

Cognitive Intelligence for Enhancing Soldier Health Predictions in Military Operations

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Abstract—In recent years, personalized health predictions are facilitated and supported by the latest advances in Information and Communication Technologies (ICTs), forming the cornerstone of the new generation of Cognitive Military Healthcare Management Systems (CMHMSs), enabling increased precision of diagnostics and novel health decision-making solutions for each soldier. The ambition of the present study is to introduce a CMHMS architecture, being able to support intelligent soldier health predictions in the field of military healthcare. The proposed framework can assist military personnel and medical workers in promptly identifying soldiers who may need medical attention, allowing for more effective and efficient treatment.

Keywords—military healthcare, soldier health, personalized health predictions, cognitive intelligence

I. INTRODUCTION

Soldier health is a crucial component of military operations and the capacity to track and forecast it in real-time can have a big impact on both the troops' well-being and the success of missions [1]. In recent years, it is possible to create personalized health predictions through the application of Cognitive Military Healthcare Management Systems (CMHMSs), by enabling increased precision of diagnostics and novel health decision-making solutions for each soldier. The above can be accomplished due to the growing number of wearable technologies, medical sensors, cognitive intelligence, machine learning algorithms, and IoT technologies [2]. CMHMSs operate because of collecting information from various sources, intelligently processing it, integrating knowledge and experience, and finally, taking the most appropriate health decisions.

In the light of the above, the scope of this study is to investigate the way that cognitive features in health management systems can enhance military healthcare. Based on this, the aim is to introduce a CMHMS architecture, namely 'i-SHM' (intelligent Soldier Health Monitoring), which aims to support intelligent soldier health predictions in the field of military healthcare, through the exploitation of a dynamic and automatic adaptation of the soldier's level of health status. The proposed functionality can gather information from a variety of sources,

intelligently processing it, integrating knowledge and experience, and finally, producing unique health forecasts and severity checking for each soldier.

The value of this study is thought to be particularly important, as this paper reports one of the first studies of its kind, where cognitive intelligence can assist medical doctors in identifying soldiers who might need medical assistance, allowing for more effective and efficient treatment. Additionally, this study offers insightful data information on the general condition of a military unit, empowering commanders to make wise choices regarding troop deployment and mission preparedness.

II. BACKGROUND

In general, Cognitive Management Systems (CMSs) are computerised tools that use techniques to synthesize and/or analyze data, and in some cases, make recommendations – even predictions – to aid human decision-making in various applications. The advantages of CMSs are often framed in terms of increased situational awareness and faster decision-making cycles [3].

In the light of the above, an area of applications where CMS could find prosper ground is military healthcare and field operations, as military commanders and others responsible for the battlefield can base their decisions on information from all sources available to them at the relevant time [4]. More in detail, Fig. 1 shows the usual decision making cycle followed in the military healthcare domain. The whole cycle consists in an interaction between the operation field domain and the military commander domain. The military commanders collect contextual information on the operation field domain. This real-time collection data, together with historical data and previous experiences, constitute the information to be analyzed by the military commanders. The analysis results in the military commander's decision upon the most appropriate manner to be applied to the operation field domain [5]. During the decision making process, the military commanders consider specific goals and policies, as well as past knowledge and experience, which is derived from previous interactions with field operations with similar physical and environmental

characteristics. So, the whole process can be reflected on a closed loop [6].

As depicted in Fig. 1, the basic motivation behind the cognitive-based decision making cycle in military healthcare domain has to do with the fact that the military commanders could be significantly facilitated by an intelligent system that keeps track of past actions, stores information on a “knowledge database” and provides this information as an input, prior to decision making. At another level, CMS may cater for fast and effective adaptations of the communication infrastructure to changing requirements, and thus guarantee unobtrusive communication during critical situations [7].

