

# Chatbot Implementation for ICD-10 Recommendation System

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**Abstract**— ICD-10 coding becomes an essential process to transform descriptions of medical diagnoses and procedures into universal medical code numbers. Because there are a large number of the ICD-10 codes, this process needs an expert or an experienced staff to proceed. However, insufficient of the staffs in this area makes this task become a difficulty for general public health staff. Therefore, a recommendation system by using chatbot technology is proposed in this work. This system is implemented by using a messaging application with auxiliary Natural Language Processing (NLP) library. The system was compared with the conventional ICD-10 application by using Analytic Hierarchy Process (AHP). The evaluation result shows that the proposed chatbot can perform an effective solution for selecting ICD-10 code. In addition, it also shows that the proposed chatbot is preferable to be applied in the ICD-10 application.

**Keywords**— Recommendation System; Chatbot; Natural Language Processing; ICD-10

## I. INTRODUCTION

Since 1994, the World Health Organization (WHO) published a book for public health officers to record statistic data of disease and health issues for the benefit of international health planning, which is called “International Classification of Disease and Related Health Problem 10<sup>th</sup> Revision” (ICD-10)[1]. It uses by medical recorders and medical statistic officers to provide ICD-10 codes. Completely and correctly ICD-10 coding requires basic medical knowledge, pathology, anatomy, and so on to understand the nature of the diseases, procedures, and treatments from the diagnosis report.

Currently, insufficiency medical recorder was founded as a big problem of contributing ICD-10 codes. It caused precipitant and careless result especially in government hospitals where the workload exceeds the workforce [2]. For this reason, many hospitals have to assign doctors, nurses or other related staffs to code instead of medical recorders. Because of lacking the knowledge and understanding the process of providing codes, there are many problems created in this process such as a mismatch between code and disease, the mismatch between code and gender or age, and incomplete code.

Because all coded information is sent to the data center, these can lead misconception of health service plan and diseases prevention. In addition, wrong coding affects error data of medical disbursement, which is important to operate the individual health insurance to health insurance funds, such as, National Health Security Office (NHSO), the Comptroller General's Department (CGD), and so on. ICD-10 code is evidence of proving medical expenses to the health insurance funds. If those organizations detect error code, the data need to

be correct again by officers in the hospital. These issues waste a lot of time and human resources.

As mentioned above, both government and private organizations noticed the problems of ICD-10 coding. Therefore, the training courses were generated for educating the staffs including medical recorders, physicians, nurses, and medical allied staffs who are involved in the coding process. In addition, many organizations have developed software or applications to support people in this process. In this work, a chatbot is proposed to serve for this task, which can be used to search, give advice, and provide guidelines for suitable ICD-10 code. The chatbot is one of the computer programs which is becoming more and popular in the present era. The chatbot can assist the communication with people and can be applied to the modern messaging application, such as Line, Viber, WhatsApp, WeChat [3].

To develop a chatbot, an advance National Language Processing (NLP) and National Language Understanding (NLU) framework are necessary, which are provided and free of charge by famous IT companies for today, e.g., Wit.ai, IBM Watson, Pandorabots, and Dialogflow. Dialogflow, which is a cloud base platform developed by Google inc.[4], was selected to develop chatbot processing of finding ICD-10 in this study. The goal of this work is to develop a chatbot for who is involved in ICD-10 coding and understand the principle of coding. To compare the performance of the proposed chatbot, the application of the Ministry of Public Health, Thailand, is used as the comparison.

The rest of this paper is organized as follows. In Section II, we review relevant research along 4 topics: 1) chatbot, 2) ICD-10, and 3) chatbot evaluation. While in Section III, the implementation details of the proposed chatbot are given and the evaluation result is given in Section IV. The last section of this paper is the conclusion.

## II. LITERATURE REVIEW

A chatbot is an online human-computer dialog system with natural language [5]. The chatbot is a demanding application that aims to administer chat service by instant texting in the proper way [6]. It has been known that it is faster and less confusing rather than application when using on website and smartphone. In addition, getting started is easy without the need for installing new software.

### A. Chatbot Types

There are 2 types of chatbot, i.e., Rule-Based chatbot and AI-Based chatbot [4].

