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Completed Research Paper

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Abstract

People rely on their trusted circle of friends for advice and recommendations on everything from travel destinations to purchase decisions. With the extensive use of social networks these relationships are now taken to an electronic platform, where they manifest as likes, comments, wall posts, etc., on social media networks. This paper explores the novel idea that such user relationships can be extracted to significantly improve the accuracy of commercial recommendation systems by identifying otherwise hidden relationships between users. A multiple linear regression based model capable of extracting such user relationships and their corresponding strength efficiently is introduced under this research and the above hypothesis is tested by integrating the predictive model to an existing social media based travel recommendation system. Finally, experimental results of the proposed model are produced, proving the capability of the model in achieving a significant increase in accuracy in travel recommendations, affirming the considered hypothesis.

Keywords: Tie Strength, Social Networks, Social Media, Travel Recommender Systems, Collaborative Filtering

Introduction

Humans in nature would rely on others they trust for advice and support when it comes to decision making. With social media now rapidly taking over the relationships we maintain, our preferences and decision making is heavily influenced by the relationships we maintain online (Håkansson et al. 2015; Matook et al. 2014). In simpler terms, people tend to do what others closer and similar to them recommend or have already done.

Based on this observation, user relationships maintained in social media sites can be analyzed to understand how recommendations from similar and trusted users influence the decision making and information seeking process of an individual (Power et al. 2011). A model that can predict such relationships can be used in recommendation systems (such as e-commerce, travel recommendations, etc.) to produce more accurate and suitable recommendations which are more likely to be accepted by users as they are already “tried and tested” by their trusted circle of friends on social media. The applications of such a model are diverse and the commercial value is identified to be significant (Kietzmann et al. 2011). Therefore, the rest of the paper limits its focus on developing a predictive model that can cater to commercial travel recommendation systems to improve their predictive power.

Thinking in the lines of online social relationships, it is identified that not all relationships influence users in the same significance. A popular concept known as tie strength should be considered when determining which relationships are important in which situations (Granovetter, 1973). Existing literature has established that stronger relationships influence the decision making and information seeking behavior more prominently (Panovich et al. 2012) while certain researchers have used this knowledge to implement solutions that can recommend new friends on social media (Naruchitparames et al. 2011). But research contributing towards a model that can efficiently predict the strength of a relationship between two given users using social media data for travel recommendation purposes is still lacking. Thus, the research questions of the study are:

RQ (1): What are the factors (tie-strength dimensions) that will impact the tie strength between two users to provide travel recommendations?

RQ (2): How tie-strength dimensions will influence personalized travel recommendations?

This paper introduces novel multiple linear regression based model which uses a significantly less number of variables to efficiently predict the strength of a relationship between any two users who are friends on Facebook. The experimentation has been conducted with the aim of using this model to improve a context aware and personalized travel recommendation system.

The rest of the paper is arranged as follows. The second section of the paper will set the necessary background understanding on the approach undertaken, while the third section of the paper discusses the methodology undertaken by the authors in developing the solution. The fourth section of the paper will illustrate the experimental results, followed by a concluding section summarizing the findings and observations established.

Background

Social Media Oriented Travel Recommendation Systems

Since travel planning is a tedious and a time consuming activity, the requirement for a personalized travel recommendation system that can extract the genuine travel preferences of a user is significant. The latest trends in existing literature encourage using social media networks such as Facebook, Flickr and Twitter to extract users’ travel preferences and sentiments towards the places they have previously travelled (Majid et al. 2013; Meehan et al. 2016; Cheng et al. 2013). Furthermore, it was identified that the existing recommendation systems support the use of collaborative filtering to recommend unvisited places in a new city or a country to a given user (Jiang et al. 2015; Costa et al. 2012).

Based on the above observations the authors have developed a robust travel recommendation system, in the form of a mobile application that can easily make travel recommendations to users, by extracting their travelling preferences represented as Facebook check-ins (Wijenayake et al. 2017). A sample Facebook check-in considered in this study is given in Figure 1. This solution implements user-based collaborative filtering to make personalized recommendations to users, extracting the sentiment of a user towards a particular location s/he has visited via the posted comments, likes and hashtags to the relevant check-in on Facebook (Chathurika et al. 2017) and then uses this intelligence to make recommendations to unvisited locations around the current location of the user identified through the mobile phone.

