AN INNOVATIVE APPROACH TO DERIVE TRUST FROM SOCIAL NETWORKS AND TO IMPROVE THE MATCHING IN DENTAL CARE RECOMMENDATION SYSTEMS

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Abstract

Social trust has been gradually transitioned from face to face to online platforms due to the increasing engagement by the internet users in online social networks. This study looks at how this affects the way medical professionals, and dentists in particular, are recommended and chosen. Based on the literature, analysis of online dental reviews and a survey, it finds that subjective qualities of both dentists and patients are important aspects of the social trust. In order to analyse those qualities, this study introduces an innovative trust-based information model to evaluate those important subjective qualities. The model evaluates 4 trust components: context, relationship, reputation and personality analysis. Dentists and patients are profiled using this model and information extracted from social networks. Dentists are profiled using subjective qualities derived from online dental reviews and patients are profiled using subjective information such as level of dental fear and personality traits, collected from the survey with 580 participants. This paper provides an overview of dentists’ profiles from online reviews and that of patients from the survey results, on a particular example as an illustration. The result of this study can be used to define a set of rules to improve the matching between patients and dentists in dental care recommendation systems.

Keywords: Social trust, explicit and implicit trust, recommendations, social networks, dental reviews, innovations, user profiling.
1 INTRODUCTION

Reviewing and ranking products, organisations and professionals as service providers is one of the core activities the internet users perform in social media. The number of reviews and rankings are increasing and impacting how products and services are recommended. Traditionally, health information is sourced from health care professionals but an increasing number of healthcare consumers turn to websites and social media nowadays for their health issues (Ratzan 2011; Eysenbach 2008; Sillence 2007). Emergence of social networks has been useful to facilitate meaningful recommendations promptly (Hackworth & Kunz 2011; Eytan et al. 2011), and thus recommendation systems are gaining popularity. For example, Amazon for books, TripAdvisor for hotels, urbanspoon, zomato for restaurants, pandora, shazam for music, Netflix, Rotten Tomatoes, IMDb for movies etc. In dental care as well, there is an upward trend that internet users are using dental care related websites for searching and reviewing dentists online. Dental care recommendation systems are relying on patient’s reviews and rankings based on specific evaluation criteria of their sites. The general consensus about dental treatment is that the most of the patients have dental fear and anxiety (Carter et al. 2014; Armitage & Reidy 2012). The invasive nature of dental treatments and associated dental fear raises the need of trustworthy information to be included in the dental care recommendations systems.

In this study, trust from the social networks has been explored to enhance the matching between dental patients and dentists. While reviewing medical professionals like dentists, their patients usually describe them with their subjective qualities such as how good they explain the treatment and/or treat them. These subjective qualities of dentists are important for any new patient who is contemplating to choose a dentist for dental treatment; therefore, the dentists are profiled from their subjective qualities in this study. Breen and Greenberg (2010) pointed that some medical professionals are better than others in dealing with difficult patients. Patients also need to be classified from their subjective qualities, while analysing what they have said about a particular dentist. It is critical that subjective qualities of patients should also be included while profiling patients because the same dentist has been reviewed differently by various types of patient for the same treatment.

Trust based information model is proposed in this study to analyse subjective qualities of both dentists and patients to improve the matching in dental care recommendation systems. Although there is a potential in classifying social network users based on their subjective qualities by analysing their online activities such as postings and other interactions, privacy and identification challenges in social media deters it. Hence, we have used level of dental fear and personality traits from one of the popular personality tests, called DISC personality test, as subjective qualities to profile dental patients (Pradhan et al. 2014) in addition to usual objective criteria such as location, types of treatment, age group, type of insurance cover etc.

In this paper, various sources of the social trust that can be derived from the social networks are addressed. Trust related information generated from different sources which can be included in their profiles is discussed. Based on the responses from 580 participants in a survey, a set of rules that can be applied to improve the matching based on their subjective qualities, is illustrated for a specific type of patients.