- Rule-Based approach is a developmental approach of the chatbot to interact with users following conditions or the rule set. The development of this chatbot needs to cover all related conditions. If not, the chatbot will not understand the conversation, which the user wants to communicate.
- AI-Based approach is a developmental approach of chatting that obtained intent and context to facilitate the chatbot. It requires NLP to analysis the words for more clearly understanding what the user exactly wants to communicate.

Typically, the basis of implementation chatbot requires dialogs that consists of questions and answers to train the chatbot. Currently, there are several ways to develop a chatbot without computer coding which makes the development of the chatbot becomes simpler and faster.

### B. Dialogflow

Dialogflow is formerly known as Api.ai, which was developed by Speaktioit. A human-computer interaction technology based on NLP [7] creates a language processing system that incorporates user contexts into the processing, such as conversation history, user position, and what user is interested in.

Dialogflow framework can be described as follows. When the user sent a message to the chatbot. Dialogflow platform will transform the message into an action object form. These data will be sent to external web servers for analysis and processing. By using the appropriate decision logic to responds to the user's expectations [8]. The model used by Dialogflow depends on an agent to select an answer to a user's query. A Dialogflow agent includes five elements to control the behavior: Intents, Entities, Knowledge, Integrations, and Fulfillment [9].

### C. ICD-10

ICD-10 is a book that collects disease codes, health issues, and public health services. In order to be able to find the medical records and collect statistics for health planning purposes, the symptoms are classified into categories, characteristic or location of the diseases. In addition, ICD-10 is essential for reporting of illness and death data, research database, and creating the Diagnosis Related Group (DRG); which is used to classify the patients based on principal diagnosis, secondary diagnosis, procedure of treatment, length of staying in the hospital, age and sex, to know the resources that operated in services [1].

ICD-10 is a code that consists of alphanumeric characters. The 1<sup>st</sup> digit uses the English alphabet, i.e., A-Z. Second to fifth digits use the number between 0 and 9 with the dots between 3<sup>rd</sup> and 4<sup>th</sup> digits, for example, "E11.9", "V22.99". It comprises 3 volumes which volume 1 contains the main classifications, volume 2 provides the user guidance, and volume 3 is an alphabetical index classification [1].

### D. AHP

AHP is a method of analysis for deciding the best alternative among the complicated data; developed by Thomas Saaty in 1970 [10]. The way of making complex decisions and prioritizing data is managing complex decisions to be sets of data, comparing sets of data in each pair, finally synthesizing the results [11]. The principle of AHP is that the structure of the problem is constructed into layers based on the related criteria. The first layer is specifying targets or objectives, then set criteria, sub-criteria and choices or alternatives, respectively. After that, the best decision is chosen by trade-off, which uses criteria to pick the pair (pairwise) for comparing the more important criteria; consideration by rating the feeling, preference or significance. After prioritizing the importance of data, the next step is investigating the criteria of all data sets. If the significance or preference score is consistency, the tool can allocate the best alternatives. Moreover, AHP has a useful technique for verifying the consistency of decision making that reduces bias on decision making as well [12] - [14].

### E. Related work

In the past, there are many types of research and innovations that used a chatbot to improve work efficiency. In 1966, the first chatbot was created by Joseph Weizenbaum, named ELIZA program [15]. The responses are constructed to messages that a user inputs via a text-based terminal. With the starting point from the ELIZA that desired to show natural language conversations with computers currently, chatbot not only able to chat alone but also lead to the development of Artificial Intelligence Markup Language (AIML). AIML is used to confirm pattern-matching rules that link input messages with the main categories. It knew as eXtensible Markup Language (XML) based system and supports several chatbot platforms in these days [6]. Presently, most of all services rely on intent concepts and entities. The emphasis of NLU is witnessed by the various cloud-based platforms proposed by the major IT companies such as Facebook, Google, IBM, Microsoft and so forth.

