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EduRobot: Intelligent Humanoid Robot with Natural Interaction for Education and Entertainment

Widodo Budiharto[a]*, Anggita Dian Cahyani[b], Pingkan C.B. Rumondor[b] and Derwin Suhartono[a]

[a]*Computer Science Department, School of Computer Science, Bina Nusantara University, Jakarta, Indonesia*
[B]*Psychology Department, Bina Nusantara University, Jakarta, Indonesia*

Abstract

This paper presents a research on intelligent humanoid robots for education focused on natural interaction for teaching basic mathematics and entertainment for students. Previously, humanoid robot focused on the architecture of body and ethical issues, but later, it is predicted that humanoid robots should consider teaching behaviour, student's interest and speech understanding. They are expected to conclude the answer through conversation under noisy environment. We propose speech recognition systems based on Google translator and basic Natural Language Processing (NLP) techniques such as stemming and tokenization. We do teach modules for elementary school in order that the robot can interact with students naturally based on psychological aspects. We also discuss about our recent humanoid robot for education in elementary school that has ability to detect user's face and accepts commands in sentences from the user to do any actions such as giving tutorial and answering questions. The average accuracy for correct recognition is 73.3% and correct answer is 63.3%. Our speech recognition system is more promising compared with NAO robot.

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Keywords: humanoid robot; natural interaction; psychology; mathematics; NLP

* Corresponding author. Tel.:+62-856-988-7384
E-mail address: wbudiharto@binus.edu

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1. Introduction

The development of humanoid robots with total autonomous for huge variety of tasks such as teaching and learning has become a popular and challenging research topic. As researchers in robotics area, we have had many experiences in helping students to solve technological design problems in robotic as well as in designing formal classroom curricula which is intended to teach science and mathematics using robots. *Human-robot interaction* (HRI) is an interdisciplinary study of interaction dynamics between humans and robots. HRI has recently received considerable attention in academic community, labs, technology companies, and media. In case of humanoid robot for education, vision system is one of the main sources for environment interpretation.

Many problems have to be solved in intelligent robot such as speech and face recognition. Hhumanoid robot gets information from the environment. It is mainly by using camera. The robot has to standby and decides the next action, such as responding questions, moving, walking, etc. Psychology can play a role for human-robot interaction. To build the real humanoid robot which has capability to imitate real teacher handling the uncertainty of the real world, it is important for robot engineer and researcher to look at how teacher performs in such a wide range of situations based on cognitive Psychology. In addition, humanoid robot for education should be part of *Socially Assistive Robots* (SAR)[1]. We compare the result with our own NAO robot which is known as one of the most popular general humanoid robots for research.

2. Intelligent Humanoid Robot

2.1 Ethical Principles of Humanoid Robot

Learning for many adults is a routine part of life. However, in developing minds of elementary grade students, learning is relatively a new concept. Currently, no universal theory of learning has been existed; therefore experts employ varied lenses of learning theory to examine important elements of learning. For example, behavioral scientists consider the observable effects of experiences and environment on learning[2]. For psychologist and educator, teaching elementary students using robots may be unusual. We should deal with ethical issues on that. There are many ways to approach potential ethical issues related to technology of robot in general and SAR in particular. Sharkey and Sharkey[3] described another significant ethical dilemma that occurs when a user becomes emotionally attached to the robot. While establishing engagement and having the user to enjoy interactions with the robot is a goal, attachment can also result in problems under certain circumstances. New technologies bring entirely unprecedented contexts for HRI and call for thoughtful and well-informed multi-disciplinary studies. They include inputs, experts and address concerns from the entire complex constituency, including social scientists, ethicists, and, most importantly, members of the broad user community[1].

2.2 Psychological Aspects and Natural Interaction in Humanoid Robot for education

Humanoid Robot has been shown to be a powerful tool of science, technology, engineering, and math (STEM) education. A central aspect of STEM education is problem-solving, and robots serve as excellent means for teaching problem-solving skills in group settings[4]. Based on the mounting success of robotics courses world-wide, there is now is an active movement to develop robot hardware and software in service of education, starting from the youngest elementary school ages and up. Robots become important tools for teaching computer science and college engineering introductory[5]. Innovative teaching methods include competitions to develop robot toys for children with ASD[6] and other assistive environments[7].