Current trend and evaluation criteria of existing dental care recommendation systems are reviewed in section 2. In section 3, the importance of social trust and how it can be derived from social networks is discussed. Various sources of explicit and implicit trust from social networks are briefly discussed in this section. Using social trust in profiling is discussed in section 4. Some results on profiling based on subjective aspects are discussed in section 5. An example of the recommended list of dentists while matching a particular type of patient is demonstrated in section 6. Finally, conclusion is drawn with future directions to improve the matching in dental care recommendation systems.
2 DENTAL CARE RECOMMENDATION SYSTEMS

As the growth of social media is influencing the way information is found on the web (Ngai et al. 2015), healthcare consumers such as dental patients are turning to digital media such as blogs, search engines or online social networks (OSNs) for any kind of dental information including symptoms, diseases, drugs, treatments and even how to find dentists. There are many sites where the dental patients can search for dentists or dental practices and read online reviews from previous patients of the dentists. These sites help patients who are looking for a new dentist for specific dental treatments. Some of the sites are created to recommend dentists while other sites provide the means for users to voice their opinions or rank the dentists in particular locations based on various criteria and ratings (DentistReviews 2015). Some of them allow reviewers to be anonymous but others require the provision of correct names and IDs.

2.1 Usage trend in dental care recommendation systems

There are only a few dedicated dentist review and rating sites exist, such as DentistDig¹, DentalFearCentral², RateADentist³, NationalDentalReviews⁴, DrOogle⁵ etc. But, there is a significant increase of visitors to the dentist reviews site. For example, DrOogle, a dedicated dentist’s guide in the US, had a substantial growth of monthly visitors from 60,000 in 2009 to 106,155 in 2014. Since dental professionals fall under the category of health, dental professionals have been also listed under other health professionals rating sites such as ‘RateMDs’⁶ and ‘HealthGrades’⁷. In addition, the generic review site ‘Yelp’⁸ has been gaining popularity in the US for dentist reviews, which allows patients to post reviews/comments about their visits to their dentists. The DentistReviews site uses reviews from Yelp to rank the dentist in any given location within the US. Amongst them, DrOogle is one of the most dedicated review sites for dental professionals in the US as it provides rankings of dentists in specific location based on positive reviews of patients (DrOogle 2015). Table 1 shows average monthly visitors to the reviews sites in the years 2009 and 2014.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Year 2009</th>
<th>Year 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>DrOogle.com</td>
<td>60,000</td>
<td>106,155</td>
</tr>
<tr>
<td>DentalFearcentral.org</td>
<td>19,500</td>
<td>51,404</td>
</tr>
<tr>
<td>Dentistdig.com</td>
<td>5,200</td>
<td>15,026</td>
</tr>
<tr>
<td>Healthgrades.com</td>
<td>2,000,000</td>
<td>9,352,220</td>
</tr>
<tr>
<td>Yelp.com</td>
<td>6,500,000</td>
<td>36,177,527</td>
</tr>
</tbody>
</table>

Table 1. Average monthly visitors (source: DentistReviews 2015)

2.2 Likelihood of using online sources by dental patients

Two separate surveys conducted in this study found that many dental patients are willing to use online search methods or dental care recommendation systems to find their dentists. In the first survey, out of 183 participants, almost 50% of the participants mentioned that they would be likely to use the recommendation system for dental care if the system was available to them. In the second survey, out of 580 participants, only 12.12% used online search methods to find their existing dentist, however

¹ www.dentistdig.com  
² www.dentalfearcentral.org  
³ www.rateadentist.com  
⁴ www.nationaldentalreviews.org  
⁵ www.doctoroogle.com  
⁶ www.ratemds.com  
⁷ www.healthgrades.com  
⁸ www.yelp.com
40% of them indicated that they would go online to find their next dentist, ahead of most popular methods such as family, friends, peer workers, doctors, or local search. 22.22% ranked online as the first preferred method, however, 6.4% and 11.45% of them ranked as second and third consecutively. Figure 1 below shows the results from those two surveys side by side.

