Vietnamese Service Robot Based on Artificial Intelligence

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***Abstract*—Service robot have been designed and developed for different objectives and requirements. Since robotic revolution, Vietnam is one of the most influenced among South-east Asia countries in developing artificial intelligence. People believe that robot will replace all blue-collars in almost company, even hospital and school in next few decades, therefore developers are trying to improve natural language interaction between human and robot, especially helping new vision for Vietnamese robotics. We have built a robot application that capable of understand Vietnamese natural language, there are four tasks which was mentioned solving the problems, even more AI method. Deep learning, on the other hand, is a sub-field of machine learning. In this paper, with these algorithms, artificial intelligent supported is much complex, people can communicate naturally with robot, not only English but also Vietnamese at well. In this paper, we will introduce the specification and intelligent interaction processing in naturally Vietnamese.**

***Index Terms*—service robot, artificial intelligence, natural language processing**

I. Introduction

Robot is often regarded as the biggest achievement of modern engineering. The modern robotics began as early as in the 1920s. Nearly a decade has gone by; the robotics field has accomplished tremendous improvement. Nowadays, industrial robots take part in the manufacturing; replace manual labors in fields that require extreme precision. Robots are even used in space exploring by scientists. Service robots recent attract a lot of attention from the public. Integrating with artificial intelligence of computer science, modern service robots has great potential as they are capable of perform many sophisticate works of the human. There is no doubt that, service robots are the prominent field in the near future. Thus, this paper is focused on Human Robot Interaction based on Artificial Intelligence. The specific target for this paper is a humanoid robot with two arms ad an animated face that is capable of expressing emotions. Its main purpose is to serve as a receptionist robot, in which robot main task range from informing customer on the center's courses, employee and teachers, thus providing users with different necessary task. [1]

The field of service robot has shown its potential in its near future, and currently attracting more researchers and technical companies more than ever. Many governments around the world also realize the potential of the field. Vietnamese government has funded many programs that their main objective is to encourage the use of robot in educational environment. It is expected that when children encountering more with robot, they will show curious and grow their interest in the technology field. Not only education benefits from service robot. In many other place in the world, service robots are also put into operation in boring, repeated task or dangerous environment. Although the topic in controversial, but it is certain that more and more service will be in operation in the near future. However, the interaction between human and robot pose some problem. The main issue is that humans hesitate when interacting with robot. From the psychological point of view, the main cause for this is that most people don't feel comfortable interacting with robot, they feel that most robot is not friendly toward them. The main key here is, beside its main functionality, service robots also have to be seen as a friendly, human-like being in order to attract their users. This also is the main objective of me and other teams working on the same project. With the use of artificial intelligence, my goal to create a robot application that capable of understand natural language and further contribute to the development of Vietnamese robotics.

Many governments around the world also realize the potential of the field. Beside the US and Japan – who are notoriously interested in the service robot field, Vietnamese government also took action. Vietnamese government has funded many programs that their main objective is to encourage the use of robot in educational environment. It is expected that when children encountering more with robot, they will show curious and grow their interest in the technology field. Not only education benefits from service robot. In many other places in the world, service robots are also put into operation in boring, repeated task or dangerous environment. Although the topic in controversial, but it is certain that more and more service will be in operation in the near future.

Fig. 1 shows the service robot in this paper. The robot possesses 2 arms that can perform many different gestures as the robot interacting with its clients. To move around, the robot relies on a wheeled platform which is controlled by embedded microcontroller and the platform controller components. The platform can perform basic

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obstacle avoidance task can return to robot's charge dock when the platform receives signal from the central controller. Robot is able to express its emotion or facial activities through a 15 inches screen mooted of the head of the robot.

Figure 1. Body of the service robot.

However, the main concentration of this paper is neither about controlling the arms, nor the platform and the face, but rather about algorithms that lay inside the component called central controller. Considering the main objective of the paper, many more components need to be integrated. As robot is a sophisticated system, multiple input and output signals need to be coordinated so that robot can function properly. Overall, there are nine separated components plus the central controller of the robot system, the each of them will be explained in detail. As the robot is required to display information about the education center as well as information on the center's student, robot needs a database that contains all this information. An adaptive, well designed and convenience user interface is also essential to encourage people to interact with the robot. This user interface is displayed on a touch screen mounted in front of the robot. [2]

However, the interaction between human and robot poses some problems. The main issue is that humans hesitate when interacting with robot. From the psychological point of view, the main cause for this is that most people don't feel comfortable interacting with robot, they feel that most robot is not friendly toward them. The main key here is, beside its main functionality, service robots also have to be seen as a friendly, human-like being in order to attract their users. This also is the main objective of me and other teams working on the same project. With the use of artificial intelligence, my goal to create a robot application that capable of understand natural language and further contribute to the development of Vietnamese robotics.

