Toward a Cross-Cultural and Cross-Language Multi-Agent Recommendation Model for Food and Nutrition

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***Abstract*—In this paper, we present our efforts to develop a multi-agent-based framework for cross-cultural and cross-language personalized health and nutrition semantic search. Many agents that share either the same culture or same language or same health profile could share valuable information found through their semantic search. Their interests in a common viewpoint have some similarities which could be used to shorten the learning curve and give good search results effectively. Each agent is representing a user with a specific culture, language and personal health profile. What an agent likes as culture is likely similar to a different agent with the same culture. The same thing applies with language and health profiles. For example, an agent with a diabetes profile could help another agent that has a similar health profile with its valuable findings. We introduce how multi-agents could team up to contribute to each other, learn from each other, and share valuable information with each other using collaborative profile ontology. We propose a cross-cultural, cross-language, health- and nutrition-based ontology profile that could be used as the basis for collaboration between different agents.**

Cross-culture; cross-language; multi-agent; recommendation model; food and nutrition; semantic web; ontology

I. MOTIVATION

Different cultures come with different customs and traditions in many respects, such as food and housing. Cultures are dispersed throughout nations and countries where they also have different languages. When tourists visit a country other than the one they live in, most are interested in exploring the secrets of these cultures and languages, in addition to tasting their local foods. However, they will be more interested in knowing the nutrition values of these types of food and if they are safe for their bodies and health.

The motivation of this work is to build a cross-cultural and cross-lingual multi-agent framework that helps in collaborating and exchanging the food and nutrition values between different cultures' agents and different languages' agents. Not only that, but also to build a personal profile that includes the required information to customize the health and food information to fit the user's culture and language. Moreover, to utilize the semantic web and ontology science in building this framework to make it capable of capturing the semantic--not just the syntax--and then to integrate it with other food and nutrition ontologies to help in getting the most relevant information to the user who is looking for food in a specific culture with a specific language.

II. INTRODUCTION

Since we are talking about culture, it is a good idea to first look at the concept and what we are including and excluding from this concept. Because we all do not share a common cultural background, we may misunderstand or be misunderstood, or ask a question that is not appropriate. Many psychologists use the words "culture," "race," "nationality" and "ethnicity" as though they have the same meaning, though they do not [1]. We use the word "culture" in our daily life with different meaning and different aspects. So, it is important in our research to define the word "culture" in order to research its relation to the food. We have many ways to define culture according to [1]. The word "culture" can be used to refer and describe many things such as: activities, behaviors, heritage, tradition, rules, norms, learning, problem solving, organization of group, origins of group, general characteristics, food, clothing, housing, technology, economy, transportation, community, government, welfare, religion, science, sex and life cycle. There are so many different things we can put under culture with its uniqueness as it represents the unique touch between one place and another.

Since the word culture has many meanings and can be applied in many aspects of life, we are focusing in this paper on including some aspects of culture. We understand that culture is affected by four things: location, time, religion and language. Since we are focusing on the food and nutrition, factors from culture can be listed as follows: (1) what food is accepted in a certain culture and what food is not accepted; (2) what food is preferred in a certain culture and what food is not preferred; (3) what popular nutrition is used by a certain culture; and (4) what recipes are commonly used by a certain culture. We also would like to emphasize that we are excluding the detailed discussion of many aspects of culture, such as religion, and we are limited to the culture's foods and health habits. On the other hand, we are not concerned about the multilingual framework in all aspects, but only in the context of food and nutrition.

The remainder of the paper starts with a survey on the related work followed by a description of the dimension of culture and how it influences the choice of the food. Then, we will talk about creating a personal profile with culture

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touches and what factors we consider in that regard. After that, we will talk about a multi-agent culture-based profile, followed by a description of the implementation. Finally, we will conclude with how we can expand this work in the future with some examples.

