A Hybrid Approach with Explicit User Information Forfood and Nutrition Recommendation System

[1]Haider Khalid, [2]Lu Rongzhu
[1]School of Computer Science and Communication Engineering, Jiangsu University, China
[2]School of Medicine, Jiangsu University, China

Abstract
As human-beings, we daily need optimal energy, but most of the people are careless about food calories and nutrition's suitability required for their health. Some people use some online web portals to calculate nutrition values, but with lacking of information that how to get nutrition naturally from food is the main objective for this research. People have personal preference for certain kind of food and to use their explicit data to get food recommendation according to their choices can be the solution. Therefore, explicit information has surety for accurate data and will be helpful to develop a framework that provides food recommendation. Furthermore, transforming the implied knowledge about nutrition into structured data is challenging, so Canadian Nutrient File database can be used to overcome this problem. We present a semantic framework using hybrid approach for combining "SELFNutritionData" web portal system and recommender system that uses the explicit information based on the users' preference. The empirical evaluation of the proposed framework shows promising results for recommending the relevant food information with a superior users' satisfaction.

Keywords
Explicit Information; Food and Nutrition; Recommendation System; Hybrid Approach

I. Introduction

Since increase of technology the amount of data and information growing rapidly. More data requires more efforts to find appropriate information. Recommendation system is a key to find and get information with less efforts and it helps the users to make decisions with better options in this world that filled with a lots of choices. In this era, people are using the famous search engines, such as Bing, Google and Yahoo, to get appropriate information on the Web. The Web search engines has their limitations and work according to their searching algorithms that may satisfy many people but many other users are not satisfied because they do not find the required results relevant to their query. That is obvious when we try to get critical information such as health and nutrition, the thing we desire more relevant and precise information from trusted resources. Most of the popular search engines work on the keywords to rank the results and they don't consider the level of the sources. Keyword-based search might not helpful if you ask a question that needs to be parsed and divide to understand first [1]. The search engine needs to understand also some information about the user in order to return the relevant result to the user's needs. This is critical in the health and nutrition domain when some foods are restricted to users because of their health conditions. The recommendation systems become more popular in most of the cases and targeted towards individual items. We will also study in this paper that how we can get the feedback and how it can be collected for the evaluation of the recommender engine and use that feedback to get much better recommendations from the system. Personalized food with nutritious level recommendation [2] is a recipe recommender system where the recipe is split up into its ingredients and the actual recipe. The weighting for the recommendation is based upon not only the recipe, but also the ingredients used to make the dish and also considering the vitamins and nutrition level to keep self-healthy. Nutrition is an important factor in this system, where the system gathers all nutrition information for each ingredient. Nutrition is used to make healthier recommendation. This system uses a query language to do the requests. This language is a content- and semantics-based approach where the attributes like ingredients and description has a significant role. In this paper, we will describe some personalization techniques to propose a semantic framework for food recommendation based on the user's preferences. Considering the user explicit information of food, the health condition of the user and the culture exert influence on the food choice including the gender, age and also body weight. This will help providing a smarter way to answer the food and health inquires and to recommend the relevant and personalized choices of food and nutrition from the trusted food and health sources. The remaining parts of the paper can be summarized as following. Section II presents a summary of the related works while Section III describes the proposed framework, method and dataset use for experiment. Section IV explains the experimental results and section V, will present conclusion and future work.

II. Related Work

A. Recommender System

The phenomenon and the concept of recommender system is to suggest items (or we can also called the products in general term) to users with their interest. The recommendations are usually based on the information that kept the system about a user, either user profile data or his history. Recommendation of items food is the main focused area for this field. When the number of items and users are in large amount then usually recommender system required to manage the information load [3]. The eq. (1) is the connection between user and item with model logic function that can define the recommendation type.

$$\text{User} \rightarrow f(\text{function}) \rightarrow \text{Item} \qquad (1)$$

B. Similar Working Systems

Personalized Health Information Retrieval System (PHIRS) [4] is a recommendation system for health information that uses a user's profile to match the retrieved health information with the user's needs. The limitation of this work is that it lacks sufficient health information to be used in the recommendation and also it does not utilize the demographic information in profile. HealthFinland [5] is a smart web portal that helps the users to find relevant information about health by using simple keywords instead of the medical vocabulary terms. While HealthFinaland provides great health recommendations but it does not includes personalization explicit information at all. CarePlan [6] is also another semantic recommendation framework for health care plans that includes the patient's health condition and personal preferences about medical knowledge and clinical pathways. The shortcoming of this approach is the limitation of personalization to be from educational health information and the ignorance of other factors such as culture and religion of the user that affect the food choice. In [7] the authors present a personalized search approach for cardiologic information from different medical sources. The proposed approach lacks the semantic techniques and the consideration of culture and religion impact on the recommendation process. In [8] the authors propose a model that centralizes the personal information management to personalize the retrieved health and medical information. Their experiments show trade-off between the performance of retrieved information and the privacy of the user information. Their proposed model does not consider the user's culture and religion.