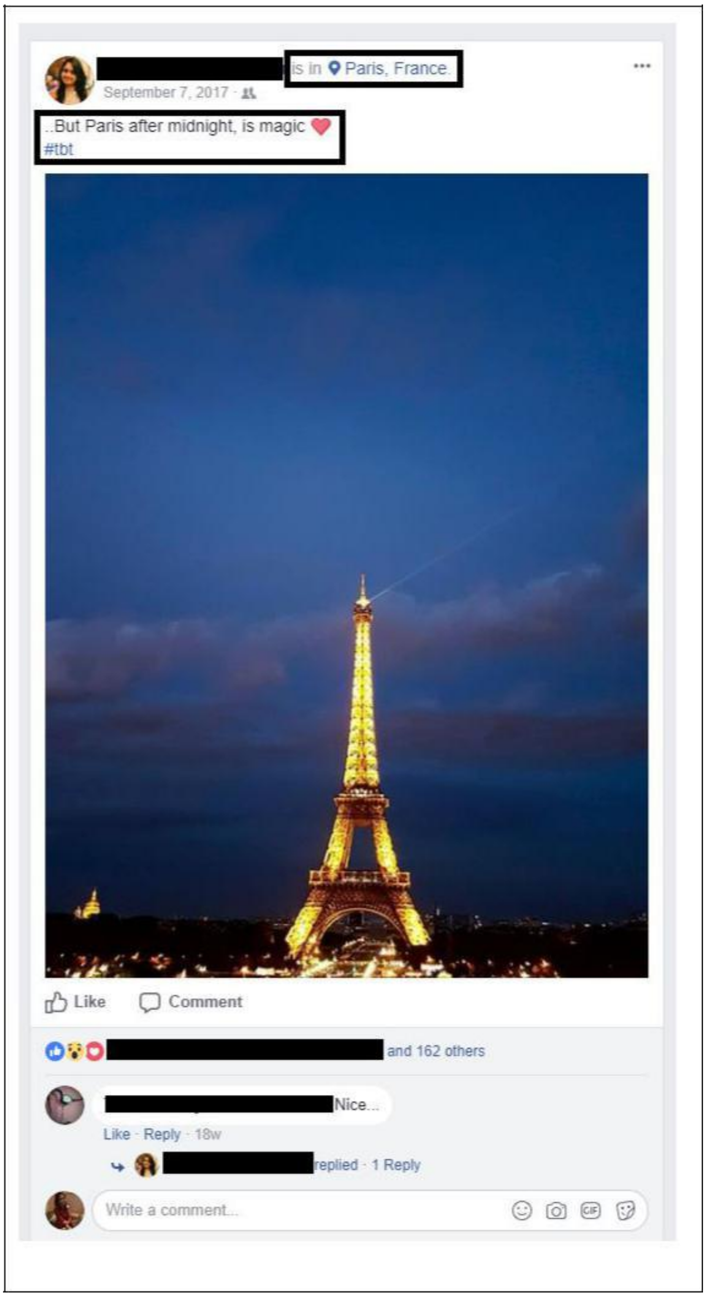


Figure 1. A standard Facebook check-in of a user with a location tag, hashtags, a message describing the user's sentiment and comments

The approach introduced in this paper aims to improve the user-based collaborative filtering mechanism popularly undertaken by such travel recommendation systems. User-based collaborative filtering basically assumes that people who have travelled to the same locations and rated them similarly, are similar in travelling preferences and thus will rate a new location in the same manner (Breese et al. 1998). Moreover, the state of the art recommendation algorithms traditionally uses the Pearson's correlation coefficient is used to measure similarities between users (Adomavicius et al. 2005), to identify top similar users so that a new location can be rated from the perspective of a user, based on how the identified similar users have rated this location. In other words, the accuracy of the recommendation depends on how well the model can identify as many similarities between users as possible.

However, the traditional approach only considers the location based similarities between two users extracted based on how they have rated the same location. Thus, other hidden similarities and relationships between users are missed in the conventional approach illustrated in Figure 2. Therefore, a system which is already integrated with the social network of a user and implements collaborative filtering can highly benefit from a model that can exploit the readily available social media data to extract hidden relationships and similarities between users.

