An initial framework for an ontology-based mobile application for vaccine information retrieval and education

Muhammad "Tuan" Amith, MS
School of Biomedical Informatics
University of Texas Health Science Center
Houston, Texas
Email: muhammad.f.amith@uth.tmc.edu

Cui Tao, PhD
School of Biomedical Informatics
University of Texas Health Science Center
Houston, Texas
Email: cui.tao@uth.tmc.edu

***Abstract*—The Center for Disease Control (CDC) distributes Vaccine Information Statements (VIS) documentation to clinician to inform patients of the benefits and risk of the vaccines that are available. The effectiveness of the learning and comprehension has been reported to have been insufficient, particularly with population with lower than average literacy rates. This paper introduces a proof of concept mobile application, driven by a vaccine ontology based on a sample set of VIS documents, as a possible solution.**

***Keywords*—Mobile agents, Knowledge engineering, Vaccines, Biomedical informatics**

I. Background

An initial literature review revealed:

- Vaccine Information Statements is informally read and comprehended by patients. [1] [2]
- Interest and efforts have been made to improve the delivery of vaccine education. [1] [3] [4]
- Internet misinformation campaign have had significant influence on attitudes towards vaccines. [5] [6]

We introduce a prototype ontology-driven application system (Vaccine Helmsman) which employs a semantic knowledge-base, that harness the use of natural language interface of a mobile client for patients to query vaccine knowledge. This prototype intends to improve patient education of vaccines as an on-demand, ubiquitous aid to provide accurate and timely information about vaccinations.

II. Approach & System Overview

With the development of this prototype mobile assistant, we plan on accomplishing the following initial aims.

- **Specific Aim 1.** Create the Vaccine Information Statement Ontology (VISO).
- **Specific Aim 2.** Vaccine Helmsman: Develop the prototype application with client and server components.

The Vaccine Helmsman system employs a client-server model - manifested by the mobile device and server application hosted on the authors' development server. Figure 1 shows an overview of the system and the communication between the mobile application and the server components. The UML diagram depicts the mobile application sending a SPARQL [7] query request to the application server after the natural language interface (NLI) retrieves the user's command and sends it to the translator component for query construction. The server responds to the request and preforms the query on a published OWL2 [8] file. The server applications returns back a JSON [9] data object to the mobile application. The mobile application parses the data object with the translator component, and the NLI component constructs a semi-structured sentence to speak back to the user with an answer for the user query.

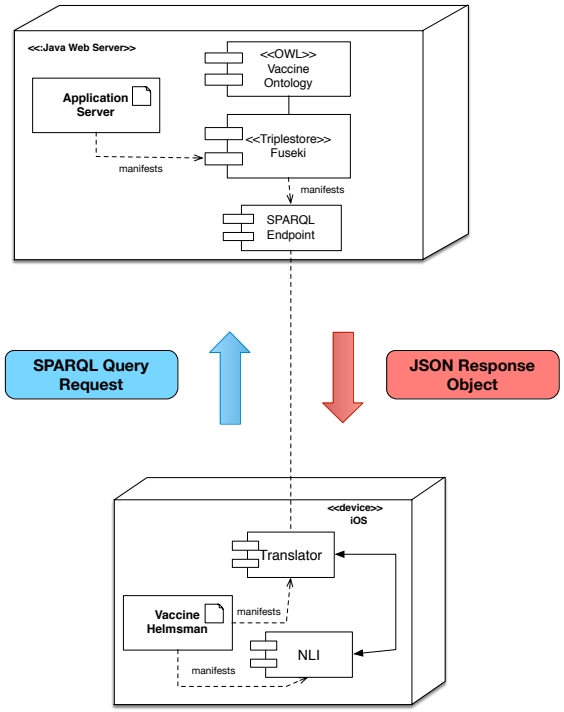


Fig. 1. System architecture of Vaccine Helmsman

Based on the architecture design described above, we have developed a working prototype that both demonstrates