C. Why We Need Hybrid Approach for Recommendation of Food and Nutrition

The above previous systems has lack of recommendations, some recommend only consideration of religion and cultural, some has lack of user information about what kind of food should be recommended. We are going make a recommendation system with hybrid approach of "SELFNutritionData" system. This is a web portal that can calculate Body Mass Index (BMI) [9] by using user's information of sexuality, height, weight, age and lifestyle (sedentary, somewhat active, active, very active) and recommend only nutrition and nutritional amount that a person daily need at minimum level. It will show in section "Nutrition Data System". As a normal person, if a person does not have medical background and mostly people don't really know what these nutrition means are and how they can get to fulfill their health desires. By keeping in mind this problem a recommendation system required that can recommend food to a person with proper nutrition level according to their daily need to keep their self-healthy. The user directly use recommender system but the background logic the recommender system connects with the Nutrition Data System (NDS) and pass the users profile data to get nutrition information. This Nutrition information will use to get food recommendation with user's choice.

III. Experimental Approach and Dataset

For a healthy life, everyone needs a certain amount of nutrition daily but unfortunately people do not pay attention on their daily nutrition intake. This behavior leads them to unhealthy condition. As an example, 7.2% Indonesian males categorized as overweight, and 10.4% for female [10]. In this situation, there is a need to keep monitor daily calories intake. The printed values of nutrition on food packages are the easiest way to measure calories. On the other hand, there are some foods with no package such as restaurant or homemade food.

A. Measuring Daily Calories

Calorie is a measurement for energy unit. Calorie is often used to measure energy which is contained in food in Kcal (kilo calories) unit. People has minimum calorie need called basal metabolic rate, or often called BMR. BMR is affected by body surface area, sex, blood circulation, and other internal body activities. Standard of BMR is 1 calorie per kilogram body weight per hour (1 Cal/kg/hour).

Daily calories need may vary between one people to another as mentioned before. This daily calories depend on physiological condition of a person. Those physiological are sex, weight and height. Daily calories can be measured by the following aspects [11].

1. Body Mass Index (BMI)

Body mass index categorize whether people is skinny, normal, overweight, or obese. These BMI can be retrieve from following equation:

$$BMI=(Body\ Weight(kg))/(Height(meter)^2) \quad (2)$$

2. BMI Categories

To categorize whether someone is skinny, normal or overweight. it can use BMI formula as mentioned in eq. (2), then the result is compared to the threshold in "Table 1".

Table 1: Body Mass Index Threshold

Status	Category	Threshold
Skinny	High level of malnutrition	<1700
Thin	Low level of malnutrition	1700-1850
Normal	Ideal	>1850-2500
Overweight	Low level of overweight	>2500-2700
Obesity	High level of overweight	>2700

3. Ideal Body Weight

Ideal body weight also become one parameter to obtain daily calories need. Ideal Body Weight (IBW) can be measured with eq. (3). Ideal BMI can be seen on "Table 1," which state normal status

$$IBW=(Height(meter))^2 \times ideal\ BMI \quad (3)$$

4. Basal Metabolic Rate (BMR)

Having ideal body weight, basal metabolic rate can be obtained with following eq. (4)

$$BMR=1Kacl \times Ideal\ Body\ Weight \times 24 \quad (4)$$

5. Measuring Daily Energy

Daily energy can be measured as described in eq. (5). Where physical activity value can be seen on "Table 2", and weight adjustment is a constant that has a value of (-500) when people want to reduce body weight, (+500) when people want to increase body weight, and "0" when people want to preserve current body weight.

$$Daily\ Calories=Physical\ activity \times BMR + Weight\ adjustment \quad (5)$$

Table 2: Activity Level

Activity	Male	Female
Very Light	130	130
Light	165	155
Moderate	176	170
Heavy	210	200

B. Experimental Structure

This section describes the whole architectural model for our experiment approach and experiment performance on Canadian Nutrient File (CNF) dataset for food and nutrition recommendation.

