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Personalized healthcare cloud services for disease risk assessment and wellness management using social media

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ABSTRACT

We propose a cloud based framework that effectively manages the health related Big-data and benefits from the ubiquity of the Internet and social media. The framework facilitates the mobile and desktop users by offering: (a) disease risk assessment service and (b) consultation service with the health experts on Twitter. The disease risk assessment is performed through a collaborative filtering based approach whereas the hubs and authorities based approach is employed to identify the health experts from Twitter. The framework is implemented as Software as a Service (SaaS) to provide the disease risk assessment and expert user interaction services. Experimental results exhibit that the proposed framework achieves high accuracy as compared to the state-of-the-art approaches in terms of disease risk assessment and expert user recommendation.

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1. Introduction

The recent growth in the number of computing and mobile devices has resulted in exponential increase in data volumes over the Internet. Apart from the gigantic data volumes, the complex task of managing the concurrently originating data from multiple sources requires Big-data enabled tools and techniques [1]. Big-data refers to the data with high volumes, high dimensionality and veracity, and greater velocity [2]. The trends in rapid growth of data have also been witnessed in healthcare domain besides the electronic commerce and various scientific domains [3]. Traditionally, Big-data related to healthcare originates from the sources, such as the payer–provider data repositories and the genomic-driven Big-data sources. The payer–provider data comprises of the Electronic Health Records (EHRs), pharmacy prescriptions, insurance data, and patients' feedback, whereas the genomic-driven data consists of genotyping data, gene extraction data, and sequencing data [4]. The need to exchange and integrate the electronic medical information dispersed across various points-of-care, laboratories, health insurance providers, and medical research centres obligates the efficient, robust, and cost effective storage and communication infrastructure. In this regard, cloud computing paradigm has exhibited tremendous potential and has also drawn the attention of both the academic institutions and research organizations [5]. Above and beyond the performance benefits of cloud computing and Big-data analytics in the healthcare domain, fiscal concern is also

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among the factors of paramount importance that harnesses the need for Big-data analytics. According to a 2013 survey by McKinsey, the healthcare expenditure of the United States has increased approximately $600 billion more than the expected benchmark [6]. By embracing the cloud computing services in the healthcare domain, the expenditures for infrastructure development and subsequent management can be reduced that can further help in cutting-down the healthcare costs. Moreover, there is also a need to formulate patient-centred methodologies that involve patients themselves to manage their health affairs and devise wellness plans.

To this end, we propose a framework that facilitates the users or patients in offering personalized healthcare services at no cost using the Internet and social media. The framework primarily offers two services namely, (a) disease risk assessment and (b) health experts recommendation from Twitter. To accomplish the task of disease risk assessment, we propose an approach called the Collaborative Filtering-based Disease Risk Assessment (CFDRA). The CFDRA approach works by comparing the profiles of enquiring users with the profiles of existing patients. The typical profile attributes that are provided as input to the framework include age, gender, ethnicity, weight, height, family disease history, and other commonly observed symptoms for a disease. Based on the attributes specified in the users' query, the enquiring users' profiles are compared with the existing users and the users are returned a risk assessment score for that disease. Contrary to the various existing approaches used to make disease assessment for only a single disease, our framework is capable of performing simultaneous risk assessments about multiple diseases for several users.

The second module of the proposed framework recommends the health experts to end-users. To identify the health experts for the enquiring users to seek advice at no cost, we utilized the tweets of the users who regularly use Twitter [7]. The users specify the name of the disease in their query and in turn are offered a ranked list of the experts for that disease. The tweets from health professionals are either related to health issues where the experts are mostly speaking about their experiences with patients or the tweets may be to promote health awareness in the public besides other social tweets. Likewise, large numbers of tweets containing health related terms are by another category of users that are not health professionals. Instead the users may be, (a) current or past patients of a disease whom they talk about more frequently, (b) family members of the individuals suffering from a particular disease, and (c) health activists and journalists who are not doctors. Such users are usually knowledgeable enough to guide the other users or patients having no or little exposure about that disease and therefore, we consider such types of users as the expert users in our framework. However, they are not regarded as the doctor experts. Hereafter, the doctors and physicians are termed as the doctor experts, whereas those mentioned above are characterized as the non-doctor experts. However, it is important for the framework to separate doctors from non-doctor experts. The tasks of user segregation and the subsequent ranking are performed by employing the hubs and authority [8] based approach.

To perform the tasks of disease risk assessment about several diseases for multiple users simultaneously and to process the large tweets repositories to identify and rank the experts, parallel task execution mechanisms and enormous amount of storage are required. Therefore, cloud computing based scalable solutions seem apt not only to support the task of parallelization but also to meet enormous data storage and processing requirements for the proposed framework. The tweet repositories are updated and maintained by executing periodic jobs in offline mode to collect and preprocess the tweets to identify disease specific experts in an efficient manner.

1.1. Research contributions

The main contributions of the paper are as follows:

- We present a cloud based framework that integrates the Collaborative Filtering (CF), social media platform, and social network analysis techniques to manage large volumes of health Big-data.
- We propose an approach for disease risk assessment using the CF. The approach is capable of simultaneously entertaining multiple users' queries to make risk assessments for different types of diseases.
- An expert recommendation module is proposed to help users seek advice from the health experts available on Twitter. The hub and authority based approach is employed to ensure that the users are recommended the most relevant and popular experts (doctors or non-doctors) as specified in the users' queries.
- The experiments for the disease risk assessment are conducted on the National Health and Nutrition Examination Survey (NHANES 2009–2010) dataset whereas the validity of expert user recommendation module is performed on a huge collection of health related tweets. Experimental results testify the effectiveness of the approach in turning the Twitter into a Web based collaborative health community.
- The framework is implemented as a Software as Service (SaaS) to offer scalable processing, storage, and task parallelization.
- The scalability analysis is conducted by increasing the workload and the number of resources for both of the modules.

The remainder of the paper is organized as follows. The motivation for the proposed work is discussed in Section 2. Section 3 discusses the architecture of the proposed cloud based system in detail. Section 4 presents the results and discussion on the performance of the framework in comparison to the state-of-the-art approaches. The related work is presented in Section 5 and Section 6 concludes the paper.

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