TABLE I. SYSTEM LIMITATIONS AND FUTURE SOLUTIONS

Limitation	Plan	Outcome
Limited vocabulary and terms recognized by system	Utilize SKOS and existing ontologies, and integrate synonymous, consumer-level terms	Recognize synonyms (& multilingual) terms for queries
Supports for only 2 (Rotavirus and Hepatitis B) VIS documents	Improve VISO design with additional VIS and vaccine sources	Better congruency with VIS and comprehensive vaccine knowledge-base
System constraints with offline speech recognition, latency network issues, lack of user evaluation, etc.	Explore options for system improvement and experimentation, and investigate opportunities for user-centered evaluation	Improved usability and overall effectiveness of the application

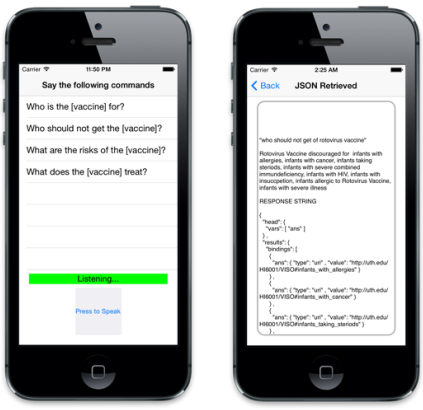


Fig. 2. Screenshots of iOS application: Input screen (left) and response screen (right).

the feasibility of the project and highlights some potential direction to continue to enhance this system. The prototype iOS application was developed in Objective-C (See Figure 2) that accepts a defined set of voice commands and sends the command to a remote application web server . The server application, a Jena Fuseki [10] install, is responsible for the queries on the published VISO OWL file and responds with a JSON object. The iOS application then constructs semi-structured sentences from JSON to speak back to the user. The application also displays the text of the speech along with the returned JSON data for debugging purposes.

Also, the authors created an initial draft of the vaccine information ontology based on the CDC's Vaccine Information Statements, identified as the Vaccine Information Statement Ontology (VISO). VISO, since it is an initial draft at the time of development, only models the Rotavirus and Hepatitis B vaccine information from their respective VIS documents. VISO was serialized in OWL2 using Protégé [11].

III. LIMITATIONS & FUTURE DIRECTION

Because it is still in the beginning stages, limitations exist with the system, which we will address as development continues. Table I outlines the limitations identified, but also describes future solutions to address them and the intended outcome. One factor is the finite vocabulary set of the system, specifically with the VISO knowledge-base, which results in semi-structured speech and limited vocabulary for query recognition. We plan on addressing this issue by utilizing Simple Knowledge Organization Systems (SKOS) [12] that will enable an ontology to add synonymous terms. SKOS may also open possibilities to utilize multi-lingual capabilities to the system. Another issue relating to VISO is the limited number of sources to generate the ontology. Only two VIS documents for Rotavirus and Hepatitis B were used for sampling, resulting in a smaller-than-ideal knowledge-base. Work is underway to improve the VISO knowledge-base by adding additional information from more VIS documents and existing ontologies, and at the time of writing, the VISO design has matured and has incorporated additional VIS knowledge. Various technical constraints exist, which is expected from a prototype. This ranges from restrictions of an offline speech recognition, latency issues relating to a client-server architecture, undiscovered usability issues, and so on. Upcoming development will explore other options to improve some of these limitations, including generating a methodology to evaluate the user experience.

REFERENCES

[1] Lieu TA, Glauber JH, Fuentes-Afflick E, and Lo B, "*Effects of vaccine information pamphlets on parents' attitudes,*" Archives of Pediatrics & Adolescent Medicine, vol. 148, no. 9, pp. 921-925, Sep. 1994.