## III. SYSTEM IMPLEMENTATION

### A. System Architecture

In this work, the Dialogflow was chosen to develop a chatbot. Dialogflow Platform functions begin from the users send their command through the system. Next, the platform processes input messages into intent and context; so the system can understand the user's volition. Then the data input was run together with fulfillment and database. Finally, the chatbot attempts to select the answers that are closest to the meaning of the user's volition and reply in term of text, audio, image data, etc. This processes can be presented as shown in Fig. 1.

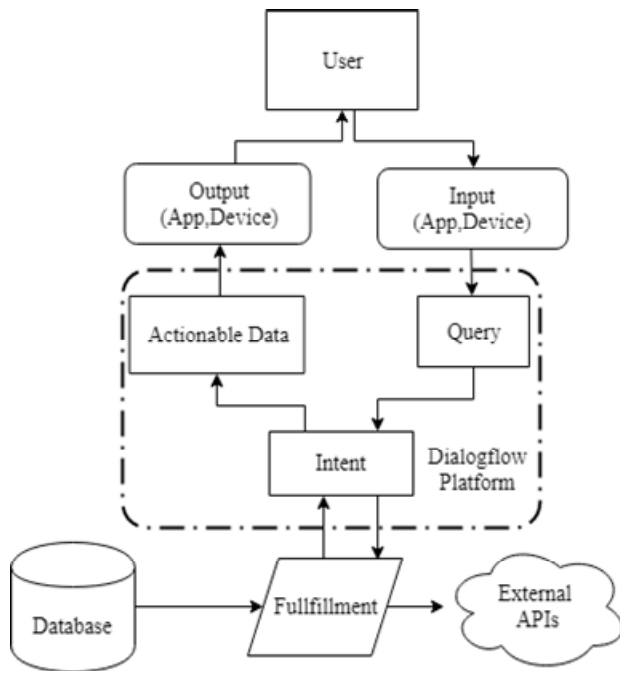


Figure 1. Dialogflow diagram.

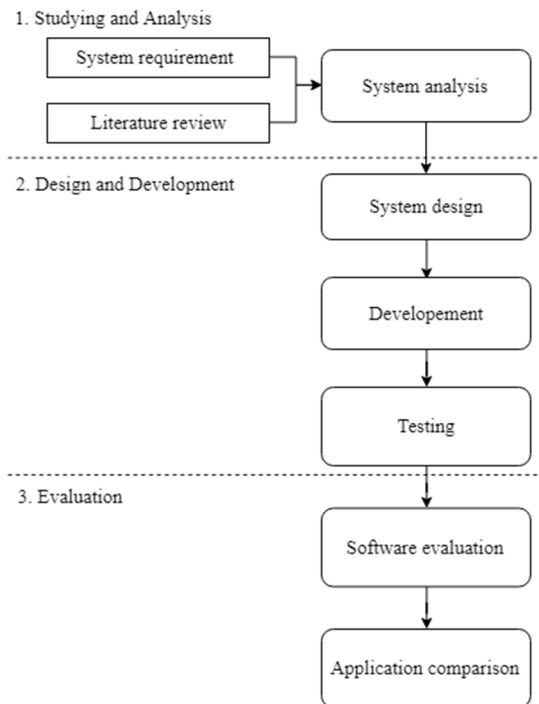


Figure 2. Methodology.

## B. Methodology

In the development of ICD-BOT, it consists of 3 steps, including the study and analyzes system requirements, design and development, and evaluation as shown in Fig. 2. Details are as follows.

### 1) Study and analyze system requirements

The requirements of the system were studied, analyzed and collected the necessary information based from THAI-ICD10 which is an application of the Ministry of Public Health of Thailand that aids to find ICD-10 codes. We found many problems affecting users as below.

- Users cannot search using abbreviations, such as CAD (Coronary Artery Disease), DM (Diabetes Mellitus), Fx (Fracture).
- There have no guidelines of important ICD-10 codes, such as dual code, some code with 4 digits.
- If the keyword of the diseases or services is incorrect, the disease code will not be displayed.
- Most of the codes are not appear in the detailed code.
- It cannot search the external cause code; a specific group disease that is difficult to find ICD-10 codes in the category from the *Alphabetical Index* book if the user is not a medical recorder.