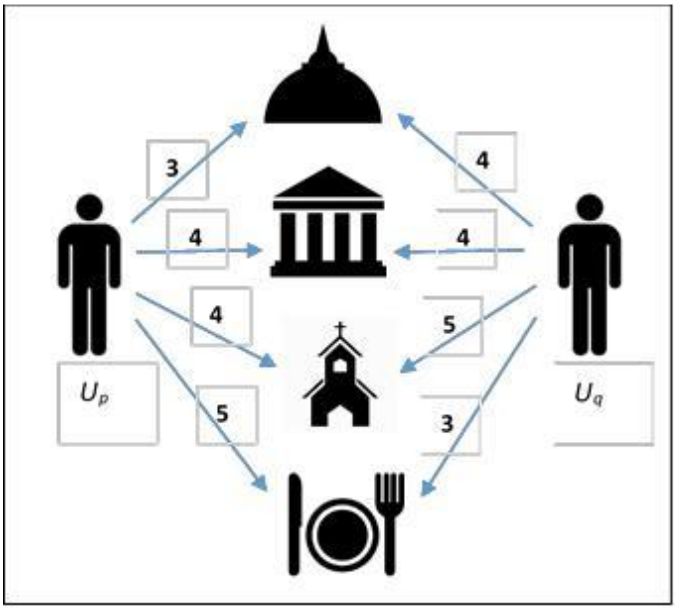


Figure 2. The traditional approach to measuring user similarities in recommendation systems based on how similarly the users have rated the locations they have both visited

Online Relationships Among Users with Different Intensities and Tie Strength

When considering relationships between users especially in the context of social media, the concept of "tie strength" is important because not all relationships influence people in the same way. According to popular literature (Granovetter, 1973) on the topic, tie strength can manifest at least under seven dimensions namely, intensity, intimacy, duration, reciprocal services, structural, emotional support and social distance, and can be identified through variables such as wall words exchanged, days since last communication, number of friends in common, age and education difference, etc., in social media (Burke et al. 2014).

The approach introduced in this paper, experiments on a model capable of identifying tie strength between any two users on Facebook, via an effective number of variables representing their onlinerelationship, which can be connected with social media oriented recommendation systems to better identify hidden similarities and relationships between users, to give them more accurate recommendations.