[2] M. St-Amour, M. Guay, L. Perron, P. Clment, G. Baron, G. Petit, and J. Lemaire, "*Are vaccination information leaflets useful for vaccinators and parents?,*" Vaccine, vol. 24, no. 14, pp. 2491-2496, Mar. 2006.

[3] T. C. Davis, J. A. Bocchini, D. Fredrickson, C. Arnold, E. J. Mayeaux, P. W. Murphy, R. H. Jackson, N. Hanna, and M. Paterson, "*Parent Comprehension of Polio Vaccine Information Pamphlets,*" Pediatrics, vol. 97, no. 6, pp. 804-810, Jun. 1996.

[4] T. M. Fitzgerald and D. E. Glotzer, "*Vaccine Information Pamphlets: More Information Than Parents Want?,*" Pediatrics, vol. 95, no. 3, pp. 331-334, Mar. 1995.

[5] A. Kata, *"Anti-vaccine activists, Web 2.0, and the postmodern paradigm An overview of tactics and tropes used online by the anti-vaccination movement,"* Vaccine, vol. 30, no. 25, pp. 37783789, May 2012.

[6] A. Kata, *"A postmodern Pandoras box: Anti-vaccination misinformation on the Internet,"* Vaccine, vol. 28, no. 7, pp. 17091716, Feb. 2010.

[7] *"SPARQL 1.1 Overview."* [Online]. Available: http://www.w3.org/TR/sparql11-overview/. [Accessed: 15-Aug-2014].

[8] "OWL 2 Web Ontology Language Document Overview (Second Edition)." [Online]. Available: http://www.w3.org/TR/owl2-overview/. [Accessed: 01-Jul-2014].

[9] *"JSON."* [Online]. Available: http://json.org/. [Accessed: 15-Aug-2014].

[10] *"Apache Jena - Home."* [Online]. Available: https://jena.apache.org/. [Accessed: 15-Aug-2014].

[11] *"protégé."* [Online]. Available: http://protege.stanford.edu/. [Accessed: 01-Jul-2014].

[12] *"SKOS Simple Knowledge Organization System - home page."* [Online]. Available: http://www.w3.org/2004/02/skos/. [Accessed: 15-Aug-2014].

An initial framework for an ontology-based mobile application for vaccine information retrieval and education

Muhammad “Tuan” Amith, M.S., Cui Tao, Ph.D.

The School of Biomedical Informatics |The University of Texas Health Science Center at Houston

UTHealth
The University of Texas Health Science Center at Houston
School of Biomedical Informatics

Background

Since the early 90s, healthcare providers have been mandated to provide VIS (Vaccine Information Statement) from the Centers for Disease Control and Prevention (CDC) to parents and patients before their children or themselves receive any vaccination uptake. Despite the initiative, there exist issues of patients not acquiring a comprehensive understanding about the vaccines and some evidence of doubt of the safety of vaccines. In addition, a significant number of patients find vaccine information on the Internet, which may inevitably influence perceptions of vaccines. This paper introduces Vaccine Helmsman, an initial prototype of a mobile client that allows for natural language querying of semantically-driven knowledge-base of vaccine information for patients.

