Recommending doctors and health facilities in the HealthNet Social Network

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Abstract. In this paper we present HealthNet (HN), a social network that helps patients to meet the best doctor for her health condition. The core component of HN is a recommender system that suggests to the user patients similar to her, and generates suggestions about doctors and hospitals that best match her patient profile. Currently an alpha version of HN is available only for Italian users, but in the next future we want to extend the platform to other languages. We organized three focus groups with patients, practitioners, and health organizations in order to obtain comments and suggestions. All were very enthusiastic by using the prototype version of HN[1].

Keywords: e-health, social network, recommender system, smart health

1 Introduction and Motivations

The *e-health*, defined as the healthcare practice supported by electronic process and communication [3], is changing the landscape of clinical practice and health care. A recent survey demonstrated that 72% of U.S. Internet users looked online for health information within the past years[2]. Similarly, in Italy, 84% of young people between 18 and 35 years old use the Web for looking for health information[3]. This new trend can be defined as an evolution of the word of mouth that generally characterizes the process that firstly conducts a patient to find a solution to her condition. Indeed, in the same above mentioned survey 60% of U.S. adults got information or support from friends and family when they have a health problem and 24% of adults got information or support from other who have the same health condition. Furthermore, the Associated Press-NORC Center for Public Affairs Research in a 2014 survey founds 4 in 10 American people saw information on a ratings website such as HealthGrades.com, Yelp.com, or Angies List as a decisive factor in deciding on a particular doctor[4]. To share

[1] An English demo of HN is available at http://193.204.187.192:8080/HealthNetVideo/
[2] http://www.pewinternet.org/2013/01/15/health-online-2013/
[3] http://it.ejo.ch/tag/eikon-strategic-consulting
[4] http://www.apnorc.org/projects/Pages/HTML%20Reports/finding-quality-doctors.aspx

health information generates a more informed and empowered patient by reconfiguring the patient/care team relationship towards a patient-centered medicine. One of the most relevant initiative in that direction is the U.S. social network PatientsLikeMe (PLM)[5]. This social network enables patients to share, compare and contrast different diagnoses and treatments with people who have the same conditions who are anywhere in the world [1]. PLM counts 300,000 patients sharing 2,300 different conditions. In addition to PLM, there are a lot of forums, blogs, and more generally web sites, that deal with health problems. However, the information available in these websites is often confused, difficult to understand and can lead to easy self-diagnosis often wrong [4].

In this paper we present HealthNet (HN), a social network whose main goal is to help a user in finding a solution for her health conditions. The main idea behind HN is the same as PLM: sharing knowledge, finding similar patients, comparing their experiences. However, the main difference with respect to PLM is the embedded recommender system that is able not only to discover similarities between patients, but also to exploit the data coming from the patient community for suggesting practitioners and hospitals that best fit a patient profile. In this way, HN deters the self-diagnosis since it just helps the patient to find a doctor or a health facility. Differently from a classical recommender system which generally builds a user profiles in order to suggest items potentially interesting for a given user [2, 7, 8], in this work the user profile is the patient health status, and the doctors and health facilities are the goal of the recommendation.

Other Health Related Recommender Systems (HRRS) are presented in the literature [12]. In [13] the authors compare content-based and collaborative recommendation techniques for developing a web-based recommender system for suggesting relevant websites related to prostate cancer. Khan et al. [5] developed a tag-based recommendation engine for suggesting users having similar health profiles, relevant information resources such as articles or blogs on health promotion, and community resources such as local health facilities. In [10] a health recommender system using rough sets, survival analysis approaches and rule-based expert systems is proposed. The goal is to suggest clinical examinations in the case, for example, the patient can afford only a limited number of tests which have to be ranked according to their priority. Roitman et al. in [11] defined a HRRS that combines Personal Health Records (PHRs) and drugs information for avoiding adverse drug reactions. In [6] Morrell and Kerschberg described a system which uses an agent based framework to retrieve content from web resources related to an individual's PHR entries. Even though semantic techniques are already used in the research community for retrieval [9] and recommendation tasks, to the best of our knowledge the HRRS implemented in HN is the first one able to suggest doctors and hospitals by performing a semantic matching between patient profiles.

