An Architectural Design of Virtual Dietitian (ViDi) for diabetic patients

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***Abstract*—Artificial Intelligence chatbot is a technology that makes interaction between man and machine using natural language possible. In this paper, we proposed the architectural design of Virtual Dietition (ViDi), a chatbot that will function as virtual dietitian for diabetic patients. A general a history of a chatbot, a brief description of each chatbots is discussed. We proposed the use of new technique that will be implemented in ViDi as the key component to function as virtual dietitian. In architectural design of ViDi, Vpath is used to remember the conversation path. The architectural design will allow chatbot ViDi to response to the whole conversation as it specifically designed to be a Virtual Dietitian.**

Keywords- Virtual Dietitian (ViDi); chatbot; pattern-matching; ELIZA; A.L.I.C.E; VPbot; diabetic; Vpath

I. INTRODUCTION

It all started when mathematician Alan Turing proposed the question "Can machines think?"[6]. He also introduces "The Imitation Game" that now are known as "Turing Test". The idea is to test if machine can fool a judge in thinking that they are having a conversation with human (as a way to counter the question "Can machines think?"). Fifteen years past and Joseph Weizenbaum, a professor from Massachusetts Institute of Technology (MIT) introduces the first chatbot named ELIZA [9] that later was referred as a pioneer in the rapid development of chatbot. In 1995, Dr. Richard Wallace, ex-Professor at Carnegie Mellon University with a background in computer vision and robotics, combined his interest in the internet and the difficulties in natural language processing to produce A.L.I.C.E. – Artificial Linguistic Internet Computer Entity which is a modern ELIZA, an artificial conversational entity or ACE. A.L.I.C.E. was a three times winner of Loebner's annual instantiation of Turing's Test for machine intelligence [5].

Apart from developing a chatbot that will mostly act as a human in a conversation (in a wide range area of knowledge), we would like to propose the technology to be implemented in Diabetes management activities with the additional components that will make the chatbot suitable for those activities. There was an effective usage of a chatbot in medical field proven by the success of VPbot, developed by Dr. Griffin Webber from Harvard University. VPbot has been particularly successful in Harvard Medical School's Virtual Patient program, in which VPbot simulates patients that medical students can "interview" through a web-based interface. Not only the students who have used the Virtual Patient scored higher in exams, but also the Association of American Medical Colleges (AAMC) has chosen the Virtual Patient and VPbot to be the core of its new nation-wide MedEdPORTAL initiative [8]. What we want to propose is slightly different from VPbot where we want the chatbot to act as a virtual dietitian (virtual doctor), not as a virtual patient as far as VPbot is concern. The chatbot will be known as "ViDi", acronyms from Virtual Dietitian.

II. ELIZA

ELIZA is a program which makes natural language conversation with a computer possible. What is important here is that the computer can read messages typed on the typewriter and respond by writing on the same instrument. Input sentence are analyzed on the basis of decomposition rules which are triggered by key words appearing in the input text. Responses are generated by reassembly rules associated with selected decomposition rules. The fundamental technical problems with ELIZA are: (1) the identification of key words; (2) the discovery of minimal context; (3) the choice of appropriate transformations; (4) generation of responses in the absence of key words; and (5) the provision of an editing capability for ELIZA "scripts" [9].

The fundamental technical problems with which ELIZA must be preoccupied are the following: (1)The identification of the "most important" keyword occurring in the input message; (2) The identification of some minimal context within which the chosen keyword appears, for example if the keyword is "you", is it followed by the word "are" (in which case an assertion is probably being made); (3) The choice of an appropriate transformation rule and, of course, the making of the transformation itself; (4) The provision of mechanism that will permit ELIZA to respond "intelligently" when the input text contained no keywords; and (5) The provision of machinery that facilities editing, particularly extension, of the script on the script writing level [9].

III. A.L.I.C.E

A.L.I.C.E. first surfaced in 1995 and resulted from a collection of dialogue default responses collected by Wallace from books read, movies seen and life experiences, ostensibly from seemingly meaningless events. The aim of his creation, says Wallace, was to keep A.L.I.C.E. talking as

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long as possible without interacting humans realizing they were talking to a machine. A.L.I.C.E.'s content "comes directly from the effort to maximize dialogue length", which is the cost of conversation. A.L.I.C.E. is built to be a flexible technology [5].

A.L.I.C.E.'s knowledge about English conversation patterns is stored in AIML files. AIML or Artificial Intelligence Markup Language is a derivative of Extensible Markup Language (XML). It was developed by Dr. Wallace and the Alicebot free software community from 1995 onwards to enable people to input dialogue pattern knowledge into chatbots based on the A.L.I.C.E. open-source software technology [1].