The proposed framework represents users to semantically get relevant information about nutrition and get the food recommendation according to their body need and nutrition level. The architecture of the main framework is composed of three major components by applying the software strategy (MVC) [12]. That represent model, view and control framework techniques can separate the outer layer user view that can also called graphical layout to interact directly to the user. Secondly in model layer where we define our software logic for execution the required query to get recommendation from interaction with controller layer with database system.“Figure: 1,” will describe the whole working structure for the experiment plan to get the accurate recommendation.

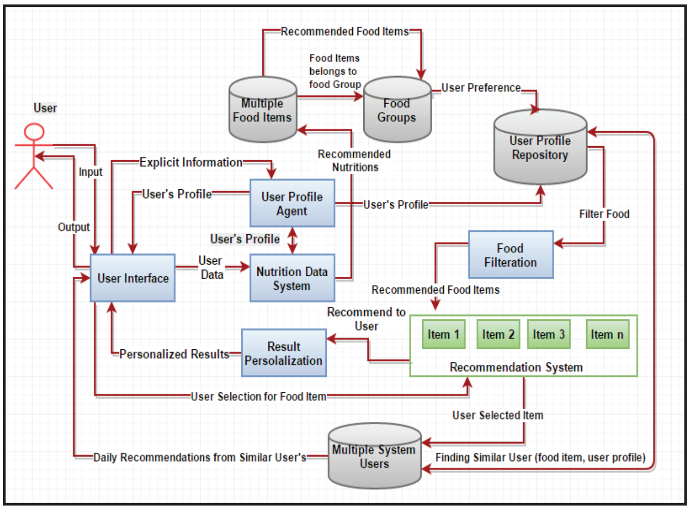

Fig. 1: User-based Framework for Explicit Information Manipulation and Personalized Recommendation

C. User Interface

The user interface is needed to interact with the user to get his input and display the retrieved results. The input could be the preferences entered explicitly by the user. These preferences will be forwarded to the User’s Profile Agent to update the user’s profile. The input could also be the user’s queries which will be forwarded to the Nutrition Data System (NDS) for manipulation. The NDS will communicate back to the user if there is a need to revise the user’s queries, get any missing information or correct the spelling. Moreover, the Interface Agent displays the user’s profile and formulates the personalized results to the user. It also monitors the user’s interactions on the results and forwards these interactions to the User’s Profile Agent to infer new preferences. The user’s interactions with the database containing food items and food groups can be either explicit or implicit. The explicit interactions can be captured by asking the user about his feedback on the results while the implicit interactions can be captured by monitoring the user’s behaviors and similar user with same preferences.

D. User Profile Agent

The User’s Profile Agent is needed to manage the user’s profile. The user is asked to fill a form that reflects her preferences or explicitly enter information. However, many users are not acknowledging the time they spend in filling such forms [13]. So, the User’s Profile Agent logs the user’s interaction with the results and then infers new preferences. It also connects with NDS and passes the user preferences to get the nutrition according to his need. In addition, User’s Profile Agent can also indulge with User Profile Repository (UPR) to save the user explicit information to the database for future use as profile related embedded systems. One major function of the User’s Profile Agent is to learn and infer new preferences based on the user’s interactions and behaviors.

E. Nutrition Data System

The NDS is needed to semantically manipulate, enrich and process the user’s explicit information. After getting the user’s information, it identifies the user sexuality, height, age, weight and his lifestyle that can be (Sedentary, somewhat active, active and very active). Then, it tokenizes the user data and calculates the Body Mass Index [9] (BMI) and recommends minimum daily needs of nutrition’s. This helps in limiting the processing for the whole system by using NDS. Then, it communicates and passes the whole information about nutrition’s to the Multiple Food Items (MFI) database. Then MFI can select the food items according to the nutrition level and pass the selected food items to the food groups to identify which food belongs to which food group. After that UPR can identify the user preferred food group and food filtration system can filter the food with user preferences and recommend multiple groups and multiple items if user explicitly mentioned multiple food groups. The “Fig. 2,” is the recommended daily nutrition that a person needs to take, and I put my data to get recommendation.