![Figure 1](a) Likelihood of using dental care recommendation system in the first survey and (b) Percentage of participants who chose online methods to find a dentist in the second survey.

### 3 IMPORTANCE OF TRUST FACTORS

Trust becomes a critical factor to find a right dentist due to the invasive nature of dental treatment and associated dental fear. Trust depends on many factors such as past experiences, opinions of actions, rumours, influence from others’ opinions, and many others (Thirunarayan et al. 2014; Kim & Ahmad 2013). Most of the people often make their healthcare decisions based on the recommendations from people they trust (Morris et al. 2010; Swaringen & Sinha 2001). The trusted people are most likely to be good friends and family members. The experience perceived by the patients during the dental treatment about how the dentist handled the situation impacts on how much the patients trust them. The patients share their experience during the dental treatments in their social networks whether it is online or offline. Hence, a platform like social media is an excellent place for patients to discuss their experience in dental treatments. Understanding who shared what, why and which information is useful and the trustworthiness within the network are important for recommendations. This adds another level of complexity to the nature of trust in the social media environment and makes the trust concept even more dynamic. But such type of information helps exploring social trust which can improve the matching between patients and dentists. These types of information can be classified into two main categories: explicit and implicit information.

#### 3.1 Trust derived from explicit and implicit dental care information

Through social networks, it is possible to capture both explicit and implicit information (Alsaleh et al. 2011). Explicit information is usually collected by asking direct questions such as demographic information, preferences and other characteristics. For example, for dental care recommendations, age groups, frequency of visits to their dentists, type of dental treatments, types of insurance covered, etc. This sort of information is used to filter appropriate dentists in existing dental care recommendation systems. Meanwhile, social networks are also able to capture users’ activities and behaviours (implicit) information such as postings, sending messages, watching profiles, etc. There are two kinds of activities or behaviours that take place online: active and passive. Active behaviours by the users are, for example, sharing information, sending invitations, commenting on posts and ratings. However,
reading other users’ posts, viewing contents, etc. are passive behaviours on the OSNs. Taking both active and passive behaviours into consideration, a behaviour graph can be drawn to understand the behaviours of the users (Nepal et al. 2013). Thus, credibility and reputation of users within the network can be determined and their influence in the network can be measured. Previous patients’ genuine views and their experiences can impact the way the new patients trust the information in the network and the particular dentist that they are contemplating on.

Many researchers (Guo et al 2014; Zhang & Yu 2012; Tselenti & Danas 2012; Alsaleh et al 2011; Bhuiyan et al. 2010) pointed out some issues with existing trust models that matching algorithms are only based on explicit information and the recommendations are made without any real values. Real meaningful relationships cannot be investigated without understanding implicit information. Therefore, implicit trust based on the activities and behaviour of the users should be considered to enhance recommendations. Zhang et al. (2013) analysed the outcome from a Facebook group concerning diabetes information and emphasised that a coherent group can produce valuable knowledge to benefit the group and eventually wider society. The same principle applies for finding a suitable dentist in the dental care social network. Strength of relationships and the reputation trust among patients as users within the social network constitute the foundation for the success of the dental care recommendation systems.

The more the dental patients share their honest opinions, the more likely the recommendation systems will be able to filter a suitable dentist, and hence gain reputation and popularity among the users. These types of information is broadly categorised into the following 3 types of sources of trust:

- Trust among dental patients as users
- Trust in the dental care recommendation system
- Trust in dentists or dental practices

Trust generated from the dental patients in the network and the trust relationship between dental patients and dentists have an impact on the way new patient trust the dental care recommendation systems. They are all facets of the same trust and interdependent on each other in such a way that when one dimension is strong, other two dimensions would also be strengthened.

4 AN INNOVATIVE APPROACH TO TRUST

The intention to use the recommended dentist from a dental care recommendation system depends on the level of trust in the system first (Hou & Shim 2010) and then the dentist. Trust components related to dental care recommendation systems are investigated from multiple perspectives. The suitability of a dentist for a patient can be investigated and analysed from many aspects for dental care recommendation systems and discussed below.