This database also keeps information on how robot responses to its users (which will be referred and natural behaviors). But before the robot can response, robot must first extract information from the user sentence using the natural language processing. To enhance its capability of holding a natural conversation, camera and Kinect are also utilized to extract basic information such as age, gender. In the later parts of the paper, the task of coordinating all these signals and information will be addressed in details (Fig. 2). [3]

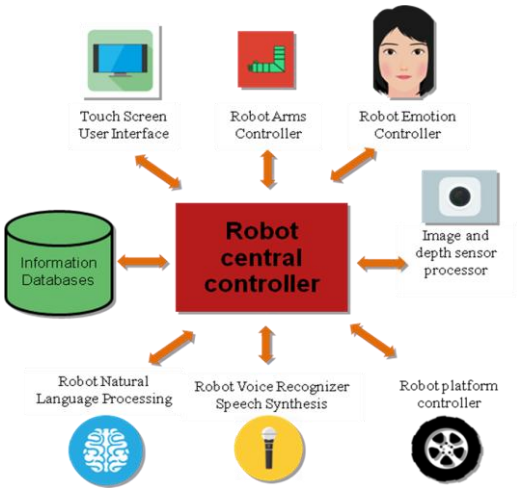

Figure 2. The robot controller system.

II. Application Structure

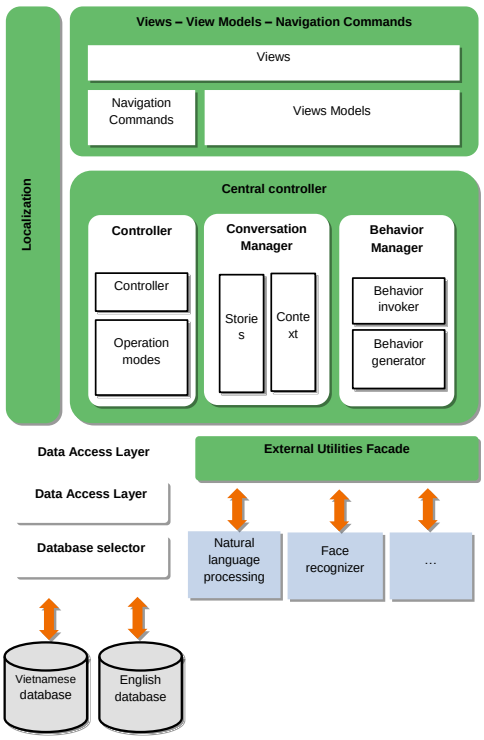

Figure 3. Application structure of controller.

Based on the requirement of the project and by utilizing the MVVM pattern (Fig. 3) and the inversion of control programming technique, the architecture of the program is designed as a three tiers application, with the View – View Model – Navigation Command layer on top, the central controller in the middle, data access layer with external utilities fa çade at the bottom of the program. The

localization module cross cuts the system. Furthermore, this module involves in every part of the application. [4]

At the top of the architecture, the views – view models and navigation commands consist of three separate parts with the same name. Just the same as the MVVM model, the views module have many sub views within, which will be referred as "slide", each of these slides possess their owns view models. Navigation command module hold commands for user and the central controller to navigate between these slides.

At the bottom of the architecture, there are the data access layer and the external utilities fa çade. Data access layer is used for accessing center information (employee, classes, course and final grade) and robot behaviors information (robot emotion, arm gesture, robot response). These data are stored in the local SQL server. The external utilities fa çade, on the other hand, act as an interface for communicating between the robot central controller and its component controllers. Using this approach, the robot controller is only exposed to necessary part of each individual component while the complexity of each module remains hidden. There are eight independently developed components which are listed in Fig. 4.

