Lecture Notes in Electrical Engineering 365

Felix Pasila
Yusak Tanoto
Resmana Lim
Murtiyanto Santoso
Nemuel Daniel Pah
*Editors*

# Proceedings of Second International Conference on Electrical Systems, Technology and Information 2015 (ICESTI 2015)

Springer

# Lecture Notes in Electrical Engineering

Volume 365

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*Editors*
Felix Pasila
Department of Electrical Engineering
Petra Christian University
Surabaya
Indonesia

Yusak Tanoto
Department of Electrical Engineering
Petra Christian University
Surabaya
Indonesia

Resmana Lim
Department of Electrical Engineering
Petra Christian University
Surabaya
Indonesia

Murtiyanto Santoso
Department of Electrical Engineering
Petra Christian University
Surabaya
Indonesia

Nemuel Daniel Pah
University of Surabaya
Surabaya
Indonesia

ISSN 1876-1100 ISSN 1876-1119 (electronic)
Lecture Notes in Electrical Engineering
ISBN 978-981-287-986-8 ISBN 978-981-287-988-2 (eBook)
DOI 10.1007/978-981-287-988-2

Library of Congress Control Number: 2015960766



Printed on acid-free paper

This Springer imprint is published by SpringerNature
The registered company is Springer Science+Business Media Singapore Pte Ltd.

# Contents

# Introduction

This book includes the original, peer-reviewed research papers from the 2nd International Conference on Electrical Systems, Technology and Information (ICESTI 2015), held during 9–12 September 2015, at Patra Jasa Resort & Villas Bali, Indonesia.

The primary objective of this book is to provide references for dissemination and discussion of the topics that have been presented in the conference. This volume is unique in that it includes work related to Electrical Engineering, Technology and Information towards their sustainable development. Engineers, researchers as well as lecturers from universities and professionals in industry and government will gain valuable insights into interdisciplinary solutions in the field of Electrical Systems, Technology and Information, and its applications.

The topics of ICESTI 2015 provide a forum for accessing the most up-to-date and authoritative knowledge and the best practices in the field of Electrical Engineering, Technology and Information towards their sustainable development. The editors selected high quality papers from the conference that passed through a minimum of three reviewers, with an acceptance rate of 50.6 %.

In the conference there were three invited papers from keynote speakers, whose papers are also included in this book, entitled: “Computational Intelligence based Regulation of the DC bus in the On-Grid Photovoltaic System”, “Virtual Prototyping of a Compliant Spindle for Robotic Deburring” and “A Concept of Multi Rough Sets Defined on Multi-Contextual Information Systems”.

The conference also classified the technology innovation topics into five parts: “Technology Innovation in Robotics, Image Recognition and Computational Intelligence Applications”, “Technology Innovation in Electrical Engineering, Electric Vehicle and Energy Management”, “Technology Innovation in Electronic, Manufacturing, Instrumentation and Material Engineering”, “Technology Innovation in Internet of Things and Its Applications” and “Technology Innovation in Information, Modeling and Mobile Applications”.

In addition, we are really thankful for the contributions and for the valuable time spent in the review process by our Advisory Boards, Committee Members and Reviewers. Also, we appreciate our collaboration partners (Petra Christian

University, Surabaya; Gunadarma University, Jakarta; UBAYA, Surabaya, University of Ciputra, Surabaya, Institute of National Technology, Malang and LNEE Springer, Germany), our supporting institution (Oulu University, Finland, Widya Mandala Catholic University, Surabaya and Dongseo University, Korea) and our sponsors (Continuing Education Centre, Petra Christian University, Surabaya and Patrajasa Resort Hotel, Bali).

On behalf of the editors Felix Pasila

# Chapter 11
# Situation Awareness Assessment Mechanism for a Telepresence Robot

**Petrus Santoso and Handry Khoswanto**

**Abstract** There are several metrics to evaluate about the sophistication of a telepresence robot. One of them is concerning operator performance especially about Situation Awareness (SA). There are many ways to enhance their awareness about situation and environment in the remote side. To do an evaluation, this paper want to propose a mechanism to do an SA assessment on a telepresence robot. The proposed mechanism is basically based on a query that randomly displayed to the operator. The operator will quickly respond to the query on the telepresence robot user interface. The query is used to assess SA, therefore all SA requirements from perception to prediction will be accommodated. The mechanism is developed and implemented on the telepresence robot prototype. Some users tried to operate and respond to the assessment queries. The user response can be stored and retrieved to be processed further to do an SA assessment. The mechanism seems to be working and can be easily deployed to another telepresence robot as long as the protocol is compatible.