4.1 Analysis of trust for dental care recommendations

Trust can be evaluated from multiple perspectives for dental care recommendation systems. In this instance, trust is analysed by asking all 7 ‘WH’ questions (who, when, why, where, what, which and how) to understand the relevance in the context of suitability of dentist to a patient. For example, the referral trust can be analysed from who has referred, when the referral was made, why are they referring, where was the patient at the time, which part of the service is referred, how the referral was provided to the patient, etc. A few more questions related to ‘WH’ questions are listed in the table below and referred as the explicit or implicit nature of questions. Reliability of the recommendation is another crucial factor while recommending a suitable dentist. A patient who is recommending should have an identity in the network with a profile. The relationship with a particular patient and credibility as an identity (who is this user) are important factors for someone who takes this user as a trusted referral party.

So trust can be measured from many different aspects and some of them are exhibited in the table below.
<table>
<thead>
<tr>
<th>WH</th>
<th>Questions (for example)</th>
<th>Types of Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who</td>
<td>Who recommended the dentist?</td>
<td>Explicit</td>
</tr>
<tr>
<td></td>
<td>Who has been to the same dentist and provided a positive rating?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td></td>
<td>Who is a trustworthy user?</td>
<td>Explicit</td>
</tr>
<tr>
<td>When</td>
<td>When was the review written?</td>
<td>Implicit</td>
</tr>
<tr>
<td></td>
<td>When did the person recommend the dentist?</td>
<td>Implicit</td>
</tr>
<tr>
<td></td>
<td>When did the patients share symptoms or opinions?</td>
<td>Implicit</td>
</tr>
<tr>
<td>Why</td>
<td>Why did the patient review the dentist?</td>
<td>Implicit</td>
</tr>
<tr>
<td></td>
<td>Why did the patient see the dentist?</td>
<td>Explicit</td>
</tr>
<tr>
<td></td>
<td>Why is this dentist so popular among others?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td></td>
<td>Why is the dentist recommended by the system or others?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td>Where</td>
<td>Where did the patient find this dentist?</td>
<td>Explicit</td>
</tr>
<tr>
<td></td>
<td>Where was the place when this treatment was done?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td>What</td>
<td>What aspect of the dentist did the patients like?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td></td>
<td>What makes this dentist stand out in the list?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td></td>
<td>What is the reason the patient chose the dentist?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td>Which</td>
<td>Which treatment was done?</td>
<td>Explicit</td>
</tr>
<tr>
<td></td>
<td>Which dentist was chosen and why?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td></td>
<td>Which system was used to choose dentist and why?</td>
<td>Explicit and implicit</td>
</tr>
<tr>
<td>How</td>
<td>How did the patient find the dentist?</td>
<td>Explicit</td>
</tr>
<tr>
<td></td>
<td>How was the treatment done?</td>
<td>Explicit and implicit</td>
</tr>
</tbody>
</table>

Table 2: List of ‘WH’ Questions to analyse types of Trust

The timeliness of the recommendations is another important factor for the dental care recommendation system. Hence, recommendations based on when and which information are critical to determine the suitability of a dentist for a patient. For example, old reviews may not be appropriate to measure the current subjective quality of a dentist. Similarly, ‘where’ (in terms of which online platform or system) is used for reviews, plays a significant role in terms of trusting the platform. In this context, ‘where’ may even refer to the geographical location and how far from where patient is situated.

Reviews are generally written when the users are either genuinely very happy (positive feedback) or very unhappy (negative feedback). It is important to have a mechanism to check the integrity of the feedback or other sources of recommendations (Kugler 2014) so that it is not created to benefit a party as a bias or fraud (shilling attacks). Understanding the genuineness of the information in terms of why the review was written is paramount. That is one of the reasons why we propose to analyse information from multiple perspectives. The semantic meaning of some words depending on the culture may have different meanings. In which context and where the information is generated from are therefore important to consider when considering the recommendation for a suitable dentist.