### 2) Design and Development

The results from the analysis of the system requirements were used for implementing the chatbot for selecting the important and complex ICD-10 codes. In order to work systematically, the mentioned disease codes were registered to analyze and design the structure. It has 3 important steps as follows.

2.1) Analyzing, selecting and classifying ICD-10 codes for finding, divided into 3 groups below.

- Diabetes Mellitus (ICD-10: E10 – E14)
- Trauma (ICD-10: S00 – S99)
- External Cause (V00-Y96)

2.2) Analyzing and writing the framework to search systems and provide guidance on ICD-10 coding. In the standard coding guideline, the codes must be classified by patient types, such as obstetrics (O), neonatal (P), trauma (S-T), or the general population. Therefore, the codes group are different according to context. It is the cause of the complicated coding process. In this step, it is a summary of the process to provide the correct coding before developing the system. In Fig. 3, an example of the Diabetes Mellitus coding process.

As providing the medical codes in diabetes mellitus group, characteristic of the patients is necessary to know, for example, neonatal group, obstetrics group or general group. Firstly, neonatal group, the codes could suddenly decide. On the other hand, secondly, obstetrics group needs to indicate diabetes type before providing codes. Lastly, the general group, need to identify the types then check condition status that is complications from diabetes disease such as coma, ketoacidosis and so on. For complete coding in this group, when patients have complication diseases, codes of those complication diseases must provide as well.

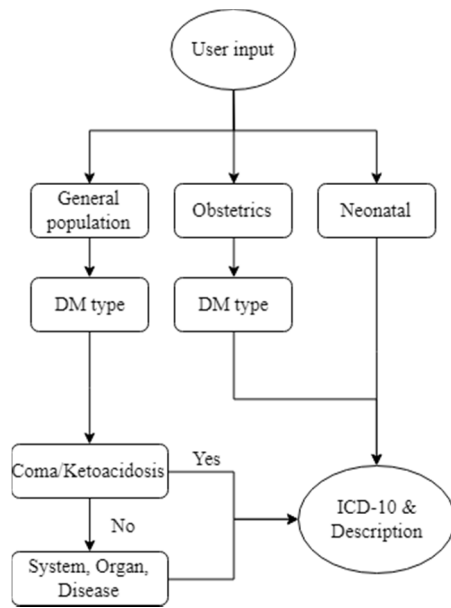


Figure 3. Diabetes Mellitus coding process.

2.3) ICD-10 chatbot was developed using Dialogflow which is 4 based on cloud, with the following steps:

- Creating an agent
- Generating intent based on disease code (ICD-10) and defining the training phrases and responses.
- Creating entities to teach a variety of disease names including the initials of each disease.

- Setting contexts of each intent to create a priority level for each intent.
- Using the integrational functions to implement chatbot shifting to LINE application.

### 3) Evaluation

AHP was chosen as a tool to evaluate the performance of chatbot in this work. Performing the AHP method, the criterion and alternative are required according to previous studies showed that criterion influences on chatbot evaluation [5]. The criteria are shown in Fig. 4. and TABLE I.

The main criteria and sub-criteria were taken to determine the weight of each criterion [13]. In order to know the criteria that affect the selection of ICD-10 coding tool, the weight of criterion was used for indicating priorities by users evaluation. In the end, each criterion was brought to compare the most appropriate tool between chatbot and application.

TABLE I. ICD10-BOT Decision Criteria

CRITERIA	SUB-CRITERIA
Performance	Robustness to unexpected input
	Usability
Humanity	Transparent to inspection (known chatbot)
	Able to maintain themed discussion
	Able to respond to specific questions
Affect	Provides greetings, pleasant personality
	Entertaining, engaging
Accessibility	Can detect meaning and intent
	Responds to social cues appropriately