**Keywords** Telepresence · Robotic · Situation awareness

## 11.1 Introduction

To implement a functionally working telepresence robot, there are several metrics that need to be taken care of. Three groups of common metrics have been elaborated by Steinfeld et al. [1] namely: System Performance, Operator Performance and Robot Performance. System performance assessment concern with how well the human(s) and the robot(s) perform as a team. Operator Performance concern with situation awareness, workload and accuracy of mental models of device operation. Robot performance deal with robot self-awareness, human awareness and autonomy.

P. Santoso (✉) · H. Khoswanto
Department of Electrical Engineering, Petra Christian University,
JL. Siwalankerto 121-131, Surabaya 60236, Indonesia
e-mail: petrus@petra.ac.id



F. Pasila et al. (eds.), *Proceedings of Second International Conference on Electrical Systems, Technology and Information 2015 (ICESTI 2015)*,
Lecture Notes in Electrical Engineering 365, DOI 10.1007/978-981-287-988-2_11

This paper wants to focus on the situation awareness (SA) aspect of operator performance. By definition, SA is an understanding of the environment state (not ignoring the relevant system parameters) [2]. It is critical to subsequent decision making, operator performance and workload in many dynamic control tasks [3, 4]. Basically SA is a very important metric for controlling dynamic system. In this case, it is very important for a telepresence robot.

There are three defined levels of SA, namely perception, comprehension and projection [2]. Perception also called SA level 1. This level is achieved if the human operator is able to perceive the information needed to do the task via the interface. This is the basic level of SA. Comprehension is the next level, it is also called SA level 2. The human operator can interpret the perceived information correctly, alone or combined with other information at hand. Projection is the highest level, it is also called SA level 3. It is the ability to predict future event based on the current situation. To achieve the highest level of SA, the user interface must be designed to facilitate the acquisition of all the needed information.

To evaluate SA, there is a common query-based tool known as "Situation Awareness Global Assessment Technique" (SAGAT) [2]. The important aspect of using SAGAT is to do a detailed task analysis. The result of task analysis is used to formulate appropriate operator queries. These queries are used to measure SA [1]. The usual scenario using SAGAT is performed using a simulator. At a certain point of interest, the simulator is frozen randomly then the operator is directed to quickly answer queries about their current perception of the situation. All the queries should contain all SA requirements from level 1 (perception), level 2 (comprehension) and level 3 (projection).

In the case of telepresence robot, it is possible to use simulator to assess SA. In the other hand, the idea of this paper is to assess SA in real world scenario. Therefore there is a need to develop a mechanism to assess SA that enable the user to respond as fast as possible and not quite intrusive. The work presented in this paper focuses on the development of mechanism to assess SA, specifically for a telepresence robot.

## 11.2 System Design

The prototype of telepresence robot used in the development of SA assessment mechanism is implemented based on the ASP framework as depicted on Fig. 11.1.

The first step of the framework is defining an architecture based on a requirement analysis. Architecture design will be followed by the service design. Service design presents all of the Service Elements needed by the system. The last step is outlined the whole system protocol. The protocol will implement all of the Service Primitives on each Service Elements [5].

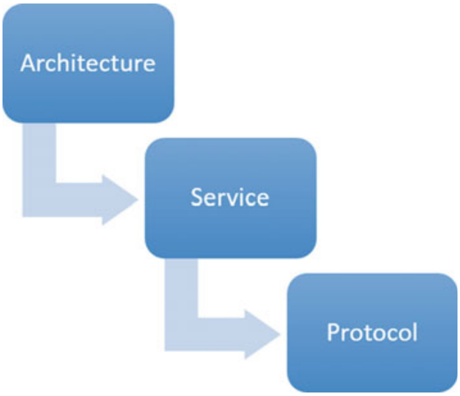



**Fig. 11.1** ASP framework

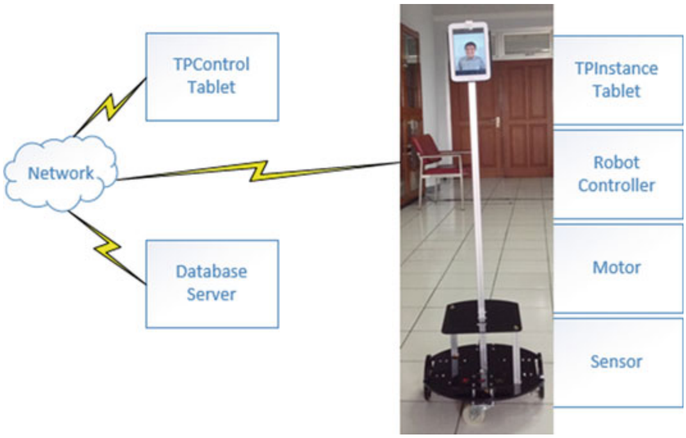



**Fig. 11.2** Architecture of telepresence robot

The architecture of the telepresence robot are shown on Fig. 11.2. The system mainly consist of three entities, namely: TPControl Tablet, Telepresence Robot controlled by TPInstance Tablet and a database server. All three are connected through a computer network, whether it is local or global.