Figure 2. Integration of trust components with three dimensions
4.2 Integration of trust components and trust dimensions

The proposed model (Pradhan et al. 2015) analyses and evaluates trust related information available in the social networks from the previously mentioned three different dimensions of trust a) other dental patients b) dentists or dental practices and c) dental recommendation system. Hence, the trust components are analysed from each dimensions as shown in Figure 2 above. For example, a new patient can evaluate trust with other users in the network which would influence the decision in choosing a dentist. Trusting dentists or dental practices and recommendation systems are majorly influenced by the other users in the social networks as well as their own subjective qualities.

5 USING SOCIAL MEDIA INFORMATION TO PROFILE

User profiling is the backbone of any recommendation system. For the dental care recommendation system, user profiling for both patients and dentists are envisioned by integrating the trust factors discussed in the previous section and briefly described below.

5.1 Patients’ profiles

Patients’ profiles have rarely been recorded by existing dental care recommendation systems except through cookies, which are temporary. Patients are only given to choose from a list of objective criteria such as location, type of dental treatment, insurance cover etc. As per the proposed model, patients are profiled based on other information such as relationships, individual personality and their subjective characteristics, the situations they are in, the types of relationship with previous patients of the same dentist, word of mouth or referrals from other patients and the perceived reputation from previous posts shared in the network. Existing review sites do not have provisions to provide any situational information from patients and therefore cannot be used to profile the reviewers. Specific questions about the dental condition, symptoms and other information such as ‘how long the patient has been feeling pain?’ or details about other previous treatments or medications, avoided medications, etc. can help to clarify the situation of patients so that profiling can be enhanced.

Although, profiling users from online social networks has been gaining popularity, there is not enough information about dental specific posts or information online to be able to profile dental patients as yet. It is anticipated that more subjective information on dental patients from other social networks such as Facebook, Twitter, Google+, Pinterest, Tumblr, etc. will be possible in the future, which will provide abundant implicit information to profile patients more accurately. Due to the privacy and identification challenges in the social networks, we have integrated the level of dental fear and the personality traits. From the online survey, only the regular dental patients were identified and profiled from their fear level and personality traits (Pradhan et al. 2015).

5.2 Dentists’ profiles

Dentists are usually classified based on their degrees and qualifications for their speciality in dentistry, the price for specific treatment and the number of years of experience, etc. But in this study, dentists are profiled based on subjective qualities extracted from online dental reviews. Patients care about what the previous patients experienced from their dentists, the way dental procedures are explained and many other details which are usually discussed in the dental reviews the patients write after visiting their dentists. Therefore, online dental review sites are explored to see how patients describe a particular dentist. Dental reviews from two of the most popular dental crowdsources in the USA; DrOogle and Yelp, are used to analyse subjective qualities of dentists, in this study. In the dental reviews, patients often provide subjective descriptions of dentists. After analysing these words, the terminologies used to describe dentists are classified into 10 dentists’ qualities: Friendly, Caring, Professional, Experienced, Knowledgeable, Explains well, Recommendable, Quality of service (QoS), Reliable and Good personality. Similar words which describe certain characteristic of dentists from the list, are grouped together to profile them.
6 MATCHING BASED ON SUBJECTIVE QUALITIES

Specific matching rule for a particular type of patient is constructed by analysing results from the survey. Based on objective and subjective criteria selected, the patient can be matched with the most suitable dentist. From the survey, other variables such as age group, frequency of visits, types of treatments etc. are collected. These variables are added to filter and create new matching rules for a particular type of patient. For example, a type of patient ‘x’ who belongs to personality trait ‘Perfectionist’ and other variables selected from the survey as shown below:

Perfectionist, Age group (26-35), fearful, visits for scaling and visits dentist annually.

Their preferred dentists’ qualities for ideal dentist are recorded in the second column of Table 3 below. Matching rules are formulated based on the preferences of subjective qualities of dentists for certain type of patients. Nearest neighbour classification is used to construct the rule for the patient type ‘x’ and tested for a random list of dentists from New York. Let’s say from the list of 7 random dentists with more than 30 reviews are named, Dentist A to G. Their profiles are shown in the table below.