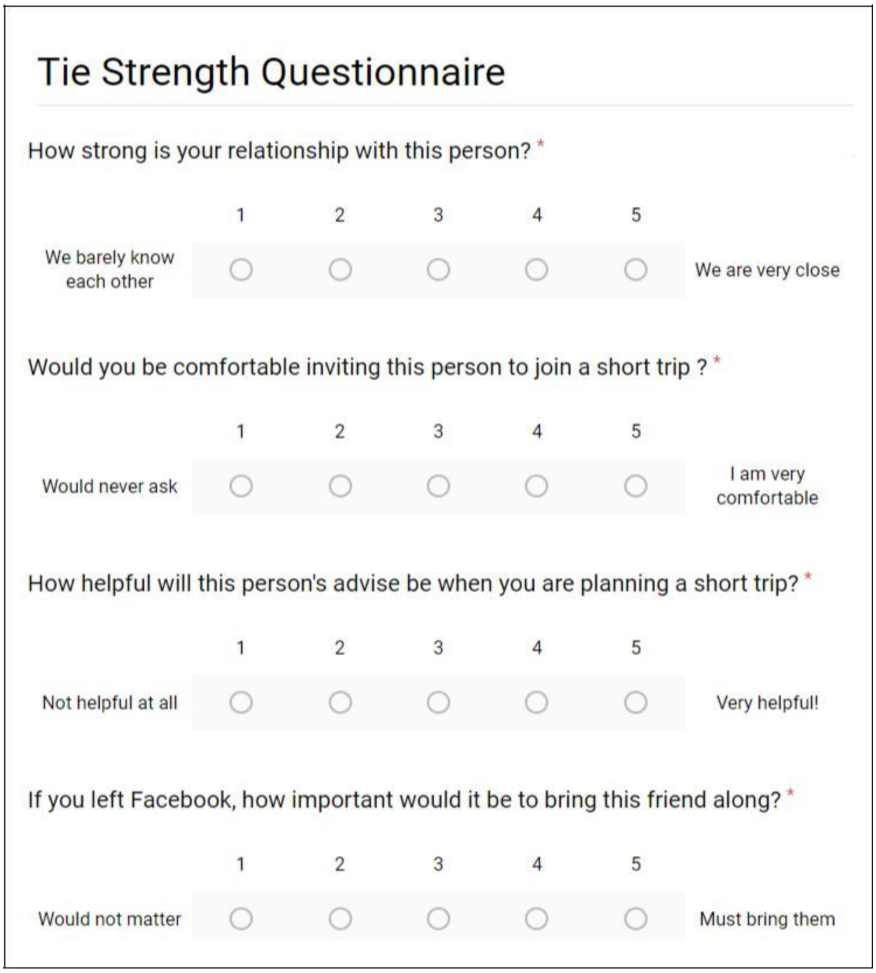
Methodology

Data Extraction

In order to create a test data set, a group of 40 undergraduates in the age range of 21 to 27, from both genders were considered for the data extraction process. To gain the most amount of data from the least number of participants, it was ensured that every participant was friends on Facebook with every other participant. A Python script was used to automate the extraction of the complete Facebook profile of a user including the public profile, wall posts, comments, likes, tagged locations, pictures taken together, friend list, etc. While the script collected the data, each participant was asked to rate the relationship with every other participant via a well-structured questionnaire.

Dependent Variable – Tie Strength

Determining tie strength between any two given Facebook friends was one of the main steps in resolving the research questions of this study. Therefore, to quantify the strength and the influence of the relationship between two given users when obtaining travel recommendations from each other, a simple questionnaire with four questions was designed. The questionnaire was designed after an extensive study on how to design research questionnaires (Burgess, 2011) to optimize the data extraction process. Since the research was conducted with the intention of integrating the model to travel recommendations, four questions were structured to capture the relationship strength between two users and its influence on travel recommendations as shown in Figure 3. Participants were instructed to rate the strength of each relationship using a scale of 1 to 5, where 1 signifies the lowest significance and 5 the highest significance.



Tie Strength Questionnaire

How strong is your relationship with this person? *

	1	2	3	4	5	
We barely know each other	○	○	○	○	○	We are very close

Would you be comfortable inviting this person to join a short trip ? *

	1	2	3	4	5	
Would never ask	○	○	○	○	○	I am very comfortable

How helpful will this person's advise be when you are planning a short trip? *

	1	2	3	4	5	
Not helpful at all	○	○	○	○	○	Very helpful!

If you left Facebook, how important would it be to bring this friend along? *

	1	2	3	4	5	
Would not matter	○	○	○	○	○	Must bring them

Figure 3. Tie strength questionnaire used to extract relationship strength between the participants

Since tie strength and its impact need to be summarized into one value, as the next step the Cronbach's alpha method was used to determine if the results of the four questions can be integrated to only one value. Cronbach's alpha calculation is a popular methodology used to determine internal consistency in questionnaires to see how closely related the questions are to one another (Tavakol et al. 2011). A higher alpha value allows the ratings given by the participants of the study for the four questions to be averaged into one value. This data set containing a single value for every relationship between any two given users considered in this study, was later used as the value set of to populate the dependent variable i.e. tie strength between users.

Multiple Linear Regression Model and the Predictive Variables

Online platforms such as Facebook enables users to expose their relationships in terms of likes, comments, wall posts, etc., which makes traditional approaches measuring relationship strength between two people purely based on the number of mutual friends two users have in common (Akcora et al. 2011), obsolete and restrictive. Social media networks are enabling users to communicate and bond with one another in numerous ways such as comments, likes, wall posts, shares, etc. Due to this enabling nature of social media networks, multiple variables should ideally be considered when predicting relationship strength between users, making multiple linear regression an ideal solution.