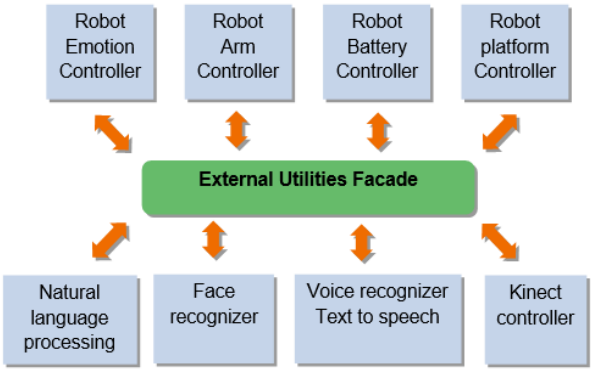

Figure 4. External utilities fa çade.

The central controller, which can be considered as the model of the MVVM pattern, has all the controlling logic for operation of the robot. There three sub modules in the controller, the controller, the conversation manager and the behaviors controller. The controller module consists of the controller and operation modes. The conversation manager handles human – robot communication. This operation consists of user appearance information extraction (gender, emotion, age) and language feature extraction (sentence intent and its entities), which then is stored in the context. There are three stories for human robot communication, which is hard coded using finite state machine automata. These stories include every possible communicating scenario so that the robot will know what it will do next based on the current situation. Depend on the controller needs, stories will be chosen accordingly. The behavior manager, which uses the results from the conversation manager, looks up the database for the correspondent response, and sends command to the external utilities fa çade layer to activate the robot action. The processing pipeline of these process can be summarized in Fig. 5.

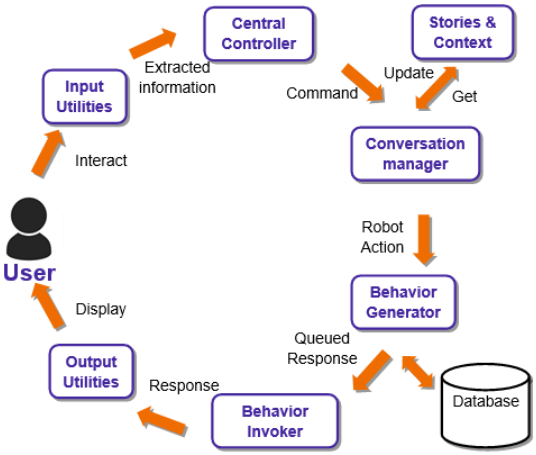

Figure 5. Service robot process pipeline.

III. Approach for Multilingual User Interface

Base of functional requirements, in other to handle a significant amount of data, robot central control application must possess a database that contains all necessary information. In order to handle multilingual requirement, multiple, identical databases are created correspondently to the required language. For instance, when robot is required to present information in three languages: Vietnamese, English and Korean, three identical databases are generated of which names end with suffix correspondent to ISO 639-1 standard for language: RobotDB_vi, RobotDB_en, RobotDB_ko for Vietnamese, English and Korean respectively in Table I.

TABLE I. List of Common Languages and Their ISO 639-1 Code

Language	Language Code
Vietnamese	vi
English	en
Korean	ko
Chinese (Simplified)	zh-CHS
Chinese (Traditional_	zh-CHT
French	fr

The multilingual language is responsibility of the localization module. This module contains a variable called CurrentCulture, which retain the information that the user interface displaying at the moment. To select needed language, user need to click on the language selector dropdown list on upper right corner of the screen. As user changes the language, user interface automatically updates the CurentCulture variable and switch back the main form in Table II. (Fig. 6)

Interchanging between databases, a module called DBSwitcher is implemented. DBSwitcher job is only the change to connection string to database server based on the current displayed language and machine name. In particular, this is the based connection string

"data source={0}\\SQLEXPRESS;initial catalog=RobotDB_{1};integrated security=True;MultipleActiveResultSets=True;App=EntityFramework"

Where {0} is machine name and {1} should be the suffix of the current displayed language. If the machine name is "AdminPC" and language is "Vietnamese", the modified connection string now becomes

"data source=AdminPC\\SQLEXPRESS;initial catalog=RobotDB_vi;integrated security=True;MultipleActiveResultSets=True;App=EntityFramework"

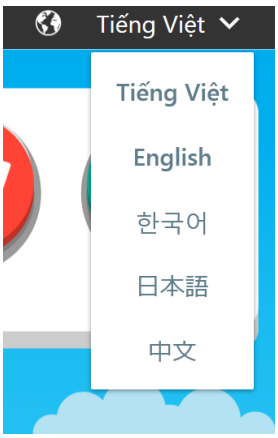

Figure 6. Language selector drop-down box.

