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DEVELOPMENT OF AN OPERABILITY EVALUATION FRAMEWORK FOR REMOTELY CONTROLLED GROUND COMBAT VEHICLES IN A SIMULATED ENVIRONMENT

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ABSTRACT–This paper proposes a systematic framework for operability evaluation of remotely controlled ground combat systems (RGCS) in a simulated environment. The popular human-robot interaction metric used in unmanned vehicle systems is called fan-out (FO) and represents the maximum number of robots/vehicles that could be controlled by a single human operator. However, FO is inappropriate for systems with a lower level of automation where vehicles are remotely controlled by a human, such as RGCS. The theoretical background of the suggested framework is based on McRuer's crossover model that was initially developed in the aviation domain for explaining pilot handling issues. In this study, an evaluation/analysis software prototype was developed, known as the RGCS operability evaluation tool in a simulated environment (ROPES). The ROPES was designed to be a simple tool for use by officers or researchers who only have intuitive understanding on the human adaptability. The ROPES includes two sub-modules; 1) an interactive interface for the configuration of the RGCS dynamic parameters and user interfaces and 2) a time-varying graphical display of system and human performance. Examples case studies demonstrate the advantage of the ROPES, and improvement points were identified for future development.

KEY WORDS : Operability, Human-robot interaction, Remotely controlled, Simulation, Crossover model

NOMENCLATURE

FO : fan-out
IT : interaction time
LAM : lethal aerial matrix
NHTSA: national highway traffic safety administration
NT : neglect time
RGCS : remotely controlled ground combat system
ROPES: RGCS operability evaluation tool in a simulated environment
UV : unmanned vehicle
WT : wait time

1. INTRODUCTION

Quantitative analysis methods of the mobility of combat systems, the effectiveness of munitions, and their vulnerability/survivability have been well established. As a simple example, according to Driels (2004), lethal area matrix (LAM) is an outcome of either the General Full Spray Material Program or the Joint Mean Area of Effects Program, and is known to be one of the most basic and accurate ways to show the effect of a weapon on a target. Columns and rows of LAM show deflection and range, and each cell represents probability of damage. The mean area of effectiveness is then obtained by multiplying the probability of damage and cell area (Driels, 2004). On the other hand, systematic operability analyses when human operators are considered for the operation of the entire system received little attention since the performance of the enabling technology should be guaranteed before system integration. In the era of pervasive advanced technologies, in the cases where human operability is combined with superior sensors, weapons, and drones, integrated performance should be reliably studied even if each of the contributing elements exhibits outstanding performance. Among the various types of integrated combat systems, this paper is concerned with the operability analysis in a remotely controlled ground combat system (RGCS). Before we proceed further, the scope of operability in our study should be well defined in conjunction with the RGCS we consider.

1.1. Operability in a Low Autonomy Combat System

As stated in the (Defense Agency for Technology and Quality, 2013), the configuration of unmanned ground combat system technology is classified in one of the following seven categories: systems integration technology, detection technology, perception/processing technology, task/operability technology, unmanned mobility technology,

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