III. RELATED WORK

In [2], the authors summarized HelathFinland that semantically publishes and retrieves health information. Their objective is to provide the citizens with reliable, up-to-date and relevant health information on the Web by mixing resources from governmental, non-governmental, business and other organizations. It handles the user's point of view by addressing the challenge of finding content using basic vocabularies compared to the technical medical terminology and then the difficulties in retrieving the relevant information from several sites. To resolve this, they have developed an intelligent semantic portal retrieving and presenting the contents from the health-interest perspectives. The limitation of this approach as suggested by the authors as future work is to address the personalization based on user's profile information.

In [3], the authors addressed the challenge faced by consumers when seeking health information on the Internet. They proposed a Personalized Health Information Retrieval System (PHIRS) to recommend health information for consumers. The system consists of four modules: (1) user modeling module which is responsible to get the user's preference and related health interests; (2) automatic quality filtering module which is identifying the quality of the retrieved health information; (3) automatic text difficulty rating module which helps in classifying the retrieved health information into two classes: either professional or patient educational materials; and (4) user profile matching module which customizes the retrieved health information to match the individuals' need. The authors conducted an initial testing and showed that the results can assist health information consumers with a simple search that retrieves relevant information. The authors conclude that the initial test result shows that the evaluated pattern of semantic features in professional and consumer health is not enough. They suggest combining some surface features, such as structure, tense, voice, with the used pattern and semantic features to help identifying the text difficulty of health information. So, the limitation of this work is not having enough features that will help in identifying the relevant health information as well as not having sufficient testing for the proposed solution. The personalization here did not touch on the culture or language of the user.

In [4], the authors presented a new system, CarePlan, which generates customized patient-specific healthcare plans in an automatic way. To determine the best clinical care plan, they utilized (1) the patient's medical personal profile, (2) the up-to date medical knowledge, (3) clinical pathways that are institution-specific, and (4) a personalized educational health care programs. They came up with a new semantic Web framework which allows for the synthesis of heterogeneous operational and medical information and knowledge resources, and renders the technical basis for a services-oriented architecture to generate and orchestrate patient-specific healthcare plans. The authors concluded with sharing their belief that the semantic Web will be the future way to get intensive knowledge and validate healthcare decisions, yet this will have many challenges. The limitation of this approach is the lack of the full implementation details as well as the food and nutrition information that are related to the patient. The personalization in this approach focuses on the educational health information and did not talk about the culture or language of the user.

In [5], the authors proposed a new adaptive searching mechanism developed using innovative technologies in order to obtain, use and manipulate medical information. The authors highlighted that medical knowledge is inherently complex and uncertain and that medical experts may provide different interpretations for symptoms since all of them also depend on a given context and most of them are established by statistical utilization. So, it is necessary to capture a whole knowledge baggage in order to understand and take care of patients with cardiovascular diseases adequately. For this reason, the authors proposed a system which has been conceived aiming at being a valuable instrument for cardiologic medical information retrieval from heterogeneous, distributed medical databases that mediates medical decision of critical health conditions. The proposed adaptation features that are supported generate a personalized searching process for the users depending on the information stored in their personal profiles. The approach is lacking the use of semantic Web as it adds a lot into such complex heterogeneous data sets and it helps the inference of the relevant information to the user. The personalization search approach did not consider the culture or language of the user.

In [6], the authors highlighted the explosive growth in number of information sources and that users now can access a wide variety of health information from the Web. However, information that may be potentially relevant to individual users remains highly scattered and users frequently have to dig and aggregate information from multiple sites. The authors introduced a trusted model as a one-stop-shop access point to personalized health and medical information. The model centralizes personal information management to facilitate specific information aggregation task of individual clients. It employs group query mixing and noise query mixing in order to hide user's profile from external eavesdropper. Experiments were conducted to demonstrate trade-off levels between retrieval performance and the degree of privacy preservation in the proposed query mixing strategies. This trade off did not consider the personalization from the user's culture and language point of view.