<table>
<thead>
<tr>
<th>Dentists Qualities</th>
<th>Patient ‘x’</th>
<th>Dentist A</th>
<th>Dentist B</th>
<th>Dentist C</th>
<th>Dentist D</th>
<th>Dentist E</th>
<th>Dentist F</th>
<th>Dentist G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced</td>
<td>0.288</td>
<td>0.16</td>
<td>0.24</td>
<td>0.09</td>
<td>0.18</td>
<td>0.17</td>
<td>0.10</td>
<td>0.16</td>
</tr>
<tr>
<td>Professional</td>
<td>0.22</td>
<td>0.11</td>
<td>0.08</td>
<td>0.15</td>
<td>0.07</td>
<td>0.11</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
<td>QoS</td>
<td>0.14</td>
<td>0.05</td>
<td>0.08</td>
<td>0.07</td>
<td>0.18</td>
<td>0.11</td>
<td>0.17</td>
<td>0.07</td>
</tr>
<tr>
<td>Knowledgeable</td>
<td>0.12</td>
<td>0.01</td>
<td>0.13</td>
<td>0.08</td>
<td>0.03</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Caring</td>
<td>0.07</td>
<td>0.05</td>
<td>0.11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Friendly</td>
<td>0.05</td>
<td>0.16</td>
<td>0.12</td>
<td>0.13</td>
<td>0.17</td>
<td>0.17</td>
<td>0.22</td>
<td>0.23</td>
</tr>
<tr>
<td>Reliable</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0.01</td>
<td>0</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Explains well</td>
<td>0.05</td>
<td>0.19</td>
<td>0.02</td>
<td>0.17</td>
<td>0.11</td>
<td>0.16</td>
<td>0.07</td>
<td>0.18</td>
</tr>
<tr>
<td>Recommendable</td>
<td>0.02</td>
<td>0.15</td>
<td>0.08</td>
<td>0.23</td>
<td>0.18</td>
<td>0.18</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Personality</td>
<td>0</td>
<td>0.11</td>
<td>0.15</td>
<td>0.07</td>
<td>0.09</td>
<td>0.08</td>
<td>0.11</td>
<td>0.07</td>
</tr>
<tr>
<td>Nearest distance</td>
<td>0.99</td>
<td>0.66</td>
<td>0.96</td>
<td>0.93</td>
<td>0.93</td>
<td>0.93</td>
<td>0.90</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Table 3: Example of dentists’ qualities preferred by Patient type ‘x’ versus available dentists

Taking all dentists’ qualities into consideration, the list is filtered by finding out the difference between the weightings of the dentists’ qualities and the preferred dentists’ qualities by the patient type ‘x’. The recommended list of dentist is shown in the descending order such as: Dentist B (0.66), Dentist G (0.90), Dentist D (0.93), and so on.

7 CONCLUSION AND FUTURE DIRECTIONS

Finding a dentist has become easier with the growing popularity of online review and rating sites and social media. However, due to the invasive nature of dental treatments, trust is an important issue for patients to determine the suitability of a dentist. Traditionally, the most trusted people in a person’s life, such as friends and family, are the major sources for dental referrals. Since the number of social networking users is growing, online information has been accepted more than before. This inherent trust can assist users when filtering a list of dentists to identify a suitable dentist for a particular need. This study considered the preferred criteria of dental patients when they search for a dentist. Online dental reviews were examined to extract the most commonly used words to describe dentists and profiled them. However, patients are profiled from subjective information collected in the survey such as level dental fear, personality traits and others. The matching between patients and dentists based on subjective qualities are determined as per the results from the survey. Certain matching rules are recommended to enhance trust in the dental care recommendation systems.

In the future, this study will continue to explore profiling of patients from their activities found in their social networks. With the increased number of users in the social networks, it will be easier to see the relationships between users to measure the social influence on dental recommendations as well. This sort of influential factor can be added to enhance the recommendations.
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