Approach

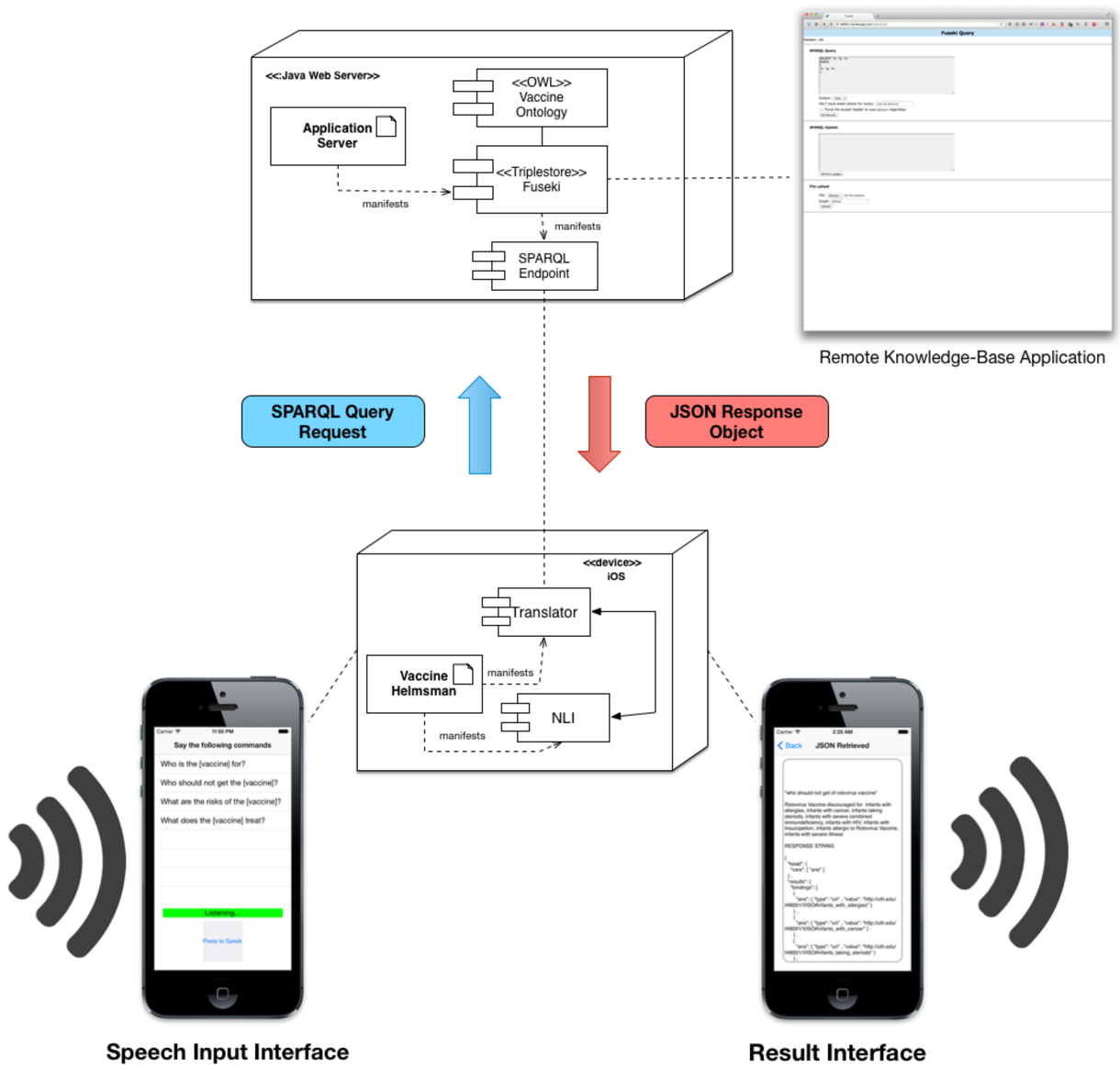
A literature review revealed that CDC-mandated VIS are seldom read or understood[1][2], and a need for better delivery of vaccine education[1][3][4]. Additionally, misinformation campaigns have influenced attitudes and decisions for uptake[5][6][7].

The authors introduces a prototype ontology-driven application system (Vaccine Helmsman) which employs semantic knowledge base, permitting the use of natural language interfaces for patients to query vaccine knowledge. The prototype aims to address the vaccine education gap.

The authors have developed the Vaccine Information Statement Ontology (VISO) that only models Rotavirus and Hepatitis B vaccine information, represented in OWL[8], using Protégé[9]. Later development will include a corpus of vaccine knowledge from CDC’s VIS.