Tie strength as discussed, can be illustrated under seven dimensions namely intensity, intimacy, duration, structural, social distance, reciprocal services and emotional support. Thus, tie strength between two given users can be extracted through numerous variables in social media such as wall words exchanged between the two users (representing intensity of the relationship), days since last communication between the users (representing intimacy), days since first communication between the users (representing duration), number of friends in common (representing structural connections), age and education difference (representing social distance), etc. It is apparent that when the number of variables been considered increases the computation effort required to measure tie strength also increases.

However, analyzed literature (Gilbert et al. 2009) also suggests that tie strength between two given users can be measured with adequate accuracy and higher efficiency using a set of 10 predictive variables representing the most significant five dimensions of tie strength as shown in Table 1. Therefore, during this study the following 10 variables were considered as the independent variables used to predict ties strength between the participants of the study.

Table 1. Selected predictive variables and the corresponding tie strength dimension

Predictive Variable	Tie Strength Dimension
Wall words	Intensity
Wall posts	Intensity
Number of likes	Intensity
Number of Comments	Intensity
Number of Friends	Intimacy
Locations visited together	Intimacy
Days since last communication	Duration
Number of mutual friends	Structural
Gender Similarity	Social Distance
Age gap (in days)	Social Distance

The training data set (70% of the complete data set) was then used to build a multiple linear regression model to fit the predictor variables to determine the tie strength between any two Facebook friends. It was decided that the accepted p-values need to be below 0.05.

Since the efficiency of a linear regression model depends on using the lowest number of variables to predict the dependent variable, as the next step the Variance Influence Factor (VIF) was considered to reduce the number of predictor variables. VIF is a popular technique used to identify predictor variables which are influenced by one another (O'brien, 2007). The VIF value for each variable was calculated to identify such influenced variables which were then removed from the model. This ensured that all the remaining variables are independently contributing towards fitting the model. This approach was continued until there were no inter-related variables and the p-values of all the variables were below the expected threshold. The process was stopped at this point to avoid overfitting.

Experimental Results

Results of Data Extraction and Pre-processing

The data extraction session was conducted under lab conditions with the participation of 40 undergraduates. The undergraduates were from different areas of the country, aged between 20 – 30 years old and from multiple disciplines of study. On average each participant was able to rate the relationship strength between 9 other friends on Facebook (using the tie strength questionnaire), resulting in a data set of 380 responses. The distribution of the answers given by the participants for the four questions in the questionnaire can be summarized as shown in Figure 4.

Once the responses for the four questions were extracted from the users, first the values were normalized to get them within the rage of 0 and 1. Next, the Cronbach's alpha was calculated for the ratings given by the participants to the four questions provided in the questionnaire, to determine the internal consistency within the questions. The results are summarized in Table 2.

Table 2. Correlations between the four questions asked in the questionnaire

	Question 1	Question 2	Question 3	Question 4
Question 1	1			
Question 2	0.780792	1		
Question 3	0.689524	0.774894	1	
Question 4	0.764473	0.711452	0.72456	1

Since the resulting alpha value was 0.92, which illustrated a very strong internal consistency among the questions, it was decided that the responses given by the participants can be aggregated together to arrive at a composite rating for each relationship. These composite ratings were then used to represent the value of the tie strength between each pair of participants of the study and was then used to train the regression model.

Results of the Multiple Linear Regression Model

The objective behind the implemented multiple linear regression model was to quantify the impact of the ten identified variables in accurately predicting the tie strength between two given Facebook users. The model was trained using Python's scikit-learn module.

Initially the model had 10 independent variables representing the five most popular dimensions of tie strength, intensity, intimacy, duration, structure and social distance. The VIF was calculated for each variable to determine any interdependent predictor variables to be removed from the model. The initial model results and the corresponding VIF values of the predictor variables are summarized in Table 3.

