CONRAD - Health Condition Radar: an Intelligent System for Emergency Support

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Abstract

Smart City initiatives have emerged as a technological solution to enhance the use of resources and improve city services. Emergency Management and Support is attracting considerable attention in this context, and several smart solutions have been proposed to support emergency services activities.

On the one hand, Electronic Health Records (EHR) data allows an emergency response system to derive a person's current health status and consequently use this information to advise emergency bodies about people with ongoing health issues requiring assistance. On the other hand, using such comprehensive and detailed data has its challenges. EHR contain an overwhelming amount of information that emergency services cannot process effectively, for both its size and specificity. Furthermore, an intelligent system automatically analysing this data will require some knowledge for representing and reasoning over the evolution of health events.

This demo paper proposes a software architecture for using EHR to extract information that supports emergency services activities. The architecture uses Semantic Web technologies as tools to derive people's ongoing health issues, specifically HECON Ontology and the KG for health evolution information. This demo paper also introduces CONRAD, the software prototype which demonstrates the architecture design in action. The prototype uses a dataset of synthetic health records as data input. Its output is a derived list of people in a vulnerable situation, a summary of their ongoing health issues and related needs.

Keywords

Intelligent Systems, Emergency Support Systems, Electronic Health Records

1. Introduction

During an emergency event (for instance, local incidents, fire, flood), emergency services require precise and accessible information that could help them act promptly and facilitate resource planning [1, 2]. Having detailed information represent a lifesaving resource for emergency responders such as firefighters, police, health bodies, or local authorities.

In the context of Smart Cities, Electronic Health Records (EHR) have been adopted as a vital source of information for emergency support systems [3, 4]. EHR contain information of people's medical events (for instance, recent procedures or conditions), revealing ongoing health issues and identifying people in a vulnerable situation. This information serves as a crucial asset for emergency services when planning evacuation and rescue tasks. For instance, a

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person using a walking stick due to a recent fracture may require special assistance to evacuate during a fire emergency. However, identifying relevant information could become a challenging task for emergency responders. Processing extensive, fine-grained and sensitive healthcare data could be time-consuming; furthermore, critical health issues could be overlooked and challenging to interpret [5, 6].

This demo paper presents a software architecture designed to extract useful data from EHR, providing ready for use and fit for purpose information to emergency services. The proposed design uses Semantic Web technologies to support the reasoning on health conditions' evolution over time (specifically HECON Ontology, FHIR and SNOMED CT taxonomy for representation and exchange, SPARQL). This process leads to identifying ongoing health issues and, therefore, enables a more accurate estimation of people's current health status. Furthermore, the system should be able to process the data and, ideally, classify the relevant health events according to UK governmental guidelines on types of disabilities [7] and ultimately reduce the amount of sensitive information analysed and exchanged. Our system prototype, CONRAD - Health Condition Radar, implements the proposed architecture. It uses as data input a dataset of randomly selected synthetic health records [8]. The final output is a list of people with ongoing health issues that potentially require assistance to evacuate during a fire emergency.

2. Architecture description

In this section, we present the system architecture based on the knowledge requirements extracted from the analysis of the use cases in [9]. The architecture illustrates the flow of information that will deliver valuable data to emergency responders. It is composed of four elements, as shown in Figure 1.

The *first component* of the design is the Health Evolution Ontology (HECON). The ontology is a formal representation of health evolution over time linked to the SNOMED CT taxonomy (a clinical terminology scheme representing medical terms). The *second component* is the Knowledge Graph (KG), representing health evolution information. Both components are the result of previous work to collect, process and represent health condition evolution [6, 9].

The *third component* is the Health Event Evolution Reasoner module (HEER). It uses the HECON Ontology and the KG of Health Evolution Statements (HES) to extract the knowledge required to evaluate the validity of a condition. Additionally, this module contains the rules for reasoning on health evolution and evaluate if a health condition (represented as SNOMED CT concept) is ongoing at a certain point in time [6]. The module's output is a list of people with one or more ongoing conditions.

The *fourth component* is the Data fitting module (DF). This module uses as input the results from the previous component. The objective here is to match the condition with each of the established types of disability [7]. The module uses a common-sense knowledge base, ConceptNet [10]. It obtains a ranked list of the most related type of disability for each medical event and delivers this information to emergency services.

3. CONRAD - Health Condition Radar

CONRAD is the prototype system that demonstrates the proposed architecture. We present a scenario where CONRAD leverages the identification of people in danger during a fire emergency

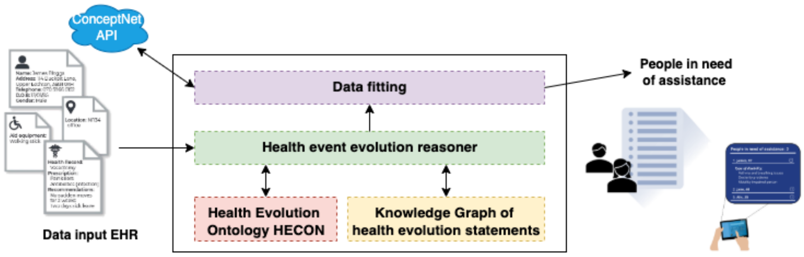

Figure 1: System architecture.

evacuation. First, the system interacts with a building's Access Control System (ACS), which has a register of people in the premises when a fire starts. CONRAD uses this information to retrieve up-to-date people's health information from the National Health Service (NHS) and uses the EHR to perform the analysis on health status. In our demonstration, we use randomly selected synthetic EHRs generated using Synthea software [8]. The EHR are encoded employing established standards, such as the Fast Healthcare Interoperability Resources (FHIR) [11], for the exchange of EHR, and the Systematized Nomenclature of Medicine, Clinical Terms (SNOMED CT)[12] for standard concept descriptions.

The system makes use of the HECON Ontology to retrieve the knowledge required by the Health Event Evolution Reasoner (HEER) module. The HEER module analyses each entry or condition name in the health records. Using the recorded health event (represented by a SNOMED CT concept), the system retrieves the health evolution description (a Health Evolution Statement - HES) from the KG of Health Evolution Statements. The reasoner contains the different rules that apply to each type of HES. For instance, the estimation of maximum and minimum duration is different for a condition such as a 'Fracture of ankle' which improves after an estimated time (the estimated HES is '*Improvement Moderate 6 weeks 2 months*'). By contrast Alzheimer's disease deteriorates over time. These rules are explained in detail in [6]. The HEER module's output is a list of people with at least one condition indicating an ongoing health event.

In the last step, CONRAD's Data fitting module (DF) identifies the type of disability related to the SNOMED CT concept in the health record. The system uses the common-sense knowledge base ConceptNet and its API to retrieve the 'relatedness value' for a given pair of terms, in this case, between a condition name (represented by a SNOMED CT concept) and a type of disability (each disability category [7] is represented by a keyword). The higher the value, the more related the pair of terms are. The system registers the average score for each type of disability and returns a ranked list of the most related disabilities. The system's final output is a list of people requiring assistance, their ongoing condition(s) and related information of the type of disability.

4. Conclusions

In this demo paper we presented the proposed architecture of an intelligent system capable of reasoning of health records to identify relevant information and support firefighters during a fire emergency. We demonstrated the use of CONRAD system, our software prototype that implements the proposed architecture to process Electronic Health Records (EHR) and performs the automatic identification of people in vulnerable situation during an emergency. Future work includes evaluating the quality of recommendations with domain experts and testing the architecture design in alternative scenarios.

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