In [7], the authors studied the major challenges in Health Information System and Retrieval (HIS/HIR) queries. More challenges were addressed in assessing the sources and quality of the health information the users find and act on it. They conclude that there is a huge need to research theoretical and practical the health information search and retrieval from the consumers' point of view. The authors think that the health care systems are transformed to be more

patient-centric and consumers are making their choices and control their personal health. Finally, the authors recommended having a mechanism for joint efforts between consumers, providers and decision makers to help come up with personalized health care. The personalization needs further detailed research and this did not consider any related cultural and lingual aspects of the user.

In [8], the authors described a mixed initiative socio-semantic conversational search and recommendation system for finding health information. They highlighted that using the proposed system users can do a live conversation about their health issues. Then, collaboration mode is started where it connects relevant users together in the same conversation and provides context-based recommendations which are related to the conversation subject. The authors then illustrated the powerful of their search which returns relevant search directly or via other users without using the conventional search engines which they believe that it causes often confusing and frustrating the users. The recommendation was based on the social context not based on the personalization factors. Moreover, the personalized culture and language was not mentioned.

Based on this survey, there is lack of cultural and lingual based personalization for the health, food and nutrition domain that will help in giving better recommendation for the users. Hence, we extend the current approaches by building a framework for cross cultural and cross lingual multi agent recommendation tool having ontology-based user's profile to retrieve the relevant health and nutrition information. So, we extend the work with cultural personalization focus and with semantic Web approach using ontology to represent the user's personal profile and matching it with the health and nutrition domain ontology to recommend the best food that fits the user's needs. This is important as the food is different from culture to culture and what food is appropriate in a place might be forbidden in another place.

IV. DIMENSIONS OF CULTURE INFLUENCE

From our research, we observe some factors that influence the choice of food: time (time in the day, month, and season), origin location, current location and religion. These factors influence the food selection with different degrees of power based on a person's culture. Many examples we can list here. An example of a Muslim Saudi centers on how much influence his place of origin has on him. When this person visits Japan, he does not eat sushi and other Japanese food if his place of origin has great influence. But if he has less influence from the food of his place of origin, when visiting Japan he is open to try many Japanese foods. The culture constraints are important in order to provide relevant results. We capture the culturally preferable food as part of the user's profile. For example, rice is culturally preferred in Saudi Arabia. Also, we capture the culturally un-acceptable food. For example, locust, a kind of insect, is not preferred food in Saudi Arabia. The religion constraints are captured to avoid inappropriate food advices. The user is asked about that. For example, if the user is Muslim, Halal food is the religiously preferred food. We also capture the religiously forbidden food. For example, alcoholic food is forbidden in Islam.

One might ask: does time and location affect culture? The answer will be shown in the following example. Different food is applicable in different times in the culture. We can take an example of Muslims' culture of food during the Hijri month of Ramadan, when Muslims fast throughout the entire month. But we can't say this about the Muslim culture in general as it is different from location to location. This shows how time and location have different effects on the culture. Not all foods which are eaten in Ramadan are used in other months. Let's say the preference for such foods during Ramadan is high, while it is lower in other months.

V. PROFILING WITH CULTURE

We believe that a personal profile which helps in customizing and personalizing the data set in any field, especially to our research field which is food, health and nutrition, needs to consider the cultural factors. Without the cultural factors, things could go wrong and advice would not be as effective. From culture, we could infer the following information from the user:

- First, origin location and how tight he is to the food that comes from it (This can be concluded from monitoring his interaction and behaviors with the food recommendation.).
- Second, current location and how open he is to the food in the new location which might be different than the origin location. Again, this could be inferred from his reactions with the food recommendation.
- Third, religion and how he is committed to its directions. Some religions come with allowed food and prohibited food. An example is that alcohol is not allowed for Muslims. However, some Muslims are not committed to that and they drink alcohol.
- Fourth, the time and its effect on the person. A good example is the month of Ramadan; for most Muslims, it has its unique foods, but for some Muslims, it does not make any difference to them.