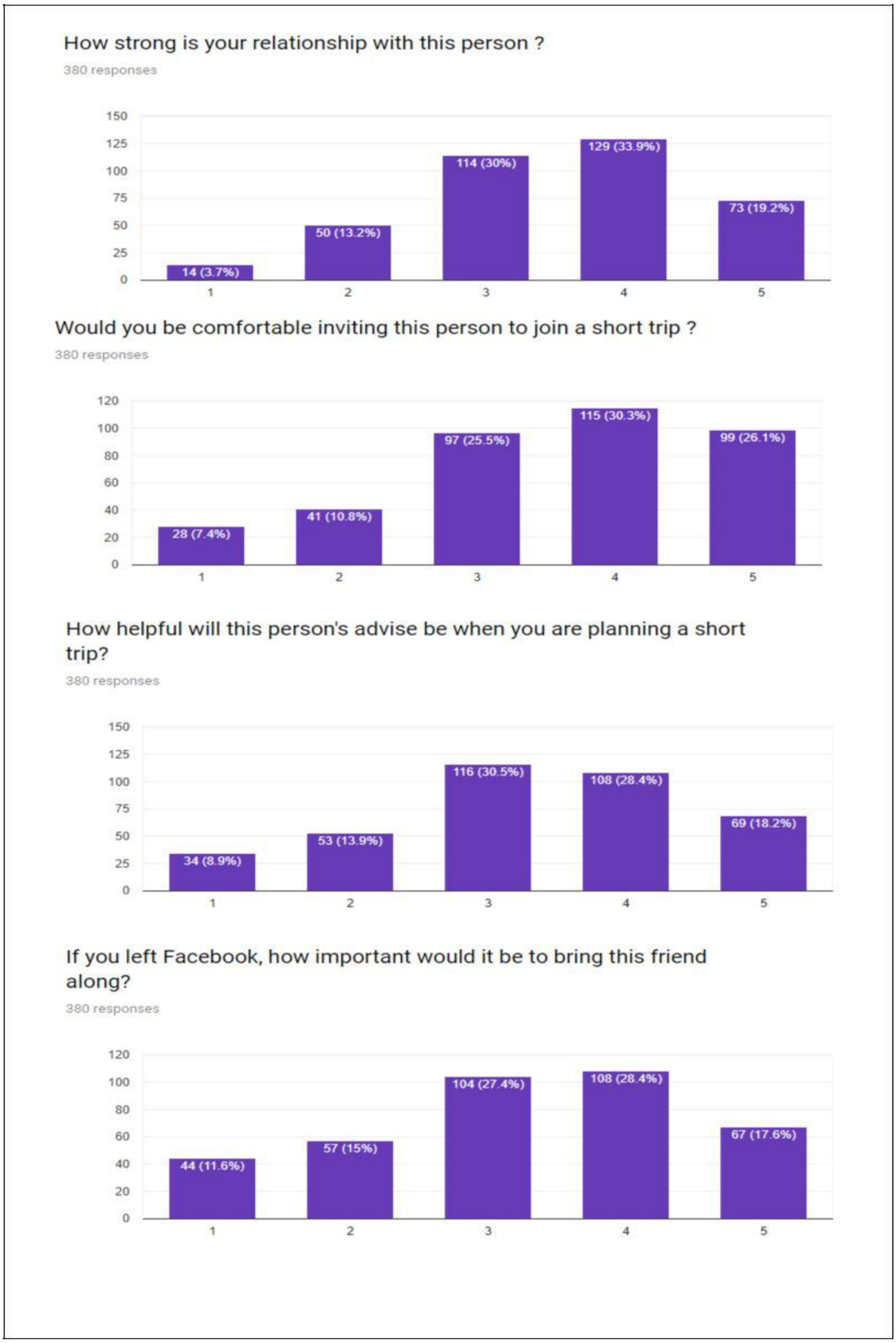


Figure 4. The distribution of the answers given by 40 undergraduates to the four questions in the tie strength questionnaire

Table 3. Initial regression results of the model

Variable	Coefficient	Standard Error	p-value	VIF
Gender Similarity	0.3710	0.123	0.003	1.096
Age Gap	0.0643	0.054	0.237	1.029
Wall Posts	0.2367	0.141	0.095	8.176
Mutual Strength	0.1303	0.073	0.076	1.950
Wall Words	0.0667	0.068	0.326	1.494
Locations Together	0.0943	0.102	0.354	4.335
Number of Friends	-0.1393	0.081	0.089	2.359
Number of Likes	0.1945	0.086	0.025	2.782
Days Since Last Communication	-0.1235	0.056	0.029	1.213
Number of Comments	0.2317	0.106	0.029	3.808
R-squared	**0.411**	**Adjusted R-squared**		**0.383**

The ideal VIF value of a predictor variable should be less than 2 for it to have an independent influence on the prediction made (Tavakol et al. 2011). Accordingly, in each step the variable with the highest VIF value was removed from the model and the model fitting process was repeated. For an example, looking at the Table 3, in the initial step the predictor variable "Wall Posts" were removed from the model and the model was fitted again. The process was repeated for several times, removing a variable in each step based on the VIF value until the final regression results illustrated in Table 4 were achieved.