The rest of this paper is organized as follows. Section 2 describes the platform and its general architecture, and Section 3 draws conclusions and future work.

[5] http://www.patientslikeme.com

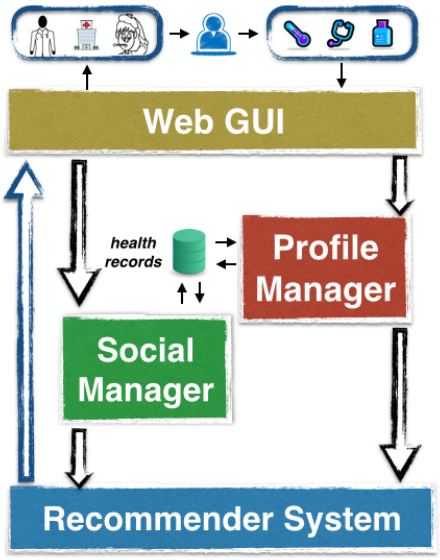

Fig. 1: General Architecture of HealthNet

2 The HealthNet social network

HN is implemented as a standard social network where users are patients. The first step of the interaction with the system is the user registration. After that, the patient can insert her medical data. More specifically, the patient can insert information about: conditions, treatments (e.g., drugs, dosages, side effects, surgeries), health indicators (e.g., blood pressure, body weight, laboratory analysis, etc.), consulted doctors, hospitalizations. In this way, HN centralizes individual's health data allowing a simple and organized access to them. Furthermore, the user can take advantage from sharing her data by obtaining suggestions in terms of doctors, health facilities, and other resources useful for her conditions. In order to receive recommendations the user should insert at least one condition she is affected by. For each condition, the user can click on the "How can I cure it?" button and receives suggestions. It is worth noting that the HN user can decide to be anonymous, by indicating only a nickname during the registration step. Accordingly, the health data inserted in HN are not linkable to a real identity thus preserving the user privacy.

In Figure 1 a general architecture of the platform is depicted. There are three main components: the Profile Manager, the Social Manager, the Recommender System. The interaction with the system occurs through a Web GUI.

2.1 Profile Manager

This component manages all information related to the patient state of health. The Profile Manager allows a user to decide which data she wants to share with the community and which data wants to maintain private. The component manages also information about consulted doctors, hospitalizations, success or failure of therapies/treatments, monitoring. The Profile Manager stores these information in a patient profile which is exploited by the Recommender System for generating suggestions. In the actual version of the system the patient profile is composed of two distinct dimensions: conditions and treatments. These are the only information exploited by the system for computing patients similarities.

2.2 Social Manager

This component manages the activities related to the social network interactions. It allows one to establish relations between patients by means of friendship connections. Friends share their updates, information about drugs, most common conditions or symptoms they are used for, side effects, dosages. The Social Manager also manages the Health Point of Interests (HPOIs). A HPOI is a point of interest which offers services related to the health domain useful for the HN community. A HPOI can be an association which offers home care, or an organization which supports patient relatives, for example. The association or organization which desires to have a page on HN for adrvetising its activities, can sign up on the platform and indicate the conditions for which offers services or facilities. The HPOIs are then suggested by performing a simple matching between the relevant conditions defined by the HPOI owner and the patient condition.

2.3 Recommender System

This is the core component of the system. The Recommender System exploits the profile of the patients to suggest other similar patients as well as the best doctors or hospitals according to a given patient profile. The similarity between patients is computed in terms of shared conditions and shared treatments. The component computes a semantic matching between the conditions by exploring the hierarchy of diseases [6]. The idea is that a patient with prostate cancer and another with testicular cancer, for example, should have a high similarity score since both conditions affects organs belonging to the male reproductive system (in the disease hierarchy). Hence, even though the two patients do not have the same condition can share useful experiences. Similarly, the matching between treatments takes into account not only their names but also the active ingredients (for drugs), and organ it affects (for surgeries). The recommender system combines the similarity score deriving from the patient conditions and the score deriving from the patient treatments to compute a similarity score between two patients. Suggestions of doctors and hospitals are thus ranked by analyzing

[6] http://apps.who.int/classifications/icd10/browse/2010/en

doctors and hospitals consulted by the most similar patients. Furthermore, the ranking takes also into account official quality indicators generated by the Italian Ministry of Health[7].