Not only do the above four factors need to be mentioned, but there also are more. We need to study each culture to understand the relation between food and the culture, religion, time and locations. Out of this study we are going to derive pre-defined profiles that could be applicable to any person based on the time, origin location, current location and religion. It is a combination of all of these factors and it derives different complexity, as it is not always "yes/no," but sometimes it is a mix. We use ontology to represent the profile as it helps in getting semantic interpretation of the user and matches it with the domain-specific ontology to infer the required information that matches the user's interest. The details of the ontology are in the implementation section.

VI. MULTI-AGENTS CULTURE BASDED PROFILE

Many researches focused on multi-agents for personal's profile and how an agent could learn from other agents in the

same community. However, having culture factors in the personal's profile would add great value to the agents' collaboration. Moreover, the factors from culture could be a major drive way of clustering agent based on the culture factors. Here, the learning of an agent would be exponential if it joins a community of culture-based agents that have similar culture background and influence power of culture.

When adding culture factors to an agent, it is similar to more sensors that the agent could learn from the food habits that are associated to a certain culture. A user could be looked deeper with these culture factors and this adds more efficiency to the agent collaboration model, how?. So, from food habits we don't learn only what the user prefers and what s/he does not prefer only, but also what food habits that work with a certain culture.

VII. DESCRIBING THE IMPLEMENTATION

This work is part of a big project that aims to build a framework that helps users to find semantically health and nutrition information fit to their needs. The architecture of the project has three components: ontology component which maintains a health and nutrition domain ontology and infers the related ontology to the user's query; annotation component which annotates health and nutrition data repositories based on the domain ontology; and query manipulation and results personalization component. This paper focused on the visible interface that users interact with and uses agent framework to personalize and recommend the relevant health and food information. The personalization concept is integrated with the proposed agent-based model to allow for analyzing the user's profile and to get relevant search results. Figure 1 shows the details of the proposed framework's architecture.

We created ontologies for the user's profile, the religion, the location, and finally, for the time, see Figure 2. Each ontology has attributes that are all correlated with the person's profile. This correlation defines how the use is influenced by these factors. The profile ontology consists of five blocks: one block with the user's basic information; one block for the user's health information; one block with the culture's information where each culture is represented and is matched with the user's culture; one block for the user's religion and its constraints; and finally, one block for the user's location where each location has its own preferences. The ontology profile impacts the recommendation as these five blocks are mixed to match the best advice for the user considering all of these factors and matching the health and food ontology.

The work is in progress and we are currently integrating the user's profile with the domain ontology and knowledgebase that contains annotated Web contents. The implementation of the end-user health portal is in progress and all screens have been developed with a complete life cycle from creating the profile to personalizing the search results. Different techniques to understand and manipulate the user's queries using templates and Natural Language Processing (NLP) for free-form texts are implemented and being tested. Finally, we will test the performance and accuracy of the proposed framework. It is necessary to have a complete prototype example in order to evaluate the performance of the framework.

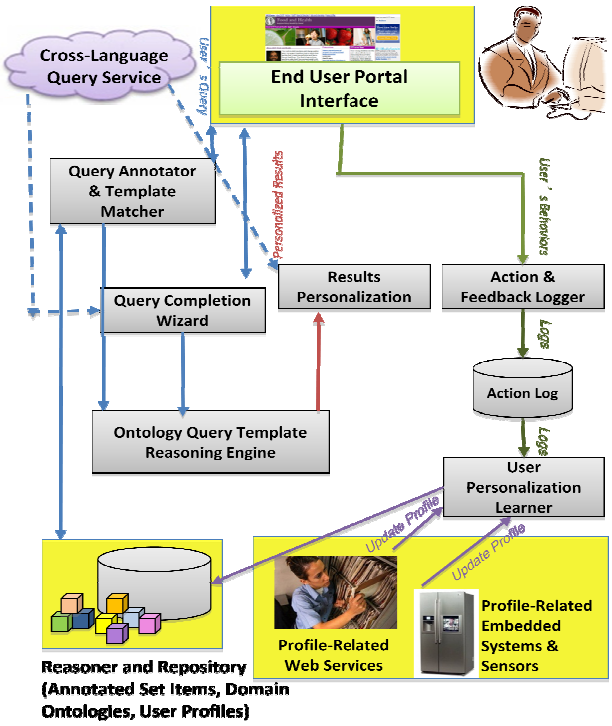

Figure 1. Framework for cross cultural and cross lingual multi-agent recommendation model for food and nutrition