Besides handling the global variable for current displayed language, the Localization module also act as a bridge between the database and the view for every user interface element, this simplifies the view model of each view. The translation for each user interface element is stored on the correspondent database. (Fig. 7)

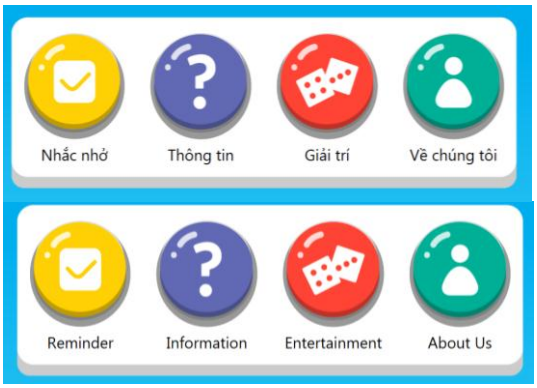

Figure 7. User interface in Vietnamese and English.

TABLE II. UIELEMENT AND ITS TRANSLATIONS IN VIETNAMESE AND ENGLISH

Index	Key	Vietnamese Translation	English Translation
1	Remind	Nhắc nhở	Reminder
2	Info	Thông tin	Information
3	Entertain	Giải trí	Entertainment
4	AboutUs	Về chúng tôi	About Us

IV. HTTP FOR SENDING REQUEST AND RECEIVING RESPONSE TO AND FROM EXTERNAL APIS

HTTP is short for Hypertext Transfer Protocol is a standard internet protocol for distributed, collaborative, and hypermedia information systems. HTTP was developed and CERN (European Organization for Nuclear Research) by computer scientist Tim Berners-Lee in 1989 and now is applied is for the whole Internet.

In field of machine learning, most people use language like Python and R for building machine learning application [5]. However, Python and R do not retain the capability to build adaptive user interface like C# do. This application is not an exception, the user interface and utilities are developed with C# while all machine learning processes for natural language processing are done using Python. In order to send and receive data between C# and Python, the HTTP is implemented.

Using python's Klien package, two local servers for natural language processing is created (at http://localhost:5000/ for Rasa NLU and at http://localhost:7000/ for NNVLP) in Fig. 8. Whenever natural language processing is needed, robot control application will post a natural sentence to either of mentioned servers for processing and extracting information. The result then is responded in JSON format for later use in the robot control application. [6]

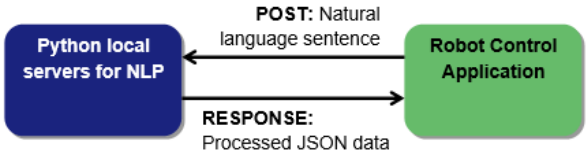

Figure 8. Simplified diagram of transmitting sentence and receiving processed result using HTTP.

V. STRUCTURED QUERY LANGUAGE

Structured Query Language (SQL) is a computer language for relational database management and data manipulation. SQL was first developed in 70s at IBM by two developers, Raymond Boyce and Donald Chamberlin, and was commercially release in 1979 by Relational Software Inc. (now Oracle Corporation). Since its release, SQL nowadays is used in many relational database management and data manipulation such as MySQL, Sybase, Informix, Microsoft Access and SQL Server. As SQL as become a standard language for database management and data manipulation for many database systems, this beneficial for database administrators since the process involved many different platforms. Microsoft SQL Server is a market-leading relational database system. Microsoft SQL server is built on top on SQL which is used by many developers around the world, it has become favorite choose for managing and querying database.

Originally released in 1989 as version 1.0 by Microsoft, in conjunction with Sybase, SQL Server and its early versions were very similar to Sybase. However, the Microsoft-Sybase partnership dissolved in the early 1990s, and Microsoft retained the rights to the SQL

Server trade name. Since then, Microsoft has released 2000, 2005 and 2008 versions, which feature more advanced options and better security. Microsoft SQL server possesses many useful features for developing application such as: XML data type support, dynamics management view (DMVs), database mirroring.

Microsoft has released many different editions for different set of feature depends on developer need, such as the enterprise edition for large enterprises with complex data requirement, or standard edition for small and medium organization. However, since the database of robot control application is simple, the express edition of Microsoft SQL server was selected. Although it is free for distribution, the express edition retains enough features for managing small and simple database and can be a better choice over Microsoft access.