As the VIF values and the p-values were within the acceptable ranges i.e. less than 2 and less than 0.05 respectively, the model fitting process was stopped here to avoid overfitting the model.

Table 4. Final regression results of the model

Variable	Coefficient	Standard Error	p-value	VIF
Gender Similarity	0.4526	0.121	0.000	1.016
Mutual Strength	0.2365	0.054	0.000	1.012
Locations Together	0.1304	0.061	0.035	1.521
Number of Likes	0.3965	0.065	0.000	1.521
R-squared	**0.366**	**Adjusted R-squared**		**0.355**

The final regression model was then used to predict the relationship strength between any two given users based on the four predictor variables, gender similarity, mutual strength (number of mutual friends in common), locations they have visited together and likes that they have shared. The predicted value for the relationship strength, a rating between 0 and 1, was then compared against the actual value which was derived as a composite rating from the questionnaire responses, to evaluate the accuracy of the regression model. Popular methods such as the Mean Absolute Error (MAE) and the Root Mean Square Error (RMSE) were used for the evaluation process of the linear regression model and the results are given in Table 5.

Table 5. Error measurements of the predictive model

Error Metrics	Error Value
Mean Absolute Error	0.6128
Root Mean Square Error	0.7586

Since the evaluation metrices used to determine the accuracy of the multiple linear regression model were within acceptable levels, it was concluded that the regression model introduced in this study can predict the tie strength between any two given Facebook users with an acceptable accuracy. The above section of the study was also capable of identifying the most influential predictor variables that can be used to determine the tie strength between two Facebook users, thus resolving the first research question of the study.

As the next step, the tie strength predictive model was integrated with a social media based travel recommendation module to evaluate the use of tie strength between two Facebook users on the accuracy of the personalized travel recommendations.

Integrating the Regression Model with the Travel Recommendation System

Once the regression model was proved to be capable of predicting the tie strength between any given two users in the system, the model was connected with a working travel recommendation system described in (Wijenayake et al. 2017) to test the hypothesis that, tie strength identified through social interactions on Facebook can be used to improve the accuracy of recommendations made.

As a benchmark for the experiment the authors selected a functioning, mobile based, context aware and personalized travel recommendation system which connects to the Facebook account of a user to determine his/her travel preferences through shared location check-in posts and their associated comments and likes. The application can suggest unvisited locations based on the identified personal travelling preference of the user, in addition to his/her current geographical context. This system uses a user based collaborative filtering mechanism (implemented using an improved version of the Pearson's correlation coefficient), to identify similarities between travelling preferences of users and recommend new locations to users with similar travelling preferences.

The selected travel recommendation module was evaluated using the Facebook profile data extracted from the participants in the current study and the results are as given below in Table 6.

Table 6. Initial error measurements of the travel recommendation module

Error Metrics	Error Value
Mean Absolute Error	0.9437
Root Mean Square Error	1.2557

Next, the tie strength predictive module was directly integrated with the recommendation module component of the above system to evaluate whether the addition of the tie strength between two users can improve the accuracy of the travel recommendations been made, by uncovering otherwise hidden relationships and similarities between the considered user pair. It was observed that the integration of tie strength resulted in a drastic reduction of the error measurements of the travel recommendation module. The new error metrices are as given in Table 7. The drop in error is as illustrated in Figure 5.