Your Recommended Minimums		
Total Carbohydrate	130.0	g
Dietary Fiber	38.0	g
Linoleic Acid	17000.0	mg
Alpha-Linolenic Acid	1600.0	mg
Protein	46	g
Vitamins		
Vitamin A	3000.0	IU
Vitamin C	90.0	mg
Vitamin D	200.0	IU
Vitamin E	15.0	mg
Vitamin K	120.0	mcg
Thiamin	1.2	mg
Riboflavin	1.3	mg
Niacin	16.0	mg
Vitamin B6	1.3	mg
Folate	400.0	mcg
Vitamin B12	2.4	mcg
Pantothenic Acid	5.0	mg
Biotin	30.0	mcg
Choline	550.0	mg
Minerals		
Calcium	1000.0	mg
Chromium	35.0	mcg
Copper	0.9	mg
Flouride	4.0	mg
Iodine	150.0	mcg
Iron	8.0	mg
Magnesium	400.0	mg
Manganese	2.3	mg
Molybdenum	45.0	mcg
Phosphorus	700.0	mg
Selenium	55.0	mcg
Zinc	11.0	mg

Fig. 2: Nutrition Recommendation

F. Result Personalization

The Results Personalization Agent is needed to personalize the retrieve recommendation results. First, it receives the multiple food recommendations and forward to the user interface to show to the user and user can select the food item as his choice. This is the last step for user interaction with the system but system does not stop working. It save the user preferred food item into the RPF for future use recommendations and multiple system user database work to find similar user by identifying food item and user profile information and these similar user recommendations can also be recommend to the user implicitly predicted recommendation from the system until user can change his explicit data to change his life.

IV. Implementation and Result Analysis

```
String nutrientID = "";
for (int h = 0; h < nutrientAmountList.size(); h++){
    if (foodIDNutrient.equalsIgnoreCase(foodID)){
        if (resultNutrientID.equalsIgnoreCase("")){
            resultNutrientID = resultNutrientID + nutrientID;
            resultNutrientValue = resultNutrientValue + nutrientValue;
        }
        else{
            resultNutrientID = resultNutrientID + "," + nutrientID;
            resultNutrientValue = resultNutrientValue + "," + nutrientValue;
        }
    }
    for (int k = 0; k < nutrientNameList.size(); k++){
        String neutrintID = nutrientNameList.get(k)[0];
        if (neutrintID.equalsIgnoreCase(nutrientID)){
            String neutriantSymbol = nutrientNameList.get(k)[2];

            if (resultNeutrintSymbol.equalsIgnoreCase("")){
                resultNeutrintSymbol = resultNeutrintSymbol + neutriantSymbol;
            }
            else{
                int x = find_str(resultNeutrintSymbol, neutriantSymbol);
                if (x == -1){
                    resultNeutrintSymbol = resultNeutrintSymbol + ","
                + neutriantSymbol;
                }
            }
        }
    }
```

Code 1: Nutrition Recommendation JAVA Code

We use RapidMiner Studio software to perform experiment on proposed framework. We use the semantic techniques as backend and the Java J2EE technology as fronted in addition using a multi agent framework to communicate between the agents. We integrated with a Java library for data modification we got from Canadian Nutrition File (CNF) database. In our experiment, we have collected 5690 data with food group Id and food items. The given "code 1," is written in JAVA J2EE for modification of dataset by integrating four ".csv" files named (Food Group, Food Name, Nutrient Amount, and Nutrient Name). We categorize according to food group id and each group id has multiple food items records. Every food Item has food item Id and multiple nutrition list and nutrition amount. The recommendations are based on the nutrition that we get recommended from NDS and user preference food Group. The "Table 3"shows that which type of food contains what kind of nutrition's and showing Nutrition values and Nutrition Symbol.

Table 3: Integrated Data with Food Items and Food Groups With Recommended Nutrition's

ExampleSet (5690 examples, 0 special attributes, 7 regular attributes) Filter (5,690 / 5,690 examples): all