VI. Database of Service Robot

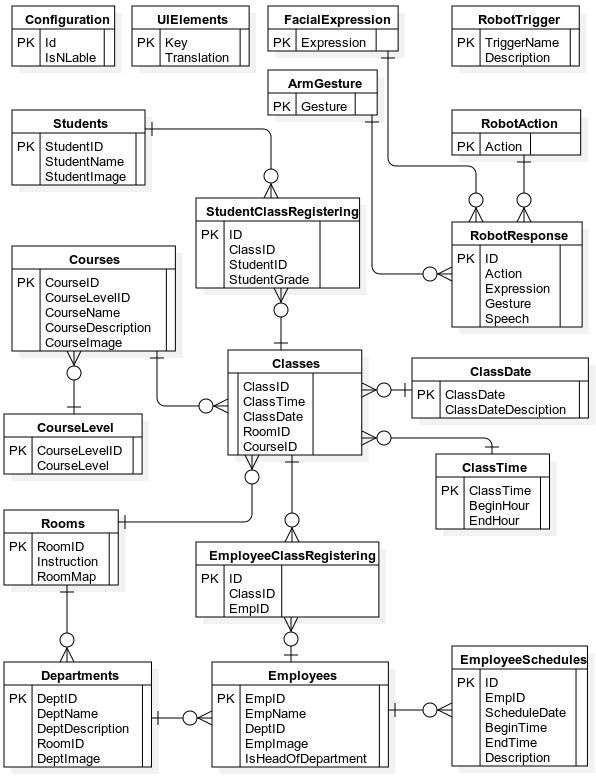

Figure 9. Database structure of service robot.

Based on application requirements, a database is created as in the Fig. 9. The application consists of multiple, identical databases for each individual language and user interface. The database consists of 18 tables, and can be separated into 4 different segments. The first segment only has 1 table for storing information whether the natural language interaction is available or not. The second segment is reserved for storing translation of user interface elements. List of available robot arm gestures, facial expression, actions and responses is stored in the third section of the database. Finally, the biggest section is for storing center information, with 12 different tables. These sections of the database are explained in detail in Table III for configuration segment, user interface elements, robot action and center information. [7]

TABLE III. Configuration Segment of the Application's Database

Column Name	Primary Key	Data Type	Foreign Key	Description
Table: Configuration				
ID	PK	Int	-	
IsNLable	-	Bit	-	Is the current language capable of natural language processing

VII. Operational Considerations of Robot

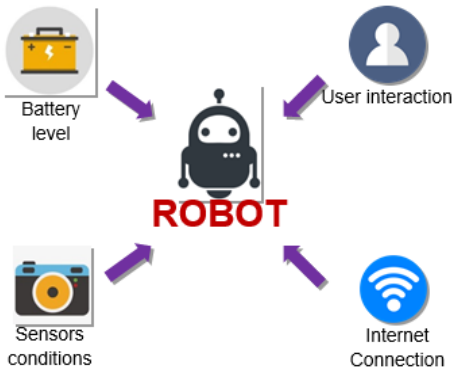

Figure 10. Factors that affect robot performance.

In action, robot system heavily depends on many factors to function stably, these factors consist of the power source level (battery), the sensors system for extracting robot surrounding working environments, internet connection for natural language interaction and the condition of surrounding humans (Fig. 10). Based on these factors, robot control system needs configure its working status accordingly. As robot main and only power source is a 12V-45Ah battery that attached to the robot base, energy consumption should be taken seriously for maximum operation time. By simple calculation base on robot's devices total energy consumption, the robot system can only operate uninterruptedly for only about 2 hours. Robot cognitive system is heavily dependent on online APIs. Although, when the connection is interrupted, robot is still able of performing basics task, however, that service that failed should be configured inaccessible. [8]

The distance between human holds just as significant as those mentioned. As a receptionist, robot should welcome people who walk by. When any person approaching, the processing of appearance information extraction should be initiated, so that when user begins interacting, robot already obtained sufficient information to hold a natural conversation.

As discussed before in the previous sections, to ensured that robot can operate autonomously, what robot

control system will execute when battery level is low, or when crucial services (such as the Internet) availability change should be taken seriously.