Table 7. Error measurements of the travel recommendation module after integrating the tie strength predictor

Error Metrics	Error Value
Mean Absolute Error	0.8806
Root Mean Square Error	1.1497

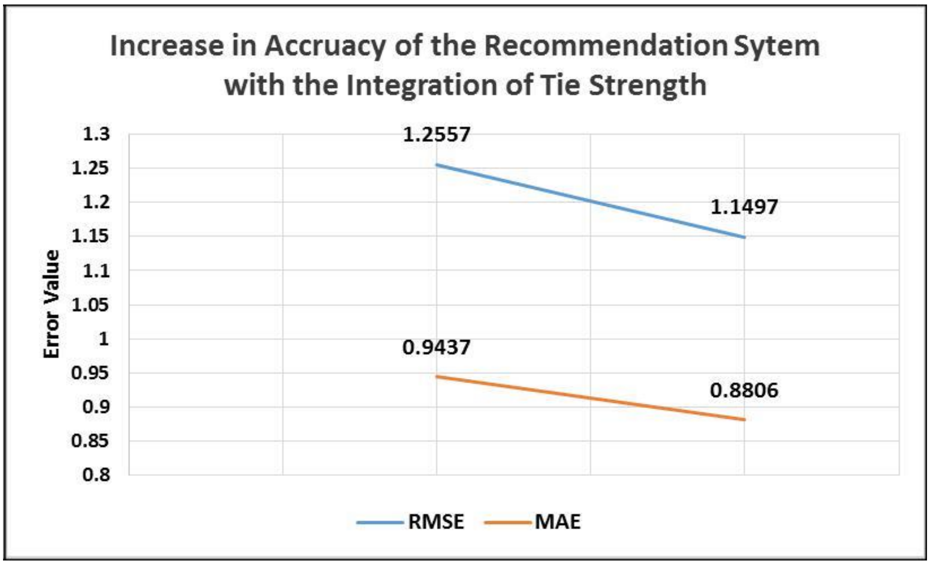


Figure 5. Improvement in the accuracy of the tested travel recommendation system after the integration of the tie strength prediction with the traditional Pearson's correlation coefficient to measure user similarities

The drop in the error suggests that tie strength between users, extracted through their social media interactions can be directly integrated with recommendation systems to improve the accuracy of the recommendations been made based on user similarities. The predicted tie strength values imply how intimate the relationship is between the user pair been considered. Thus, the increase in accuracy suggests that, recommendations which are made taking the intensity of user relationships into consideration are more likely to be accurate than the recommendations which are based only on similarities in their basic travel preferences.

Conclusion and Further Work

Humans rely on others who are closer to them and have similar preferences as them, for advices and recommendations on a variety of things ranging from online purchases, movies, entertainment, travel, etc. Moreover, as people become more conscious of their online presence, these human interactions occur more frequently via social media networks such as Facebook and Twitter making them populated with valuable relationship data that indirectly explains similarities between people and how the impact of thus identified relationships on decision making.

This paper explored the possibility of the application of such relationship rich data available on Facebook in terms of likes, comments, wall posts shared, locations tagged together, etc., to understand the similarities between users' travel preferences to determine hidden user similarities that can be integrated with recommendation systems to improve their accuracy.

The presented solution introduced a novel multiple linear regression model which can capture the relationship strength between any two Facebook users, and used this information to improve personal travel recommendation systems. The initial part of the study was focused on affirming that the introduced solution can determine the relationship strength between Facebook friends using a minimum number of predictive variables thus significantly improving the efficiency of the predictive model. The paper also established that the accuracy of the multiple linear regression model is within acceptable levels via experimentation results.

As the next step, the tie strength predictor model introduced was integrated to an existing travel recommendation system to evaluate whether tie strength between users is a significant variable to be considered when making personalized travel recommendations. The latter part of this study confirmed that the model introduced can accomplish a significant increase in accuracy in such systems, paving the way to similar integrations in other commercial recommendation systems such as movie and product recommenders.

In conclusion, the novel regression based solution introduced in this paper has established the hypothesis that relationship data can be used to identify hidden similarities in user preferences, which can then be used to accomplish significant improvements in accuracy of recommendation systems that ideally relies on such intelligence.

In terms of further work, the multiple linear regression model can be further improved by considering the interactions between variables in addition to the impact of each independent variables alone. The regression model for tie strength could also be applied in other recommendation systems such as movie recommendation systems to test its applicability in other domains to affirm the tested hypothesis.

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