Ro...	Food...	FoodG...	FoodItemName	FoodGroup	NutrientID	NutrientValue	NutrientSymbol
1	2	22	Cheese souffle	Mixed Dishes	323,619	2.03,0.484	ARG,LEU,22:1c,PRO,CARB O,CARB
2	4	22	Chop suey, with meat, canned	Mixed Dishes	852,827,339,512,430	0,0,0,0.085,16.9	ARG,LEU,22:1c,PRO,CARB O,CARB
3	5	22	Chinese dish, chow mein, chicken	Mixed Dishes	516,854,833,840,831	0.237,0,0,0,0.128,0,(	ARG,LEU,22:1c,PRO,CARB O,CARB
4	6	18	Corn fritter	Baked Products	418,832,404,304	0.319,0.004,0.223,2	ARG,LEU,22:1c,PRO,CARB O,CARB
5	7	22	Beef pot roast, with browned potatoes,	Mixed Dishes	510,262,315	1.06,0,0.139	ARG,LEU,22:1c,PRO,CARB O,CARB
6	8	22	Fried chicken, mashed potatoes and ve	Mixed Dishes	617	3	ARG,LEU,22:1c,PRO,CARB O,CARB
7	9	22	Meat loaf with tomato sauce, mashed p	Mixed Dishes	303,417,301	1.3,10,19	ARG,LEU,22:1c,PRO,CARB O,CARB
8	10	22	Sliced turkey with mashed potatoes an	Mixed Dishes	601,268,646,854	32,468,0,0	ARG,LEU,22:1c,PRO,CARB O,CARB
9	13	2	Vinegar, cider	Spices and Herbs	613,508,410,810,317	0,0,0,0,0.1,0,0,5,0,0,	ARG,LEU,22:1c,PRO,CARB O,CARB
10	14	2	Vinegar, distilled (white)	Spices and Herbs	516,825,339,255	0,0,0,94.78	ARG,LEU,22:1c,PRO,CARB O,CARB

We perform experiment by applying collaborative filtering recommendation algorithm to get user preference food group and as a return system recommended the food items in that food group with different nutrition that we recommended by "SELFNutritionData" (SND) web portal according to user BMI. The "Table 4" shows the recommended results with user explicit data.

Table 4: Recommended Food Items With Nutrition Values by User Explicit Information

R...	Fo...	FoodItemName	FoodGroup	NutrientID	NutrientValue
1	9	Acerola (West Indian cherry), raw	Fruits and fruit juices	324,339,291	0,0,1.1
2	9	Acerola juice, raw	Fruits and fruit juices	831,317	0.044,0.1
3	9	Apple, raw, without skin, sliced, cooke	Fruits and fruit juices	406,612,306,268,502,000	0.061,0.002,93,234,0.01,0.01
4	9	Apple, canned, sweetened, sliced, he	Fruits and fruit juices	501,262,836,404	0.002,0,0,0.009
5	9	Apple, dehydrated (low moisture), sul	Fruits and fruit juices	305,204,610,815,306,000,000,000	55,0.58,0,1,640,3,55,0.001
6	9	Apple, dehydrated (low moisture), sul	Fruits and fruit juices	221,511,507	0,0.009,0.004
7	9	Apple, dried, sulphured, uncooked	Fruits and fruit juices	835,317,619,501,303	0,1.3,0.016,0.009,1.4
8	9	Apple, dried, sulphured, stewed, no a	Fruits and fruit juices	834,291,430,601,501,000,000,000,000	0,2,0.7,0,0.002,0.013,0.3,0,0.007

The "Fig. 3," is showing the Nutrition value in food group for multiple recommended food items. Some food items have less nutrition vales and some are approximately equal to nutrition values that recommended by SND. The red points are representing the Nutrition Values and the blue points are representing Food Groups.