TPControl Tablet is the main control unit held by telepresence operator. This tablet is used to give command to telepresence robot and receive information given by telepresence robot. TPInstance Tablet is used as the receiving unit. It receives command from TPControl Tablet, interprets the received command and drives the robot accordingly. It also collects information from the available sensors and sends

**Table 11.1** Service primitive

| Service element | Service primitive (SP) |
|---|---|
| Movement | Forward_Req |
| | Backward_Req |
| | Left_Req |
| | Right_Req |
| | Stop_Req |
| | Move_Ack |
| Monitoring | Video_Req |
| | Video_Ack |
| Video Call | Call_Req |
| | Disc_Req |
| | Add_Recipient_Req |
| | Remove_Recipient_Req |
| Auxiliary | Send_Robot_Status |
| | Send_Aux_Req |
| | Get_Aux_Req |
| | Aux_Ack |
| SA Assessment | SAQuery_Begin<br>SAQuery_Req |
| | SAQuery_Respond |
| | SAQuery_Store |
| | SAQuery_Ack<br>SAQuery_End |

the information to the TPControl Tablet. The Database server is added to the system to collect user's responds concerning SA Query.

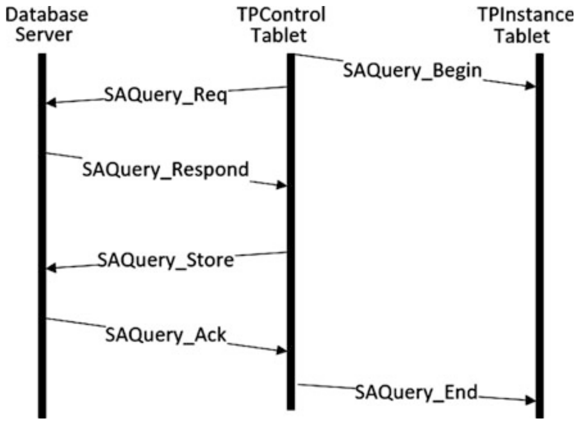
Focusing on the additional service for SA assessment, the revised service design from [5] is shown in the service primitives list on Table 11.1. The additional service element is printed in bold.

The SA Assessment service element deals with SA assessment mechanism. It is a sequence of SPs represent notification to the TPInstance Tablet and information exchange between TPControl Tablet and database server.

As for the protocol, a time sequence diagram for SA Assessment service is outlined at Fig. 11.3. The involved entities are TPControl Tablet, TPInstance Tablet and the database server.

The depicted time sequence diagram depicted the flow of SPs throughout SA Query process.

Fig. 11.3 SAQuery time sequence diagram




## 11.3 SA Assessment Mechanism

The proposed SA Assessment tool is the SAGAT query tool. Some discussions have been done to do a detailed task analysis of telepresence robot. A database of SA Query has been developed. Some sample questions can be seen on Fig. 11.4.

The detailed SA Assessment mechanism can be seen also on Fig. 11.3. SAQuery_Begin tells the TPInstance Tablet to pause all operations during SA Assessment. TPControl then retrieves SA questions from database server with

