Chapter 66
Dependability Levels on Autonomous Systems:
The Case Study of a Crisis Management Robot

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ABSTRACT

Professional robots should be endorsed with great autonomy capabilities when designed for release into the market. The need for autonomy is further reinforced when robots are meant to be used for crisis management situations, where close collaboration with humans and trustworthy operation in hazardous environments is necessary. To this end, this article quantifies the system's autonomy by measuring its dependability. This is achieved by defining a qualitative metric system regarding the different levels of dependability that autonomous systems should retain in order to operate in various crisis situations. It provides a detailed analysis of each level of dependability and proposes the minimum requirements that should be fulfilled in each level, thus realizing a ranking system that outlines the overall system's ability to operate autonomously. The proposed analysis is applied on a real robotic prototype developed for crisis situations and evaluates the system's autonomy capabilities by qualitative assessing the levels of dependability it retains.

INTRODUCTION

The concept that integrates systems attributes such as reliability, availability, safety, confidentiality, integrity, and maintainability is known as dependability (Laprie, 1992). Dependability as a measure has its beginnings around 1980 when it has been utilized to outline aspects like fault-tolerance and system

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reliability (Dugan, 1989). Since then, all these attributes were considered mandatory for the autonomy definition of contemporary semi/un-supervised systems. More recently, in accordance to (Dubrova, 2013), the dependability was associated with the amount of autonomy a system can retain.

International crisis management organizations identified the need of the utilization of autonomous robotic systems for the management of crisis situations, a strategy that gave thrust to the roboticists to steer their efforts towards the development of highly autonomous systems that require minimum human supervision (Carlson, 2003). Indeed, the need for highly dependable systems, which act autonomously, is more intensive in crisis management situations, where the increased chance of risk is present, due to unpredictable conditions occurring at the scenery of the incident. After the 9/11 World Trade Center collapse, assistive rescue systems have been widely utilized. Since then, one of the major concerns of the respective scientific community is the construction of dependable systems allowing autonomous operation without jeopardizing human lives (Murphy, 2016).

However, to be able to design an autonomous system, which humans can trust to collaborate with, in hazardous situations, an in-depth analysis of its dependability should be conducted starting from the early phase of its design (Zacharaki, 2017). Based on this perspective dependability can be viewed "… as the level of trust a human operator can put on the system to operate without human supervision for a specific time frame." This definition is applicable both for personal and professional service robots. Taking, for example, the RAMCIP robot (Kostavelis, 2015) which aims to assist older adults with early Alzheimer, the dependability of this system is expressed as the trust we put on it to look after a patient for one day. Similarly, in the domain of space applications, the main objective of Mars Sample Return (MSR) mission is to extend the traverse capabilities of the Sample Fetching Rover and increase the trust that can operate autonomously, without human supervision, to effectively compensate the sparse communications window among Earth and Mars (Kostavelis, 2014).

To this end, the main objective of this work is to outline a hierarchical framework for defining and measuring the dependability of a system, to retain increased human trust in hazardous events. More precisely, six levels of dependability have been identified, i.e. Level-0 to Level-5, and are presented. These levels concern the hardware and software means required to construct an autonomous system during the design phase, as well as the methods adopted to preserve their autonomy in a mission-level engagement. An analysis of the existing means that contribute to the autonomy of the system at each identified level is conducted, and the tools for endorsing that system with the respective level are discussed. The dependability analysis is applied then on a recently developed real robotic agent namely, Autonomous Vehicle Emergency Recovery Tool (AVERT) on which the basic software and hardware components are presented and discussed regarding their dependability during their development. As an outcome, an overall dependability assessment of the examined system is performed aiming to provide insights about the trust the operators can put on the system to operate autonomously.

BACKGROUND

The Dependability of Contemporary Autonomous Systems

The goal behind the concept of dependability comprises the abilities of a system to deliver a service that can justifiably be trusted to avoid failures that are more frequent or more severe, and outage durations that are longer than is acceptable to the user(s) (Bischoff, 2004). This requirement is probably the