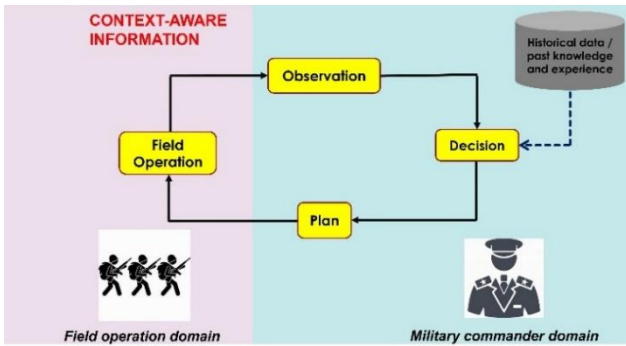


Fig. 1. The decision making cycle in military healthcare domain: a cognitive-based approach

What can also be stated is that the above show how novel management functionalities, enhanced with cognitive networking capabilities, may be needed for the provision of military healthcare in field operations with faster transmissions, as well as higher reliability and availability. Such cognitive systems are most severe in battle environments for providing efficient strategic decisions and greater personalization of the field operations. Before CMS can be deployed in military healthcare applications, they need to be trained through data that are generated from operational activities, so that they can learn similar groups of subjects, associations between subject features and outcomes of interest [8].

CMS trainings are based mainly on machine learning (ML) techniques, where data-analytical algorithms can extract features from data [9-11]. With respect to military healthcare, inputs to ML algorithms include field operation traits and sometimes combat outcomes of interest [9-11].

III. METHODOLOGY

In this section, the context in which an intelligent management platform for the health monitoring of soldiers in a military operational field, namely ‘i-SHM’, is envisaged to operate, is presented in detail.

As mentioned previously, the manner in which the military commanders remain engaged with the battlefield and monitor the soldiers, as well as the central system receives data associated with the soldier’s health status and environment, can change from time to time. Thus, an cognitive management functionality is required in order to be able to adapt, in a real-time manner, the soldier’s level of health status due to change of associated variables of interest [12].

In this respect, the proposed ‘i-SHM’ functionality is aimed to interact, on behalf of the commander/user, with all the available levels of health status, being able to make intelligent health predictions, by taking into account the commander’s/user’s request, the available set of input features-parameters, the policies, and previous knowledge. Communication among the commander/user and the proposed ‘i-SHM’ functionality can be performed through the existence of a well-designed interface system [13].

In a more detailed analysis, as shown in Fig. 1, ‘i-SHM’ functionality uses as input:

- parameters associated with historical health data – medical statistics, i.e., data on specific medical conditions within the military healthcare context,
- biological parameters, i.e., data relating to the soldier’s body that impact on health (e.g., blood pressure, heart rate, ecg rate, body temperature, etc.), and
- physical environment contextual parameters, i.e., actual data associated with environmental aspects in the battlefield (e.g., humidity, weather condition, dust density, etc)

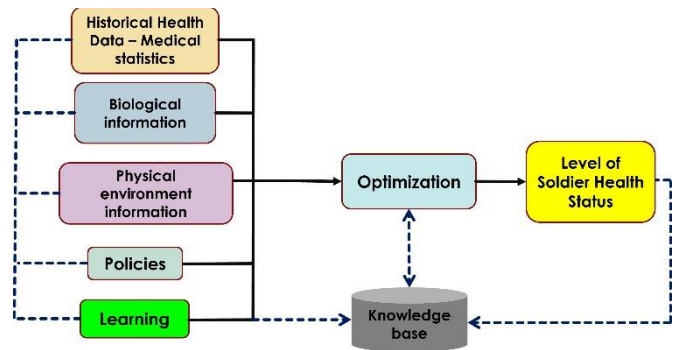


Fig. 2. i-SHM functional architecture

Furthermore, ‘i-SHM’ functionality uses as input two sets of overarching policies towards the importance of associated parameters. The first set of policies reflects commander’s/user’s preferences towards a set of predefined biological parameters. To do so, commander/user needs to specify the importance he/she attributes to each of those parameters. This is achieved by attributing each one of the predefined biological parameters with a certain weight value between 0 and 1, with 0 implying that the biological parameter has the lowest importance for the commander/user and 1 pointing at the highest importance. Of course, it is possible that some biological parameters could have the same weight value for the commander/user. For instance, a commander/user may consider blood pressure and heart rate equally important.