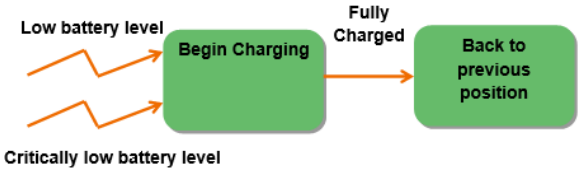

Figure 11. Robot action when battery level is low

There are two battery levels involves in triggering the robot charging program, these are low battery level and critically low battery level at 20% and 10% respectively, and is treated as interrupt signals in embedding programming. For most of the time, robot will automatically go charging when its battery level hits the low level, except when this signal is overwritten in some particular situations. Upon battery is fully charged, robot then automatically returns to its previous position. (Fig. 11)

Figure 12. The interrupt signal of the availability of crucial services change.

When the availability of crucial services such as Internet, Kinect or the Camera change, robot will automatically reconfigure it program depends on what services still remain fully functional. For instance, when the internet connection is down, most of internet-relied functionality will be reconfigured inaccessible and unusable. (Fig. 12)

From the previously discussed considerations, a state machine model was constructed for the autonomously operated service robot. Overall, the state machine model consists of 10 operation modes and 12 triggers signals. Initially, as the robot boot, the startup mode enters. When entering the startup mode, crucial services of robot such as the natural language processing services, camera sensing services, will be launched, as some of these services can take up the 5 minutes to be ready. After all necessary service is ready; a signal is then invoked so that the robot switches to the next mode, the idle mode. Upon entering the idle mode, robot begins erasing all information from previous conversations and waiting for new people coming by. When robot notices human walking by (by measuring distance from the robot to the nearest human using Kinect depth sensor, this distance is about 2 meters), robot will enter the welcome mode. This mode involves sending signal to actuators, so that robot will wave and say hello to the nearest human. When the distance between the robot and human is less than 1.5 meter, this usually mean that this human is approaching toward the robot, the signal named Human approaching is triggered, robot will now begin extracting user appearance feature. These features include human emotion, gender and age. This process is time consuming, and that is the ready why the process needs to be executed as early as possible, so that when human begin interacting, robot will have sufficient information of its interacting user. [9]

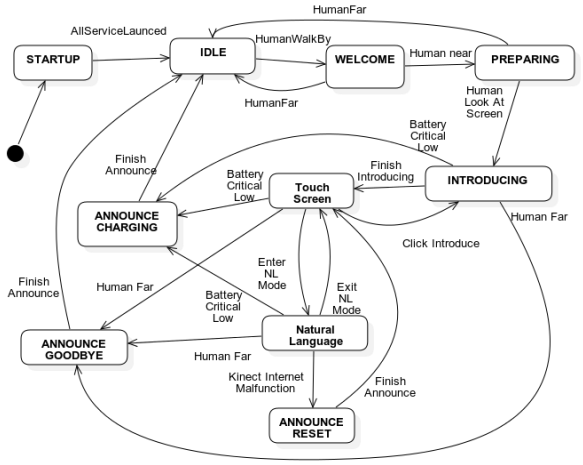

Figure 13. Operation modes for the service robot.

When to measured distance is less than 1 meter, the yaw angle of the human head is measured. When the yaw angle is less than 10 degree, which means the user now look directly and the robot, the robot will now prepare and configure for communication.

As the robot and user is interacting, there are two distinguished communication mode, the touch screen mode and the natural language mode, which is switched concurrently based on user activities. (Fig. 13)

When human and robot are interacting and the battery reaching critical low level, robot now initial the announce charging operation mode, by using pre-recorded audio, user now is informed that robot need to return to its charging dock. If Kinect or Internet availability changes and human and robot interacting using natural language operation mode, robot will automatically switch to the operation mode of announce reset. Upon entering this mode, just as what happens in the announce charging mode, robot will response using pre-recorded dialog, turn off and disable the natural language functionality. [10]

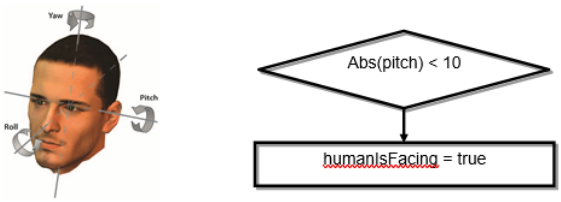

Figure 14. Roll Pitch Yaw angles of a human head and algorithm for detecting human look at screen signal (source: intechopen.com).

