Towards Collaborative Support System for Teamwork between Robots and Human in Hazard Incidents

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***Abstract*—Search and Rescue (SAR) missions for unexpected catastrophic incidents requires fast response and should provide safety especially that they lead to extreme exposure to risk of either potential victims or elements belonging to first responders team. New solutions based on robots and different techniques have been used to enhance the SAR missions in the last decade. This paper addresses a proposed solution that can be used to support collaborative teamwork between teams of robots and human in safety missions.**

I. INTRODUCTION

Nowadays, the threats for citizens of developed countries are related with strong increase in the need to respond effectively to catastrophic, unexpected incidents that include natural and civil disasters (e.g. collapses, fires, floods, and earthquakes), industrial accidents or technological disasters (e.g. accidents in nuclear reactors, refineries, etc.), and terrorism acts and crime (e.g. bomb attacks). Currently, there is a lack of specialized equipment to increase productivity on safety tasks and search and rescue (SAR) missions which leads to extreme exposure to risk of either potential victims or elements belonging to first responders' team. This context provides an opportunity for development of new solutions and techniques based on robotics which would provide benefit on society by increasing safety and fast response in context of unexpected incidents. Murphy in [1] mentioned several attempts of researchers to deploy robots to collaborate beside first responders of human team in SAR missions in real incidents in the last decade. There are many challenges in such contexts especially when using robots; one of them is how the collaboration between the two teams is [2].

The paper will be organized as follows: first the related works will include lists a number of works and then discusses the collaboration aspects that from our prospective are important to have. After that, the paper elaborates more on the proposed solution for the collaboration between teams of robots and human. Finally, the conclusion and future work are presented.

II. RELATED WORK

Collaboration between robots and human is considered challenging especially in SAR missions because it requires communication between the two teams and coordination which different from context to another. On the other hand, the collaboration should ensure that the decision making is distributed in a way that robots would work with different capabilities than the human team, yet beside them to complete the mission. Therefore, from our prospective, there are several aspects to be there in order to achieve such collaboration. They are going to be listed in this section and considered when reviewing related works from the literature.

A. Collaboration Aspects

Based on the literature we have found that the collaboration aspects, which we consider them essential for a more effective and efficient collaborative system, are: coordination, context awareness, decision making, and performance. The coordination which describes the way the two teams deal with each other and how the tasks are being delegated which includes: roles assignments, mission planning, and tasks allocation. The context awareness ensures that the robots and human teams should be aware of the contexts they are in so that they can collaborate in an efficient way. The decision making should be distributed so that the two teams work together based on their different capabilities so that they achieve missions goals. Finally, the performance of the tasks within one mission is critical since it will affect on the whole mission. The results out of a number of tasks performed by robots and human can be considered essential for other tasks within the mission. Therefore, the performance measuring will be used for the collaboration as well as it might affect on the coordination and decision making

B. Collaboration between robots and human in SAR

There are a number of solutions proposed by researchers in the context of SAR. Nourbakhsh et. al proposed to use multi-agent system [3]. For every physical robot there will be a software robot agent which will then deal with other four types of software agents; interface, task, information, and middle agents. Operators can make decisions on behalf of the robots by commanding them. On the other hand, robots can shift to another mode to be semi autonomous. For instance, they can search and when they cannot reach a position they will alert operators. Driewer et. al discussed the collaboration between

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teams of robots and human where they share map, environments, their locations and tasks [4]. The collaboration is centralized since it based on client-server. A supervisor will be in charge of updating the map based on the information received and make decisions on behalf of teams. S/he will, also, be handing the tasks allocation, planning the mission, and the roles and resources assignments which makes the system centralized. Hoffman et. al emphasized on an essential aspect of the interaction between robot and human which will lead to efficient collaboration [5]. In order to go beyond such interaction, robots are proposed to observe and save behaviors and thus look for patterns. This will allow the robots to anticipate and provide adaptive actions selection facility to the robots. The agent can learn the parameters of a Markov process using a naive Bayesian estimation. Kruijff et. al suggested to maintain a level of transparency between the teams of robots and human in SAR missions [6]. According to the authors the transparency level was important because it can help in achieving a decent amount of collaboration where robots can take decisions and at the same time make the human team aware of that.

III. Proposed Solution

Figure 1 illustrates an overview of the proposed architecture of the system. From down- to-top, the actors (human and robot teams) in the real world would need to use a communication channel so that they can interact with each other.

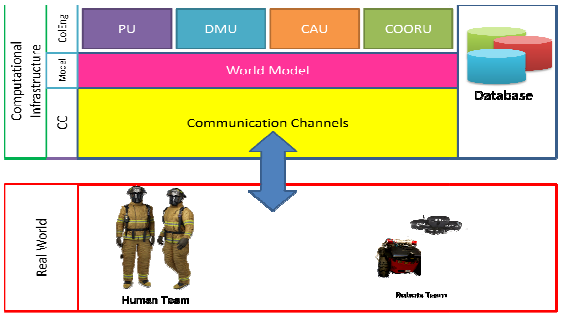

Figure 1. An overview of the proposed architecture of collaborative supporting system

There can be different human-robot interfaces (HRI) such as video/images, text (messages), EEG signals (such as using Emotiv www.emotiv.com) …, etc. On the other hand, robots would use a common operating system such as ROS (http://wiki.ros.org).The proposed solution is based on the fact that there should be a virtual layer (world model) where heterogeneous members of first responders (robots and human) can communicate and thus collaborate. To build such model there are different tools to do that such as Vizard (www.worldviz.com) and Unity (www.unity3d.com). Furthermore, the system will include what we call it Collaboration Engine (ColEng) which will consist of four main components that will ensure to have the collaboration aspects mentioned earlier. The components are: Performance Unit (PU), Decision Making Unit (DMU), Context Awareness Unit (CAU), and Coordination Unit (COORU). There are different techniques and algorithms that can be applied in this architecture such as game theory, multi-dimensional approach for recommender system …, etc. A semantic ontology could be used for the CAU so that objects within a context can be identified. Software agents can also be utilized since it can enhance the performance for the advantages of such systems.

IV. Priliminary Results

We have applied a recommender system approach called multi-dimensional that it is described in [7]. The purpose of using it was to test if it can allocate/reallocate tasks (part of coordination/COORU) between robots and human. We have built a program in Java to perform a simulation of a scenario to test this technique. The results are promising in a way that tasks allocation/reallocation is assigned each time to the most suitable actor based on different parameters in several trials that have been conducted

V. Conclusion and Future Work

This paper presents a proposed solution to increase safety of infrastructures as well to provide cost effective response to catastrophic incidents, through the use of robotic agents in collaboration with teams of human rescuers, a.k.a. first responders in the context of search and rescue or in safety operations. The proposed system uses ColEng in which a number of components to achieve the collaboration between robots and human in SAR missions. We are intending to apply different techniques such as the game theory and discrete event system (DES) and compare the performance of the system so that we can have a system that allow heterogeneous teams to collaborate in an efficient and effective manner in hazardous incidents.

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