AIML, describes a class of data objects called AIML objects and partially describes the behavior of computer programs that process them. AIML objects are made up of units called topics and categories, which contain either parsed or unparsed data. Parsed data is made up of characters, some of which form character data, and some of which form AIML elements. AIML elements encapsulate the stimulus-response knowledge contained in the document. Character data within these elements is sometimes parsed by an AIML interpreter, and sometimes left unparsed for later processing by a Responder [7].

IV. VPBOT

Where A.L.I.C.E. is a modern ELIZA, the concluded distinctive between those two can be described as [4]:

- ELIZA – Keyword spotting and pattern-matching with 200 stimulus response pairs.
- A.L.I.C.E. – Case-based reasoning (CBS) for extraction of correct context of ambiguous words, random sentence generator, knowledge base (temporal, spatial, etc.), spell checker, and 45,000 stimulus response pairs.

Apart from ELIZA and A.L.I.C.E., there is VPbot, a SQL-Based chatbot for medical applications. VPbot, which stores 'language rules' in a relational data model. It shares many of the same features as A.L.I.C.E., but it is often easier to define new language rules in VPbot that with AIML. Whereas A.L.I.C.E. is designed to be able to produce generic responses to a wide range of topics, VPbot is best suited for a targeted topic of conversation. The VPbot algorithm accepts three input parameters, a *vpid*, *the current topic*, and a *sentence*. The *vpid* is a unique identifier for each VPbot instance. The topic is an optional parameter, which can be used to handle pronouns. Although the topic is an input parameter in the general VPbot algorithm, in the Virtual Patient implementation, the student can neither see the topic nor change it. It is simply a variable that the Virtual Patient stores internally and returns to the chatbot with the next question. Note that while the VPbot topic serves a purpose similar to that of the AIML <topic> and <that> tags, it is used differently in VPbot. The output of VPbot is a new sentence and a new topic. As with AIML, the output sentence can be dynamically constructed using parts of the input sentence; the database does not have to store every possible response [8].

Although VPbot uses SQL rather than AIML, there is a certain limit. As stated by Dr. Webber in his thesis, there are some limitations on what is possible with a single SQL statement, primarily because true recursion is not supported. However, in a restricted domain, such as a doctor-patient conversation, the full capabilities of AIML are not needed [8].

V. CHATBOT FOR DIABETIC

Diabetes affects 246 million people worldwide and is expected to affect some 380 million by 2025. Each year, 3.8 million deaths are linked directly to diabetes-related causes including cardiovascular disease made worse by diabetes-related lipid disorders and hypertension [2]. 6% of the global adult population has affected by diabetes. Every year, over 3.8 million deaths are due to diabetes, making diabetes a more significant global killer than HIV/AIDS and malaria combined [3].

Diabetes cannot be cured at the moment, but it can be properly manage in order for patients to have a healthy and active life. Three major components in managing diabetes are monitoring (blood glucose level), proper diet (by following dietitian advice) and patients/guardians motivation (to motivate diabetic to have the urge of managing their disease). The second component where patients get a diet advice is usually done in a hospital/clinic where patients have a session with dietitian. The session generally is a question and answer session and at the end, dietitian will give the diet advice that is most suitable for the patient (a real-time session study is done in Hospital Tengku Ampuan Afzan (HTAA), Kuantan, Pahang, Malaysia). From this scenario, we thought that maybe a chatbot can replace the dietitian where the session can be done without the present of the actual dietitian. We propose to develop ViDi, a Virtual Dietitian for diabetic patients.

The process flow the chatbox is that the patient will have a regular chatting conversation with ViDi which will be a question (ask by ViDi) and answer (input by patient) session. This session will continue until the patient is successfully being diagnosed by ViDi and patient will get their most suitable diet advice for their Diabetes condition. In order to clarify the diagnosis, ViDi will ask several sequence questions and those questions will be selected based on the answers given by the patient. This means ViDi need to know the whole conversation flow.