The user starts with the registration in the system and fills in all required information to build the personal profile. Then, the user logs into the system and makes his/her query; i.e. "which fruits are suitable for me?" First, the system manipulates the user's query and converts it into ontology-based structured information using NLP techniques and health and nutrition domain ontology. It finds the right query template that matches the user's query. Then, the converted query (modeled information) is enriched with some attributes in the user's profile, such as age (50 years), gender (male), blood type (O+), medical condition (diabetes, iron-deficiency anemia), culture (Middle Eastern), religion (Muslim) and other dynamic attributes based on the season (summer), location (Saudi Arabia), etc. After that, the system looks at the knowledge base for fruits that suit the person with low concentration of iron (as he has malnutrition) and less sugar (as he is diabetic). Also, it should match his age and gender (some foods are not good for older males) and finally associates the results with his culture (some foods are preferred more in some cultures), religion, location and the season (summer fruits are preferred as it is in summer). After that, the enriched query is used to search in the knowledge base that has been populated from annotated trusted Websites related to the health and nutrition domain. The results of the search are refined again to match the user's preferences based on the user's profile (such as knowing

from history that the user prefers some specific types of foods so that we give it precedence). After that, the user's agent looks at other agents within the same culture and have similar constraints to see their recommendation as well. Then, the personalized results and collaborated results are displayed to the user. Then, the system monitors the user's interactions while navigating through the results and collects the user's feedback to update the user's profile.

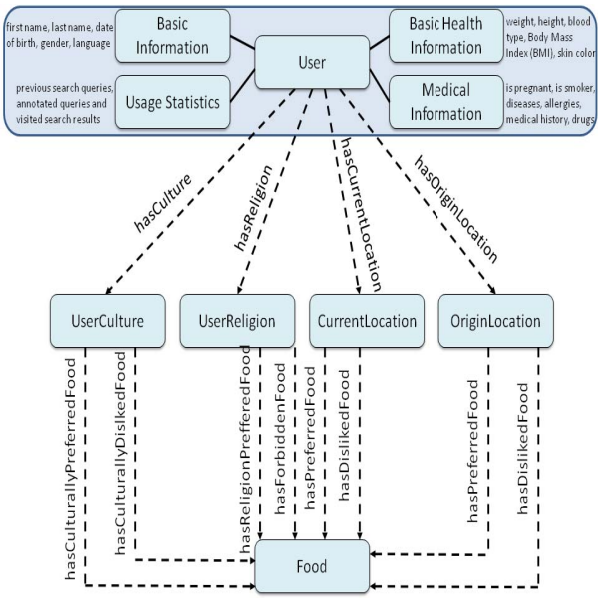

Figure 2. User's Profile Ontology

VIII. EXPANSION AND FUTURE WORK

The importance of cultural effects on a person is not limited to food only, but also has many applications, such as housing, technology, etc. A culture can involve common things for some activities and behaviors for some group of people. Location, religion, and time, among others, are factors that could help in classifying people and clustering their habits, which will help in advising and giving the best recommendation. This could be utilized in commercial use, as well as for advertisement recommendation. What motivates this as a future work is the popularity of social networks such as Facebook, which helps in finding similar culture between different people. In conclusion, the cultural factors are important in other applications in addition to food, and these findings in multi-culture can be expanded to fields beyond health and nutrition.

One example is utilizing the cultural factors to recommend and help with the choice of clothes shopping. Many shopping centers sell different clothes for different cultures. In Arabian Gulf countries, for example, they have "Thobe," which is similar to a robe and covers the entire body. Not all shopping centers sell this kind of clothing, so with the personalized culture-based multi-agent framework, this could be achieved and the persons are advised with the shops that provide clothing suited to their culture.

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