In addition, the second set of policies, which are associated with the physical environment contextual parameters, is established by the operator system, based on real-time information extracted from infrastructure’s sensors. In a similar way like previously, the operator system attributes each of the physical environment contextual parameters with a certain weight value between 0 and 1. The value 0 implies that the physical environment contextual parameter has the lowest

importance for the operator system, whereas the value 1 pointing at the highest importance. It should be noted that as physical environment contextual parameters can change rapidly from time to time, the central operator system may need to adapt frequently their respective weight values.

Based on the above, all combinations of input data (including historical health data – medical statistics, physical environment contextual parameters, policies, learning scheme) with the related decisions are kept in an appropriately structured database. On this way, whenever a specific input situation is encountered, ‘i-SHM’ performs an initial search in the appropriate part of the (classified) database, so as to check whether a similar situation has been encountered also in the past and how it has been tackled. In affirmative, the algorithm does not need to run and the previous decision, through the exploitation of knowledge and experience, is applied again.

Otherwise, ‘i-SHM’ functionality and its algorithm need to run and reach a decision, through the process described in the following. For example, since sensor data fusion systems provide ‘i-SHM’ with input physical environment information continuously, the algorithm needs to run only when something changes, i.e., when the present input situation has not been addressed before. In this respect, parameter changes are adapted fast and successfully, valuable time is saved and the overall complexity of the proposed platform is reduced.

What could be considered in this stage is that the above methodology presents the theoretical basis of the ‘i-SHM’ functional architecture. As future activities in this area one could consider the proposed ‘i-SHM’ to be implemented and verified on a practical basis, by using dataset examples, system mockups, pilot studies, etc. In this context, sufficiently large and realistic field tests are necessary by evaluating important performance metrics like computational efficiency and scalability.

IV. CONCLUSIONS

In general, cognitive computing in military healthcare is a hot and promising topic. Both academics and industry are making big efforts to improve the performances of current systems and to propose novel health decision-making solutions. In this context, health predictions within the military healthcare setting is of crucial importance, as it is associated with significantly worse outcomes in soldiers health.

In the light of the above, the proposed ‘i-SHM’ is introduced, targeted at cognitively managing, quickly and efficiently, the commander’s/user’s request, real-time crucial information associated with the physical environment, historical health data and biological determinants, policies, and previous knowledge turned into experience. This conceptual framework aims to: (a) make more informed health decisions at the point of care within the military healthcare setting, (b) heighten the confidence of military commanders and healthcare professionals by leveraging evidence-based recommendations backed by deep knowledge towards soldier health predictions, and (c) identify the strength of key factors to help make critical decisions towards soldier health predictions fast, clinically consistent and accessible. In this context, the proposed ‘i-SHM’ functionality aims to enhance the monitoring and tracking of soldiers’ health, minimize response time in case of a medical emergency, and provide immediate care to those soldiers who need it.

Last, this work opens the gates to a series of exciting work areas. First, interoperation and communication issues among different sources and devices shall be explored due to their crucial importance towards effective soldier health predictions. Second, advanced AI-enabled solutions and cognitive decision making algorithms should be implemented in the proposed ‘i-SHM’ conceptual framework for making life-critical health decisions and predicting adverse outcomes before they happen, better manage highly complex situations, and ultimately allow military clinicians to spend less time analyzing data and more time harnessing their experience and human touch in delivering care. Finally, what could also be investigated is to understand aspects that are likely to maximize adoption of cognitive health management systems in military healthcare domain.

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