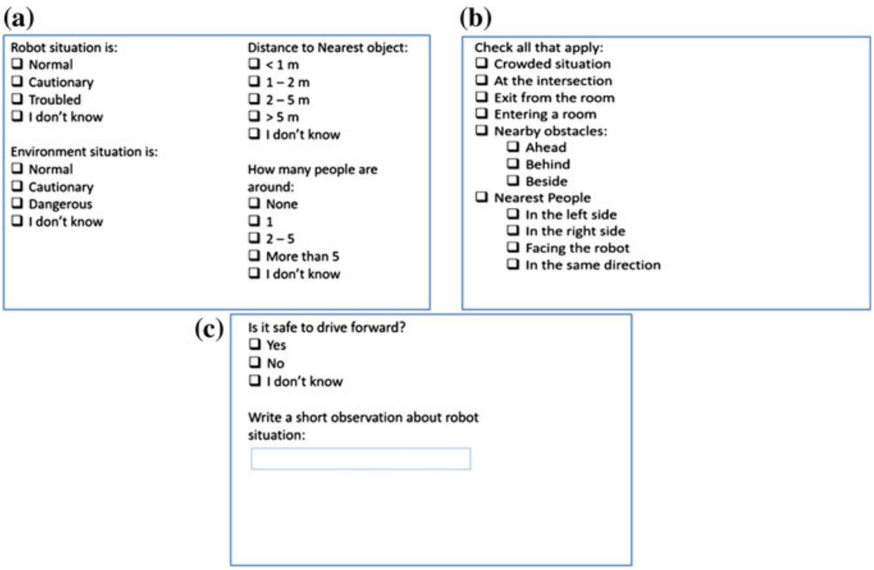



Fig. 11.4 SA Query examples **a** SA Level 1. **b** SA Level 2. **c** SA Level 3

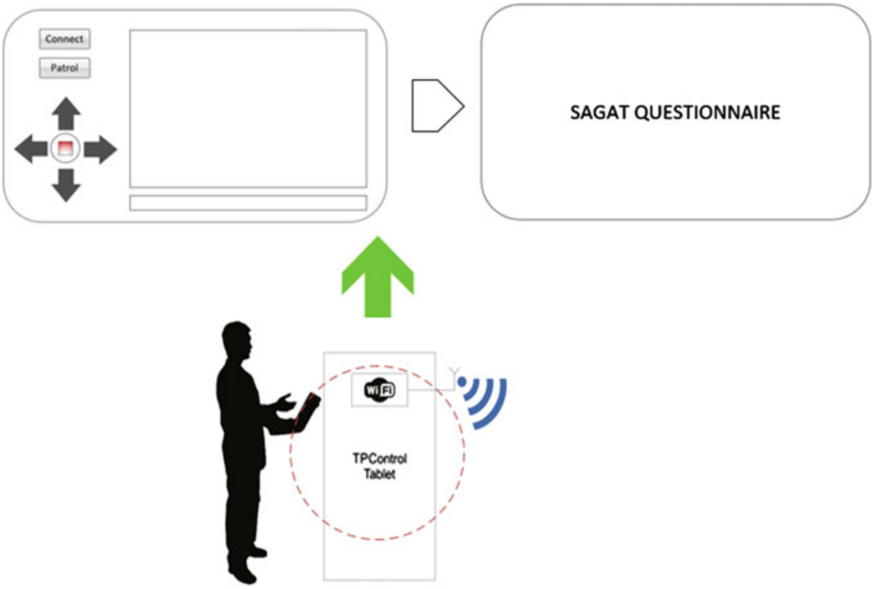



**Fig. 11.5** Interface of the SAGAT query

SAQuery_Req. It is responded by SAQuery_Respond. SA questions then displayed on TPControl Tablet. The operator responds, the result is sent to the database server by SAQuery_Store. Acknowledge given by database server and TPControl Tablet tells TPInstance Tablet to resume all operations.

All the depicted mechanisms are mainly happened on the TPControl Tablet. An illustration of the interface as seen by telepresence operator is shown on Fig. 11.5.

## 11.4 Result and Discussion

The SA assessment mechanism has been implemented and deployed to a working telepresence robot. Several operators have been doing beta testing toward the SA assessment mechanism. After several beta testing, the implemented mechanism is considered suitable for real SA assessment process.

The result of beta testing can be summarized as follows. The designed mechanism is work as expected, TPInstance can be paused during SA assessment, SA query and response works, normal operation can be resumed after SA assessment. The time taken for a single SA assessment can be done below 5s for each displayed query. Most of the operators considered that the assessment method is still intrusive, but in the other hand can give a good insight on SA performance.

Further improvement can be made to make the mechanism less intrusive. SA query and respond can be stored locally and later synchronized to the database server when the situation is possible. This mechanism will reduce the time needed to do an SA query and can be considered less intrusive.

## 11.5 Conclusion

The depicted mechanism in this paper can be considered working without problem. It is easily deployed to all our current prototypes of telepresence robot. It is a useful assessment mechanism to evaluate the performance of telepresence robot, therefore it will be used in all the next iteration of our telepresence robot development.

**Acknowledgments** This Research is funded by Competitive Research Grants fund of Indonesian Higher Education Directorate under contract No. 30/SP2H/PDSTRL_PEN/LPPM-UKP/IV/2015.

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