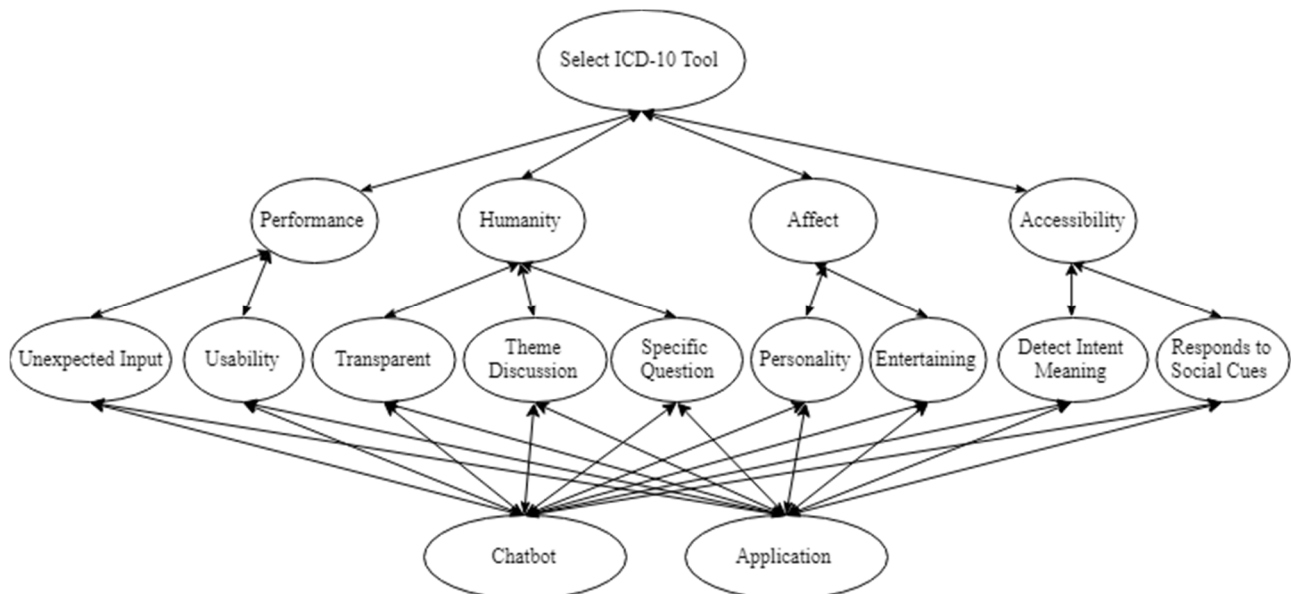


Figure 4. ICD10-BOT Hierarchy Structure.

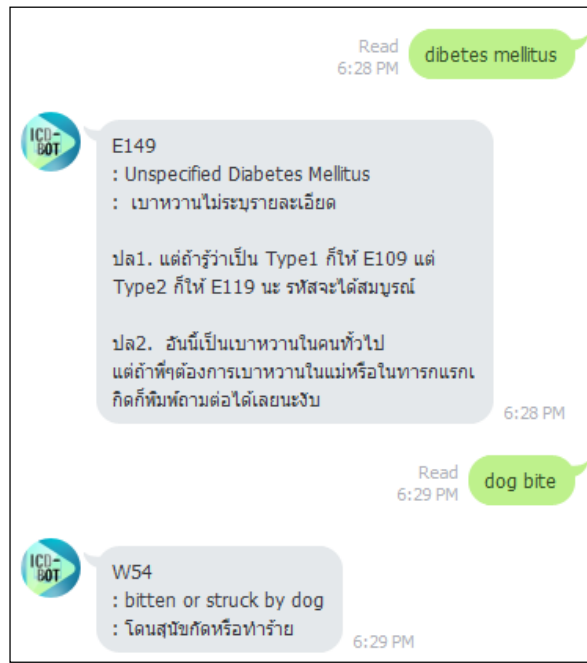


Figure 5. Example of conversion between user and ICD-BOT.

#### IV. EXPERIMENTAL RESULTS AND DISCUSSION

Regarding the implementation and development of chatbot for searching and giving advice on providing ICD-10 codes, users can specify the information; the name of the disease, symptoms, and external causes. After the chatbot processes the information that the user sends, it will show the suggestible and appropriate ICD-10 code along with instructions for providing code. The example of conversation of the user and ICD-BOT is shown in Fig. 5.