Referring to the literature of a chatbot, the flow of a chatting session is a user enters an input, and chatbot will response. The logic of the process is like a search box where user input the searching parameter and the search engine will return a result regarding that parameter. It is likely a single flow of process where previous input is not related with the current and future input. Thus, in chatbot technology, there is a way where chatbot can remember the previous conversation. By using "Wildcards", chatbot will be able to "copy" some phrase/words that user input, and "paste" it in the response that will be given back to the user. Chatbot also have the ability to "remember" topic of the conversation that will make the generated response stay in the topic. Although those functions are really effective, it still does not allow chatbot to remember the whole conversation whereabouts. As Abu Sawar and Atwell stated that the most common drawbacks of a chatbot is that they did not save the history of conversation and does not truly understand what the conversation is all about, it just gives user the response from the knowledge domain stored in the "brain" [1].

To fill those gaps, we propose a process architecture that will made ViDi remember the conversation whereabouts that later will be used to diagnose the patient. The key is to made ViDi know the path where patient takes in the questions and answers session. The path will be determined by analyzing parameter called "Vpath". Fig. 1 shows the graphical description of how ViDi will determine Vpath.

In Fig. 1, the circle shape with "Q" inside represent the question ask by ViDi and the circle with "A" inside represent the answer input by patient. Fig. 1 shows the path that was taken by patient (represent by bold line and text) in three levels diagnose session with the maximum questions for each level are nine (note that the actual session may take more levels, and the questions for each level maybe less than nine, depends on the actual dietitian questions and answers session that later will be designed). For each level, patient will only be asked one question but if ViDi did not detect any keywords from the answer, several questions will be asked until the keywords is detected. Note that the level will only be increased when ViDi detected the keywords. The flow of the process is described in Fig. 2.

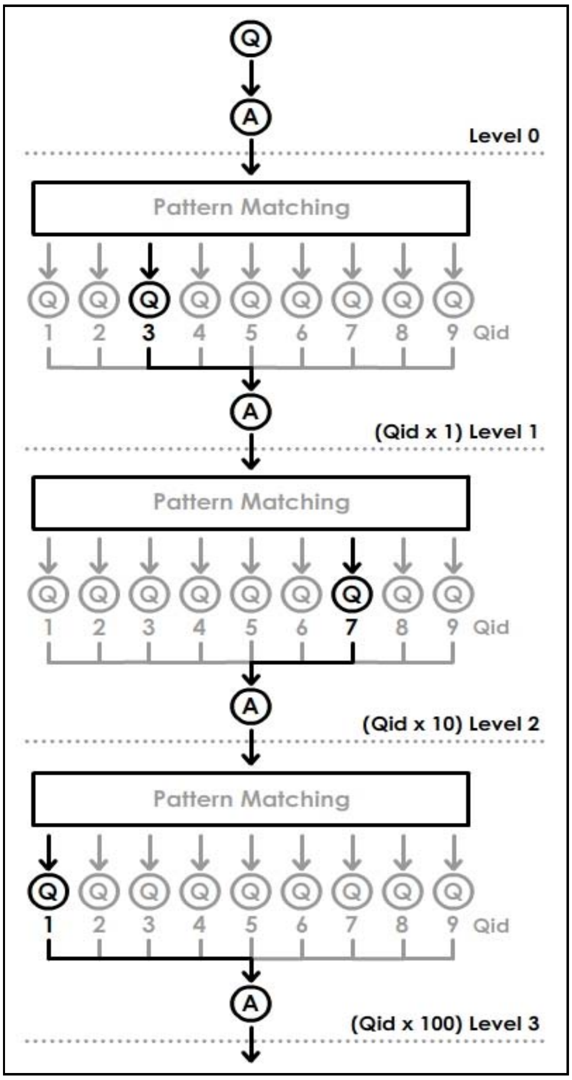

Figure 1. A sample of path taken by patient in conversation with ViDi

For the three levels diagnose session (as shown in Fig. 1), the total probability of the possible path is 729 (9 * 9 * 9 = 729) with the Vpath value are 111, 112, 113, 114, 115, 116, 117, 118, 119, 121, 122, 123, 124, 125, 126, 127, 128, 129, 131, 132, 133, 134, 135, 136, 137, 138, 139, … until 991, 992, 993, 994, 995, 996, 997, 999. Although there is a 729 possible path that can be taken by patient in this session, the conclusion maybe not equal to 729 because the diagnosis can be flexible and also the total questions for each level can be less than nine. All those components will be determined when designing the session's questions and path with actual dietitian.

