can be divided into two categories: (1) functional and (2) non-functional. Among the common techniques to elicit requirements are such as interview, brainstorming, survey, observation and survey questionnaire. Although eliciting requirements has been increasingly recognised as important, the elicitations of trust requirements, particularly for autonomous cars have been largely ignored.

This research aims to propose a new trust requirement approach for eliciting requirements that captures accurate functional requirements for autonomous car. It focuses on identifying the trust requirements approach for developing autonomous car. It is believed that the identification of the trust requirements for autonomous cars enhances the user's acceptance to drive autonomous car, thus addresses the issues of lacking of trust among autonomous car users.

This chapter introduces this research project by first presenting the background information of this study. The next section provides the main concepts that frame this research, which are the trust requirements and the elicitation of requirements for autonomous car. Additionally, the motivation of study is presented, followed by the statements of the research questions and the research objectives. The contribution of this research is provided next, and this chapter ends with the organization of the thesis.

1.2 Research background

A new revolution of automotive industry is hitting the industry with the needs of having an autonomous vehicle. This is also in line with the Mega Science 3.0 Roadmap 2020-2050 that requires the industry to provide safer and more efficient driver-free driving. However, the acceptance level of autonomous car is still minimum due to the lack of trust on the autonomous technology. Further, the current practices of car manufacturers do not consider trust requirements when designing the car. Therefore, this study proposed a new trust requirements approach to assist the elicitation of trust requirements before the designing process of autonomous car.

1.2.1 Requirements engineering

Requirements are the needs or expectations of customers regarding the product developed in a particular industry. In the context of this research, the product developed by the industry is the autonomous car. There are two main reasons why requirements are necessary for a particular product. Firstly, specific product demands certain functions or qualities, and secondly, customer wants requirements to be part of the development of the product (Abraham et al., 2016). Therefore, requirements based on user's needs are essential for the creation and development of the autonomous car.

Requirements consist of two classifications: functional requirements and non-functional requirements. Functional requirements are an action that the product must take if it is to be useful to its user. It relates to any actions, such as calculation, technical details or other specific functionality that define what a system is supposed to accomplish.

Non-functional requirements specify how the product should work and the qualities the product must have. The non-functional requirements for autonomous car describes properties, such as the look and feel of safety, security and privacy, which are critical to the product's success based on the user's expectations and demand. In this case, correct non-functional requirements are important to ensure the developed autonomous car looks secure and safe. In the next section, we describe the trust requirement.

1.2.2 Trust requirements

Trust requirements is defined as the needs to address the issues of safety, reliability and comfort of drivers or users (Schoettle and Sivak, 2014). The trust preference is based on three aspects: i) Customer's satisfaction with the technology provided, ii) Willingness of learning and using the automated features in the current autonomous technology in a car, and iii) Preferable method for learning to use the automated features (Pettersson and Karlsson, 2015).

The importance of trust in the autonomous car is related to the factors for creating willingness to use an autonomous car system and ensuring its correct usage (Pettersson and Karlsson, 2015). Currently, most studies focus on user's expectations or acceptance of the system, ignoring the trust aspect of the autonomous system. It is identified that trust plays an important role in enhancing the acceptance of autonomous cars. Trust contributes to the confidence level of the drivers, especially when they achieve knowledge-drive and emotion drive (Wagner and Koopman, 2015; John and Kristen, 2019).

In summary, this research advocates the importance of developing an autonomous car based on user's need and expectations. Further, considering the trust factors in the development of the autonomous cars enhances the acceptance of the autonomous technology. However, most of the existing works such as Saffarian et al. (2012) and Pettersson and Karlsson (2015) tend to focus on human-machine interaction rather than user's acceptance.

1.2.3 Autonomous car

Autonomous cars (ACs) are driverless car and involve in control function without direct driver input. The National Highway Traffic Safety Administration (NHTSA,2013) explained that autonomous cars have some aspects of safety-critical control function such as steering, brake assist, self-parking and other function occur without direct driver input. According to Fitch et al. (2014), driving ACs greatly improves safety as it reduces crashes that result from human error and human distraction . The NHSTSA (2016) differentiates five level of AC, as described in Table 1.1.

With respect to the development of autonomous cars in Malaysia, the Deputy Minister of International (2017) mentioned that Malaysia is making headways in the development of autonomous car and its related technologies. There have been an increase interests in the research and development of autonomous technology in Malaysia. For example, the *Universiti Teknologi Malaysia* (UTM) has conducted research and development (R&D) activities on developing a fully automated vehicle since 2017. An autonomous car prototype was developed through the collaboration between UTM and Moovita Pte.Ltd. The prototype is based on 7-seater vehicle and after just six months of extensive development and testing, the vehicle made its debut to the public in January 2018.

As the world moves towards the adoption of industry 4.0, the government is making a lot of efforts for the transformation of the industry players towards the adoption of automation and smart manufacturing concepts and technologies. Nowadays, Malaysia companies are taking the opportunities and re-strategizing their plans and actions to ensure greater value for their business, industry and Malaysia at large.