##### A. Procedure

In this work, it was evaluated by various professional in Ratchaburi hospital, Thailand. Both experienced and inexperienced in providing ICD-10 codes, which are detailed in TABLE II. In each evaluation, the time spent in chatbot and application testing and answer the questionnaire for approximately 1 hour. The sample group was divided into 2 groups, experienced and inexperienced in ICD-10 coding. The experts were asked to answer the questionnaire by scoring the importance of each criterion including the rating of the tools between chatbot and application, which tools are appropriate for use, where the level of importance is divided into 9 levels, i.e., 1-9 [10]. The main criteria and sub-criteria were taken to determine the weight of each criterion. In order to know the criteria that affect the selection of ICD-10 coding tool, the weight of criterion is used to indicate priorities by users evaluation. In the end, each criterion was brought to compare the most appropriate tool between chatbot and application.

TABLE II. Information of each respondent

No.	Position	Number	Experience in ICD-10 Coding		Responsibility of ICD-10 coding	
			Yes	No	Yes	No
1	Physician	6	3	3	3	3
2	Registered Nurse	2	0	2	0	2
3	Occupational therapist	1	0	1	0	1
4	Statistical Technical officer /Medical statistician	10	9	1	10	0
5	Medical statistics officer	1	1	0	1	0
6	Data officer	4	0	4	4	0
7	Plan and policy analyse	2	0	2	1	1

TABLE III. AHP Result of tools selection

criteria	global priorities	chatbot	application
<b>Performance</b>	37.44%		
Unexpected Input	20.19%	17.21%	2.98%
Usability	17.25%	14.95%	2.31%
<b>Humanity</b>	15.47%		
Transparent	5.64%	2.66%	2.97%
Theme Discussion	2.08%	1.80%	0.28%
Specific Questions	7.76%	6.35%	1.41%
<b>Affect</b>	13.49%		
Personality	5.31%	4.63%	0.68%
Entertaining	8.17%	7.18%	1.00%
<b>Accessibility</b>	33.60%		
Meaning Intent	9.08%	7.70%	1.38%
Social Cues	24.52%	20.11%	4.41%
Select between chatbot and application		82.58%	17.42%

##### B. Results and Discussion

Experimental results of research and development by using the AHP process is shown in TABLE III. For this work, the Consistency Ratio (CR) is 0.06. According to Saaty, CR value should be less than 0.1. Therefore, the consistency of the comparison is in acceptable values. It was found the main criteria affected program selection for providing ICD-10 codes. Firstly, Performance (37.44%) is the most influential criterion for choosing tools which include the robustness to unexpected input (20.19%) and Usability (17.25%). Secondly, the secondary main criteria are Accessibility (33.60%) that consists of chatbot can detect meaning and intent (9.09%) and chatbot responds to social cues appropriately (24.52%). The most important points that most participants perceived are: the program must be able to provide accurate and appropriate information, not only can understand but also respond to medical terms and abbreviations; both Thai and English language, and must be easy to use and access. Due to working in a hospital requires special medical knowledge that has various patterns such as, diseases' name, health service's

name, abbreviation, and etc. Therefore, programs that may help to provide the coder could understand the meaning of words variety. In addition, programs need to be easy to use, rapid and uncomplicated for staffs owing to insufficient medical record knowledge and experience. For Humanity (15.47%) and Affect (13.49%) are the issues that participants gave the least importance of weight. However, both criteria also affect tool selection because conversation impression and several patterns of answers were happened by those criteria. In this evaluation, priority alternative tools for providing ICD-10 codes is chatbot (82.58%), followed by application (17.42%). Except Transparent, participants preferred choosing to use via the application (2.97%) rather than chatbot (2.66%) regarding some participants still believe that the application offers more accurate information.

## V. CONCLUSION

Regarding the development of chatbot in this work, a chatbot system for ICD-10 Recommendation System is presented. It could respond to users in various aspects. Chatbot has clearly displayed its strengths when implementing to provide ICD-10 code especially Performance and Accessibility, which has a complicated process. The chatbot can react the user requirements, such as understanding of Medical Terminology, usability, and accuracy. This work could help users have proper options for practical usage, both experienced and inexperienced in ICD-10 coding. As well as another way to develop the ICD-10 system to be more standardized in the future.

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