More formally, the similarity score between two patients is computed as follows:

$$s(p,p') = \alpha \frac{\sum_{i=1}^{k}\sum_{j=1}^{n} s_c(p_{c_i}, p'_{c_j})}{k+n} + \\ +(1-\alpha)\frac{\sum_{i=1}^{z}\sum_{j=1}^{r} s_t(p_{t_i}, p'_{t_j})}{z+r}, \tag{1}$$

where k (respectively n) is the number of conditions p (respectively p') is affected by, p_c is a condition of the patient p, z (respectively r) is the number of treatments for p (respectively p'), p_t is a treatment for the patient p, $s_c(p_{c_i}, p'_{c_j})$ is the condition similarity between c_i, and c_j, $s_t(p_{t_i}, p'_{t_j})$ is the treatment similarity between t_i, and t_j, computed as follows:

$$s_c(p_{c_i}, p'_{c_j}) = \begin{cases} 1 * log\frac{\#C}{\#P_{c_i}}, & \text{if } c_i = c_j \\ \frac{1}{sp(c_i,c_j)}, & \text{otherwise} \end{cases} \tag{2}$$

$$s_t(p_{t_i}, p'_{t_j}) = \begin{cases} 1, & \text{if } t_i = t_j \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

If the two conditions are the same, the similarity score s_c is equal to a weight computed as the ratio between the number of conditions in the database ($\#C$) and the number of patients affected by that condition ($\#Pc_i$). The goal of this additional weight is to give higher similarity to patients which share rare diseases. If the two conditions are different the score s_c is computed as the reciprocal of the length (number of edges) of the shortest path sp which connects the two conditions in the disease hierarchy. More simply, the treatment similarity is 1 when the treatments are the same or (for drugs) have the same active ingredient, 0 otherwise. Treatment similarity and condition similarity score can differently contribute to the patient similarity score by changing the α value. The patient similarity is thus used for ranking the list of suggested doctors and hospitals. Doctors and hospitals are ranked according to the *scoreDoc* and *scoreH*. The *scoreDoc* for the doctor d_z and the patient p_i is computed by multiplying for each patient p_j in the database the similarity score with p_i and the rating assigned by p_j to the doctor d_z. Similarly, the *scoreH*, takes into account the similarity patient, the user rating r_j for a given hospital h_m and a quality indicator produced by the Italian Health Ministry for each Italian hospital[8]. The community indicator and the ministry indicator can be differently weighted by changing the β value.

[7] For each hospital the number of admissions and the number of deaths are reported for a given treatment. http://95.110.213.190/PNEed13/

[8] http://95.110.213.190/PNEed13/

$$scoreDoc(d_z, p_i) = \sum_{j=1}^{p} s(p_i, p_j) * r_j(d_z) \tag{4}$$

$$scoreH(h_m, p_i) = \beta \left(\sum_{j=1}^{p} s(p_i, p_j) * r_j(h_m) \right) (1 - \beta) qi(h_m) \tag{5}$$

3 Conclusion and Future Work

In this paper we presented HealthNet, a health social network available in alpha version for Italian users. HN suggests doctors or health facilities for a given patient condition by using experiences shared from the patient community. The recommender system implements a semantic matching able to compute a similarity also between patients which do not share the exact same condition. We are building a dataset in order to test our algorithm trough an in-vitro experimental evaluation. Subsequently we intend to perform a case study with real users. In the future work we want to extend the system to other languages, evaluate different similarity measures and allow user to export and share (e.g, with her practitioners) all her health data.

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