Predicting Medical Resources Required to be Dispatched After Earthquake and Flood, Using Historical Data and Machine Learning Techniques: The COncORDE Emergency Medical Service Use Case

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ABSTRACT

This article presents a method to predict the medical resources required to be dispatched after large-scale disasters to satisfy the demand. The historical data of past incidents (earthquakes, floods) regarding the number of victims requested emergency medical services and hospitalisation, simulation tools, web services and machine learning techniques have been combined. The authors adopted a twofold approach: a) use of web services and simulation tools to predict the potential number of victims and b) use of historical data and self-trained algorithms to “learn” from these data and provide relative predictions. Comparing actual and predicted victims needed hospitalisation showed that the proposed models can predict the medical resources required to be dispatched with acceptable errors. The results are promoting the use of electronic platforms able to coordinate an emergency medical response since these platforms can collect big heterogeneous datasets necessary to optimise the performance of the suggested algorithms.

KEYWORDS
Deep Learning, Earthquake, Flood, Historical Data, Linear Regression Models, Medical Resources Prediction, NLP

1. INTRODUCTION

Demand prediction and forecasting after natural disasters are especially critical in emergency health management (Ardalan et al., 2009). According to WHO (World Health Organization, 2007), large-scale disaster situations causing mass casualty incidents are characterised among the others by:

- Large numbers of patients, which require the mobilisation of increased hospital personnel and equipment;
- Large numbers of the same type of injury (e.g. skin damage in fire or breathing problems in a gas leakage) that may require equally large amounts of the same type of medical supplies and specialists;

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Injuries that require immediate and simultaneous highly specialised intervention;

- Ambulances availability to deliver several patients;

- Stress and panic situations and, very often, inaccurate estimates of the number of injured people who need treatment.

Preparing essential parts of the healthcare system such as hospitals to prevent, respond, and rapidly recover from these threats is critical for protecting and securing the entire health infrastructure. Incidents such as the 2009 H1N1 influenza pandemic (Shrestha et al., 2010), the Fukushima tsunami (Bachev, 2014) and the hurricane Sandy (Kryvasheyeu et al., 2015) highlighted the importance of preparedness for hospitals against potential threats and their consequences in the community. We should also note that these threats, are added to the considerable multiple challenges faced by trauma centres operating in hospitals and healthcare systems on a daily basis. However, during the emergency response process, in reality, it is difficult to obtain an accurate estimation and prediction of commodities demand after natural disasters because traditional statistic methods such as time-series forecasting methods seem to be ineffective (Zhao and Cao, 2015).

Recent years, aiming at this problem, new technological advancements (Web 2.0 services, broadband communications, and the ability to process, and analyse big heterogeneous data-streams) have been applied to get an insight into the fast-changing situation and help drive an effective disaster response. More specifically Haiti earthquake motivated ICT usage driven crisis since big data collected during the crisis (Meier, 2014) helped to find information about the affected population. After this disaster, data and technology-driven disaster response have become a norm leading to the emergence of a new kind of distributed intelligence (Crowley and Chan, 2011). The 2013 World Disasters Report1 highlighted the importance of disaster response in the perspective of big data and technology.

However, still, large-scale disasters and emergency situations expose the lack of integration and collaboration among all the involved organisations revealing challenges for useful decision support tools. The COncORDE as a technology research project (www.concorde-project.eu) tried to cope with the gaps mentioned above. The project developed a platform of ICT tools that make the best use of existing and emerging technologies for healthcare emergency management and a Decision Support System (DSS) to improve preparedness and interoperability of medical services during emergencies and mass disaster events. The aim of this study, which conducted within the realm of the COncORDE project, is to integrate and experiment with existing tools and techniques to predict victims that need Emergency Medical Service and hospitalisation after earthquake and floods within acceptable errors. This paper describes the architectural design of the generated decision support service which integrates simulation tools, web services, historical data and machine learning techniques (regression modelling framework, Natural Language Process models, deep neural networks) and provides and discusses some first promising results.

The following section presents the background and related work of similar systems and studies. Section 3 describes the architecture of the prediction service for all the use cases while Section 4 presents and discusses some first results of the models, followed by the conclusions part in Section 5.

2. BACKGROUND AND RELATED WORK

In recent years, software platforms2 and information management systems are used to collect data, to provide situational awareness and actionable insights for decision-makers and increase and improve information exchange in emergency situations (Garret et al., 2003; Shen and Shaw, 2004; Demchak et al., 2006; Chua et al., 2007; Chen et al., 2009; FAO, 2011; Balfour, 2012).

Furthermore, online social media, like Twitter and Facebook, have matured into prominent communication platforms and provide an unprecedented opportunity to record and analyse vast amounts of information (Lazer et al., 2009). The potential of these networks is already leveraged during natural disasters (Watts et al., 2013), with applications in situation awareness (Caragea et al.,
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