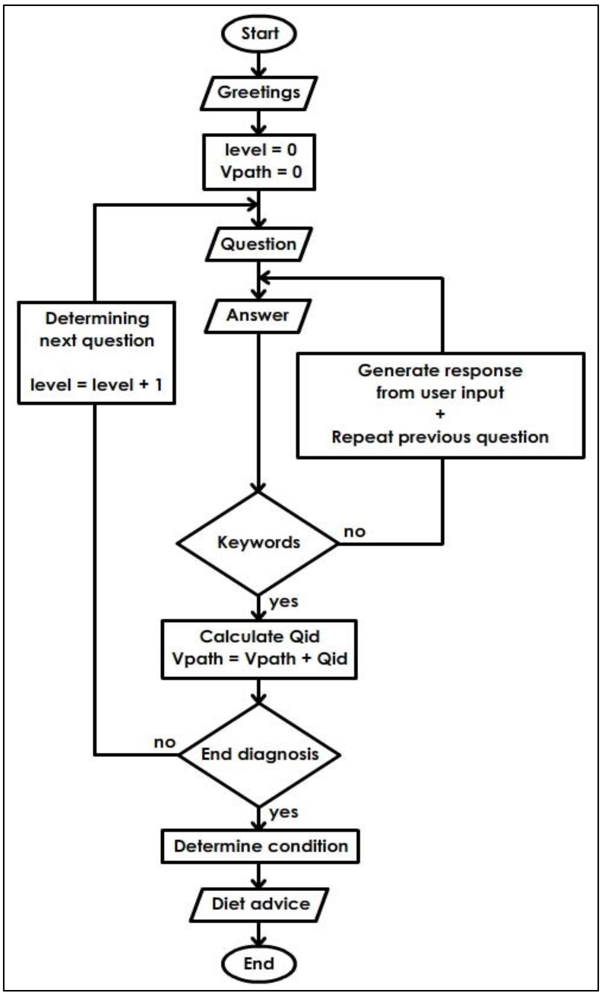

Figure 2. Flow of process for patient conversation with ViDi

Each questions has their own value define by parameter called "Qid" and each Qid will be multiply by specific value for each level which is the value of increasing multiply 10 starting with 1 for level 1, 10 for level 2, 100 for level 3 and so on. Vpath is a total value of Qid referring to the path where the conversation takes place. In Fig. 1, the calculation for Vpath can be described as; Qid for level one is 3 (3 * 1), level two is 70 (7 * 10), and level three is 100 (1 * 100) and so the Vpath is 173 (3 + 70 + 100).

VI. ViDi Pattern-matching

For each level, a pattern-matching process will be done in order for ViDi to detect keywords from patient's input data. Several steps need to be done in the process and the steps are as follows:

- Receive input data from patient.
- Convert all alphabets into lower case.
- Separate words from sentence by dot ".", comma "," and space " ".
- Put all words into an array.
- Create an array of possible input to be match (sentence, phrase and words).
- Matching the array to "keywords" database one-by-one starting from the full sentence until for the each words (note that matching will based on level where the conversation is located).
- Exit all loop if matching were found.

The total possible input to be match is calculated by the Triangular Number equation, as in (1).

- m = Variable for matching
- n = Total words in input data

$$T_n = \frac{n(n+1)}{2} = \sum m \qquad (1)$$

For example, if the total words of an input sentence are 5, then the total number of possible input to be match is 15. It can be described as shown in Table 1 (let say the input sentence is "Yesterday, my chest hurt badly").

TABLE I. Possible Input to be Match for 5 Words Input Sentence

Possible Input to be Match	Input Sentece				
	Word 1	*Word 2*	*Word 3*	*Word 4*	*Word 5*
1	yesterday	my	chest	hurt	badly
2	yesterday	my	chest	hurt	
3		my	chest	hurt	badly
4	yesterday	my	chest		
5		my	chest	hurt	
6			chest	hurt	badly
7	yesterday	my			
8		my	chest		
9			chest	hurt	
10				hurt	badly
11	yesterday				
12		my			
13			chest		
14				hurt	
15					badly

VII. Conclusion

The architectural design of ViDi is yet to be implemented but first, the virtual dietitian session must be designed with the actual dietitian. In architectural design of ViDi, we proposed the used of Vpath, a way for ViDi to remember the conversation path. We also design the conversation to be controlled by ViDi rather than by user (likes any other chatbot program) by making the user stick to the conversation topic and not to enter any irrelevant input, and if they do, ViDi will response that the input was not understandable and keep repeating the previous question (with a good manner) until the keywords is detected. The suggestion also will be provided as guidance for patient to answers the questions correctly. It was certainly suitable for ViDi following the actual dietitian questions and answers session. Rather than one response for one input, this architectural design will allow chatbot ViDi to response to the whole conversation as it specifically designed to be a Virtual Dietitian.

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