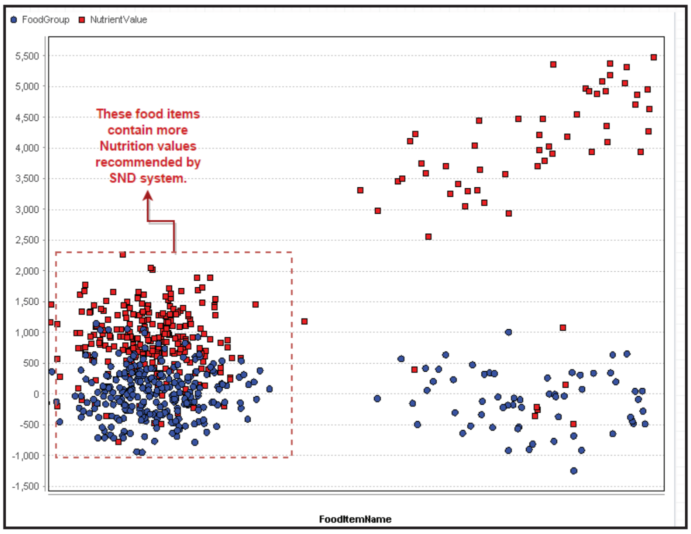

Fig. 3: Recommended Nutrient in Multiple Food Items with Preferred Food Group

V. Conclusion and Future Work

To sum up, the current research in semantic and personalization techniques for the health and food information. We propose a hybrid approach and combine two systems one is "SELFNutritionData" web portal and other is recommender system with user explicit data approach to get food and Nutrition Recommendation. A user-based explicit data processing and results analysis that consists of four different CNF databases file. We explain each agent of the framework and its functionalities. Then, we explain how we capture the preferences and construct the food recommendation. Next, we show the implementation of the framework and the results of our experiments. The empirical evaluation of our system shows how accurate we got food recommendation according to user preference, which gives promising results. As a future work, if we combine three systems and make a hybrid system that contains nutrition values, health information and recommender system with multiple databases vary from countries, then we can serve more users from our system.

References

[1] A. Al-Nazer T. Helmy,"User's Profile Ontology-Based Semantic Framework for Personalized Food and Nutrition Recommendation," In 5th International Conference on Ambient Systems, Networks and Technologies, 2014, pp. 101–108.

[2] J. Freyne, S. Berkovsky,"Intelligent food planning: Personalized on Intelligent user interfaces," In Proceedings of the 15th international conference, ACM, 2012, pp. 321–324.

[3] K. B. Fard A. H. Nabizadeh Rafsanjani N. Salim N.Mohammadhossein,"New recommendaation system in model based on Simentic Similarity on Movie Domain," In Jornel of Basic and Applied Scintific Research, , 2013, Vol. 3(7), pp. 258-273.

[4] Z. Liu Y. Wang,"Personalized health information retrieval system," In AMIA Annual Symposium Proceedings, Washington DC, 2010, pp. 1149-1156.

[5] E. Hyvönen, K. Viljanen, E. Hukka O. Suominen, "HealthFinland a national semantic publishing network and portal for health information," Web Semantics: Science, Services and Agents on the World Wide Web, 2014, Vol. 4, pp. 287-29.

[6] H. Chen S. R. R. Abidi, "Adaptable personalized care planning via a semantic web framework," in 20th International Congress of the European Federation for Medical Informatics, Maastricht: Netherlands, 2006.

[7] L. Juang D. Matsumoto, "Culture and Psychology," Cengage Learning, Vol. 5th edition, United States, 2012.

[8] J. Mostafa, X. Wang Y. Li, "A privacy enhancing infomediary for retrieving personalized health information from the Web," In Personal Information Management, A SIGIR Workshop, 2013, pp. 82-85.

[9] K. Surendro R. A. Priyono,"Nutritional Needs Recommendation Based on Fuzzy Logic," In The 4th International Conference on Electrical Engineering and Informatics, ICEEI 2013, pp. 1244-1251.

[10] Sanjaya et. al.,"Prevalence of Excess Nutrition and Obesity of Adult Population in Indonesia," 2005.

[11] Sunita Almatsier, "Diet Guidance New Edition," Jakarta: PT Gramedia Pustaka Utama, 2004.

[12] Wei Zheng, Ming Zhang , Jing Zhang, G. Zhuang, T. Ding Xuan Yin, "A modularized operator interface framework for Tokamak based on MVC design pattern," Fusion Engineering and Design, May 2014, Vol. 89, No. 5, pp. 628–632.

[13] Y. Li, N. Zhong X. Tao,"A personalized ontology model for web information gathering," In IEEE Transactions on Knowledge and Data Engineering, IEEE Computer Society Digital Library, 2011, Vol. 23(4), pp. 496–511.

Haider Khalid received his Bachelor of Science and Master of Science in Information Technology degrees from University of the Punjab, Lahore Pakistan in 2010 and 2012 respectively. During 2012-2013, he did job as Software Engineer in private Software Company in Pakistan. In September 2013, he moved to China for his 2nd Master's degree in Software Engineering in Jiangsu University on Chinese Scholarship Council (CSC). During his studies in China, his research field is Information Retrieval, Recommendation Systems and Data-mining.

Lu Rongzhu, MD, MPH, PhD Professor, PhD Supervisor and Chair Department of Preventive Medicine and Public Health Laboratory Sciences School of Medicine Jiangsu University. He got his Master of Medicine and PhD in occupational health and environmental health from Fudan University China, in 1996 and 2002 respectively. His research field is Natural products and cytoprotection. He got his Postdoctoral Research fellow from Vanderbilt University, Tennessee USA in 2007.