By measuring the pitch angle of the human head, Kinect manger module notifies the external fa çade (Fig. 14). The signal now trigger operation mode to enter the introduction mode. As pointed out in previous section, introduction mode is classified as a interacting. This is why, when user walks out of robot vision range, the

received signal in external façade can trigger operation mode and turn it into goodbye mode. After waving goodbye to the customer, operation modes return to idle and reset robot configuration as mentioned before. [11]

VIII. Experiments and Discussions

To simplify the testing process, none of the external utilities such as Robot's voice or emotion was implemented with the system during simulation evaluation. Instead, a constant duration for each out is set for each component: Text to speech 3000 microseconds, Emotion 4000 microseconds and arm gesture is 2000 microseconds. Therefore, the time duration of the robot responses is equal to the longest component at 4000 microseconds. (Fig. 15)

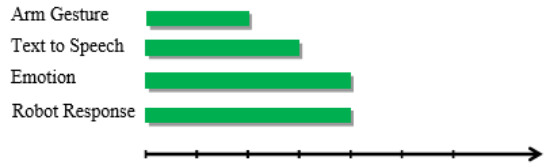

Figure 15. Robot response time duration during simulation testing.

The goals of these tests are to ensure that there is no overlapping in robot output utilities. Many different tests are conducted on the system, however, only four of them is presented here.

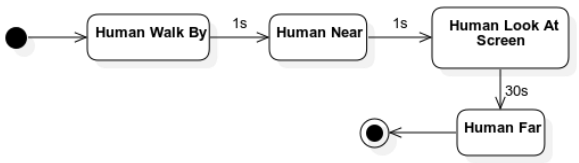

Figure 16. Normal human robot simulation case.

```
Boot
12:09:36 PM Xin chào ban đến với stem center Start
12:09:40 PM Xin chào ban đến với stem center Finish
12:09:40 PM Chào cô, con là jcbot Start
12:09:44 PM Chào cô, con là jcbot Finish
12:09:44 PM Cô sử dụng ngôn ngữ nào ? Start
12:09:48 PM Cô sử dụng ngôn ngữ nào ? Finish
12:09:48 PM Hello, i am jcbot Start
12:09:52 PM Hello, i am jcbot Finish
12:09:52 PM Please select your language ? Start
12:09:57 PM Please select your language ? Finish
12:10:08 PM Chào tam biệt quý khách Start
12:10:12 PM Chào tam biệt quý khách Finish
```

Figure 17. Normal human robot simulation result.

This case stimulates a normal conversation case between robot and human (Fig. 16). Simulated signals are raised sequence. First, Human walks inside of robot's vision range. Then, after one second, the user is now near robot and look at the screen one second later. Robot and the user star interacting with each other for about 30 seconds and then the human leaves.

After experiment, every robot response is written to log file. The result from the normal human and robot interaction is presented in Fig. 17

Form the results get from simulation, at the end of each response is noted with start when robot starts giving response and finish when robot finished that response. The result shows that there is no overlapping in the output utilities, so robot will operate well in normal human and robot interaction.

This case involves with two different users interacting with the robot. The first person enters robot vision range, approaches near the robot after one second and looks at the screen one second later. Then, one second later, while robot is still responding, this user then leaves and another user approaches near the robot almost instantly interacts with robot for a while then leaves. The detail of this case test is illustrated in Fig. 18.

Fig. 19 shows the result of this testing case. Note that after the first user leaves, robot supposes to say good bye to this user. However, since the previous hasn't finished yet, so this response is put on hold. But the second user walks into vision range almost instantly afterward that is why the good bye response is never invoked. Instead, robot will wave welcome to the second user. Finally, there is no overlapping in this test case, so the system work properly in this simulates testing case.

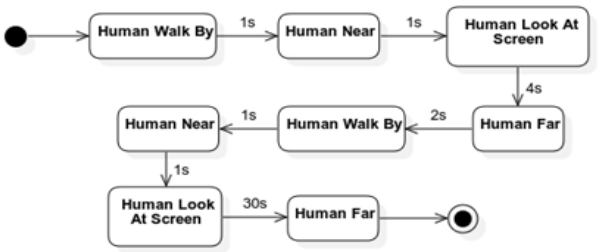

Figure 18. Complex human robot simulation case.

```
Boot
12:13:21 PM Xin chào ban đến với stem center Start
12:13:25 PM Xin chào ban đến với stem center Finish
12:13:25 PM Chào cô, con là jcbot Start
12:13:27 PM Chào tam biệt quý khách Hold
12:13:29 PM Chào cô, con là jcbot Finish
12:13:29 PM Xin chào ban đến với stem center Start
12:13:33 PM Xin chào ban đến với stem center Finish
12:13:33 PM Cô sử dụng ngôn ngữ nào ? Start
12:13:37 PM Cô sử dụng ngôn ngữ nào ? Finish
12:13:37 PM Hello, i am jcbot Start
12:13:42 PM Hello, i am jcbot Finish
12:13:42 PM Please select your language ? Start
12:13:46 PM Please select your language ? Finish
12:14:02 PM Chào tam biệt quý khách Start
12:14:06 PM Chào tam biệt quý khách Finish
```