In conjunction with the creation of VISO ontology, the authors have developed a prototype iOS application in Objective-C that accepts defined set of voice commands and sends the command to a remote Java web server. The server application, a Jena Fuseki[10] install, queries the published VISO OWL file and responds with a JSON[11] object. The app then constructs semi-structured sentences from JSON to speak back to the user.

System Architecture



Limitations	Plan	Outcome
Limited vocabulary and terms recognized by system	Utilize SKOS and existing ontologies, and integrate synonymous, consumer-level terms	Recognize synonyms (& multilingual) terms for queries
Supports for only 2 (Rotavirus and Hepatitis B) VIS documents	Improve VISO design with additional VIS and vaccine sources	Better congruency with VIS and comprehensive vaccine knowledge-base
System constraints with offline speech recognition, latency network issues, lack of user evaluation, etc.	Explore options for system improvement and ex-perimentation, and investigate opportunities for user-centered evaluation	Improved usability and overall effectiveness of the application

Future Direction

Because it is still in the beginning stages, limitations exist with the system, which we will address as development continues. One factor is the finite vocabulary set of the system, specifically with the VISO knowledge-base, which results in semi-structured speech and limited vocabulary for query recognition. We plan on addressing this issue by utilizing Simple Knowledge Organization Systems (SKOS)[12] that will enable an ontology to add synonymous terms. SKOS may also open possibilities to utilize multilingual capabilities to the system. Another issue relating to VISO is the limited number of sources to generate the ontology. Only two VIS documents for Rotavirus and Hepatitis B were used for sampling, resulting in a smaller-than-ideal knowledge-base. Work is underway to improve the VISO knowledge- base by adding additional information from more VIS documents and existing ontologies, and at the time of writing, the VISO design has matured and has incorporated additional VIS knowledge. Various technical constraints exist, which is expected from a prototype. This ranges from restrictions of an offline speech recognition, latency issues relating to a client-server architecture, undiscovered usability issues, and so on. Upcoming development will explore other options to improve some of these limitations, including generating a methodology to evaluate the user experience.

References

1. Lieu T, et al. Effects of Vaccine Information Pamphlets on Parents’ Attitudes. Arch Pediatr Adolesc Med. 1994; 148: 921-925.
2. St-Amour M, et al. Are vaccination information leaflets useful for vaccinators and parents? Vaccine 24, 2006: 2491-2496.
3. Fitzgerald T, Glotzer D. Vaccine Information Pamphlets: More Information Than Parents Want?. Pediatrics. March 1995 : 331-334.
4. Davis T,et.al.Parent Comprehension of Polio Vaccine Information Pamphlets. Pediatrics Vol 97,No 6,June 1996: 804-810.
5. Kata A. Anti-vaccine activists, Web 2.0, and the postmodern paradigm - An overview of tactics and tropes used online by the anti-vaccination movement. Vaccine 30, 2012: 3778-3789.
6. McRee A, Reiter P, Brewer N. Parents’ Internet use for information about HPV vaccine. Vaccine 30, 2012: 3757- 3762.
7. Kata A. A postmodern Pandora’s box: Anti-vaccination information on the Internet. Vaccine 28, 2010: 1709-1715.
8. OWL 2 Web Ontology Language Document Overview (Second Edition). http://www.w3.org/TR/owl2-overview/. Published December 11, 2012. Accessed March 1, 2014.
9. Protégé. http://protege.stanford.edu/. Accessed March 10, 2014.
10. Fuseki: serving RDF data over HTTP. https://jena.apache.org. Accessed April 24, 2014.
11. JSON. http://json.org/. Accessed April 25, 2014.
12. SKOS Simple Knowledge Organization System. http://www.w3.org/2004/02/skos/. Accessed April 25, 2014.

Contact Information

For more information on this poster, please contact **Tuan Amith, MS** at muhammad.f.amith@uth.tmc.edu, **Cui Tao, PhD** at Cui.Tao@uth.tmc.edu