Figure 19. Complex human robot simulation result.

IX. Conclusions

The research focuses on designing and developing human robot interaction application for a receptionist service robot.

The research has conveyed on many different topics including history and development of robot and service robot in particular, personal assistant on smart phones, artificial intelligence and its approach for natural language processing and the specific implementation for human and robot interaction.

For the user interface, the system employs windows presentation framework and the model-view-view model for creating pleasant looking interactive user interface. Multiple, identical SQL databases are used to store information for user interface as well as to keep robot responses and triggers.

Finite state machine automata technique is utilized for robot operation modes as well as for managing different conversation stories. There are total three different stories in the applications. Furthermore, 12 intents were trained on data consists of more than 2000 natural sentences to produce an intent classifier for both English and Vietnamese.

Natural behavior generators after getting pre-defined responses, which are stored on the databases, is then refined by replacing neutral pronoun with more proper ones based on users age and genders. The behavior invoker, on one hand invokes responses generated by the generators; on the other hands ensure that no overlapping occurs in the output utilities.

Last but not least, whole system is evaluated for any malfunctions. Firstly, the intent classifier is evaluated for accuracy and F1-score. Secondly, simulated test is performed on behaviors invokers to ensure no overlapping occurs during operation. Finally, practical experiment is where the whole system is put into operation.

Potential for future development of the paper is really wide. Beside intent classifiers, the natural language processor can extract essential information called entities from a natural sentence. This can improve user experience tremendously. With same principle as presented the paper, other purpose service robots such as personal assistant bot can be built easily.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Nguyen Tran Thanh Phong, Luong Huu Thanh Nam, Nguyen Truong Thinh contributed to the analysis and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors discussed the results and contributed to the final manuscript. Besides, Nguyen Truong Thinh conceived the study and were in charge of overall direction and planning. Nguyen Truong Thinh is a corresponding author.

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References

[1] Dowling, K., (1996) Robotics Frequently Asked Questions List.
[2] Engelhart, K.G., and Edwards, R.A. (1992). Human-robot integration for service robotics. In Rahimi, M. & Karwowski (eds.) Human-Robot Interaction. London:Taylor & Francis Ltd.\
[3] Lim,W. Y., (1991) Self-awareness in Mobile robots. In SPIE Vol. 1613 Mobile Robots VI.
[4] David Ferrucci and Adam Lally. 2004. UIMA: an architectural approach to unstructured information processing in the corporate research environment. Natural Language Engineering
[5] Steven Bethard, Philip Ogren, and Lee Becker. 2014. ClearTK 2.0: Design patterns for machine learning in UIMA. In LREC 2014.
[6] Richard Socher, Alex Perelygin, Jean Wu, Jason Chuang, Christopher D. Manning, Andrew Ng, and Christopher Potts. 2013. Recursive deep models for semantic compositionality over a sentiment treebank. In EMNLP 2013
[7] Kristina Toutanova, Dan Klein, Christopher D. Manning, and Yoram Singer. 2003. Feature-rich part-ofspeech tagging with a cyclic dependency network. In NAACL 3, pages 252–259
[8] R. K. Ando and T. Zhang. A framework for learning predictive structures from multiple tasks and unlabeled data. Journal of Machine Learning Research (JMLR), 2005.
[9] Y. Bengio and R. Ducharme. A neural probabilistic language model. In Advances in Neural Information Processing Systems (NIPS 13), 2001.
[10] Y. Bengio, P. Lamblin, D. Popovici, and H. Larochelle. Greedy layer-wise training of deep networks. In Advances in Neural Information Processing Systems (NIPS 19), 2007.
[11] Y. Bengio, J. Louradour, R. Collobert, and J. Weston. Curriculum learning. In International Conference on Machine Learning (ICML), 2009.

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