Psychology is a multifaceted discipline and includes many sub-fields of study such areas as human development, sports, health, clinical, social behaviour and cognitive processes[8]. For example, there was a system developed to identify people's characteristic by analysing his/her social media's account[9]. Further exploration on how psychology penetrated to technology especially for human characteristic has been described as well[10]. Basically, *Human Robot Interaction* (HRI) should consider psychological aspects to work naturally so that it can be accepted by young students at class. In case of humanoid robot for teaching mathematics, it is important for the robot to know the ethics in teaching elementary students such as using correct words and providing clear feedback on student responses so that the class knows which answers are right and vice versa. Natural interaction in robot is the investigation of the relationships between humans and machines aiming to create interactive artefacts that respect and exploit the natural dynamics through which people communicate and discover the real world[11]. The basic courses of

mathematics proposed in the behavior-based humanoid robot for elementary students are addition and multiplication. They have been implemented with the ability for singing and storytelling[12].

3. Proposed Method

3.1 Architecture of the humanoid robot based on NLP

Only a few papers show the development of humanoid robot especially for teaching basic mathematics using robust face and speech recognition systems. Behavior-based robots (BBR) are a term to show more biological-appearing actions than their computing-intensive counterparts, which are very deliberate in their actions[13]. Recently, BBR approach for humanoid robot is used by researchers worldwide by imitating human behavior and psychological benchmarks to measure success in building increasingly human like robots. A behavior is simply defined as sequence of actions performed to achieve some goals. Considering young students in elementary school by giving good response whether answer is correct or wrong should be considered. When the student gives a completely wrong answer, robot should give a correction, but do so in a softened way. Before a computer can even understand what you mean, it needs to understand what you said. Giving response to robot with natural interaction is important, because usually we gives response not only 1-2 words.

Our previous research for speech recognition using NLTK's named entity recognition (NER) classifier by the Stanford NER tagger, but the result is not satisfied. In order the robot able to understand speech from student, we should translate from speech to text and find some important words on the text. The block diagram for speech recognition and robot response is shown in fig. 1. For example, if a student speaks to the robot then he/she needs an answer:

Derwin has 5 apples and then he buys 3 apples. How many apples does Derwin have now?

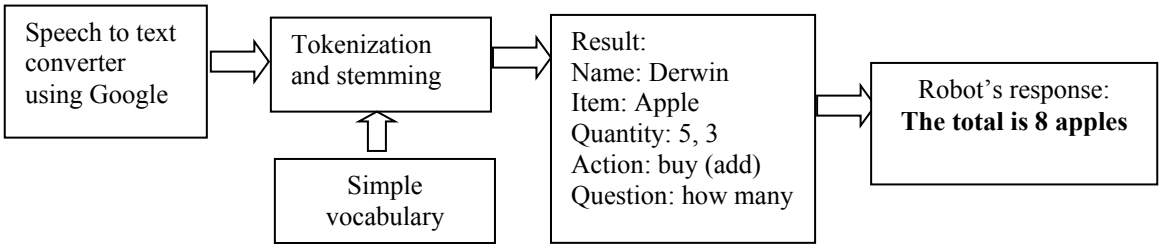

Fig. 1. Block diagram of the tokenization and stemming process until the robot able to answer the question from user.

3.2 Flowchart and Algorithm

Speech recognition is a challenge task in robotics[14]. We did experiments utilizing probabilistic robotics for the humanoid robot by implementing partially observable Markov decision process (POMDP) using[14,15] in speech recognition. From previous work, speech recognition is based on Google technology and we improve using stemming and tokenization for asking a question mode to robot. Speech to text recognition based on Google is used to recognize important words. Given a character sequence and a defined document unit, tokenization is the task of chopping it up into pieces, called token. Stemming is the process of reducing a word into its stem. Student will say a sentence (in Indonesian language) and the raw text will be tokenized and stemmed. Using simple vocabulary, the important words will be used to be processed by the robot. Based on the flowchart in Fig. 2, we explain in detail the flow of the system in detail:

1. The program will detect a face using Haar cascade classifier as general and effective object detection. If face is detected then robot will say welcoming message to student and also ask him/her whether he/she is ready to learn or not.
2. If the student is ready for learning, the robot will ask and giving option to student. There are some options for student such as learning mathematics, doing entertainment (singing and storytelling) and asking questions to robot. Special for asking a question mode, tokenization and stemming (text from speech

processed using NLP) will be processed. The results are important words from user and the response from robot.

3. The program will loop as long as the student wants to listen the tutorial and answer the question from robot.
4. If the student wants to continue the learning, then robot will stop asking the student and say “goodbye”.

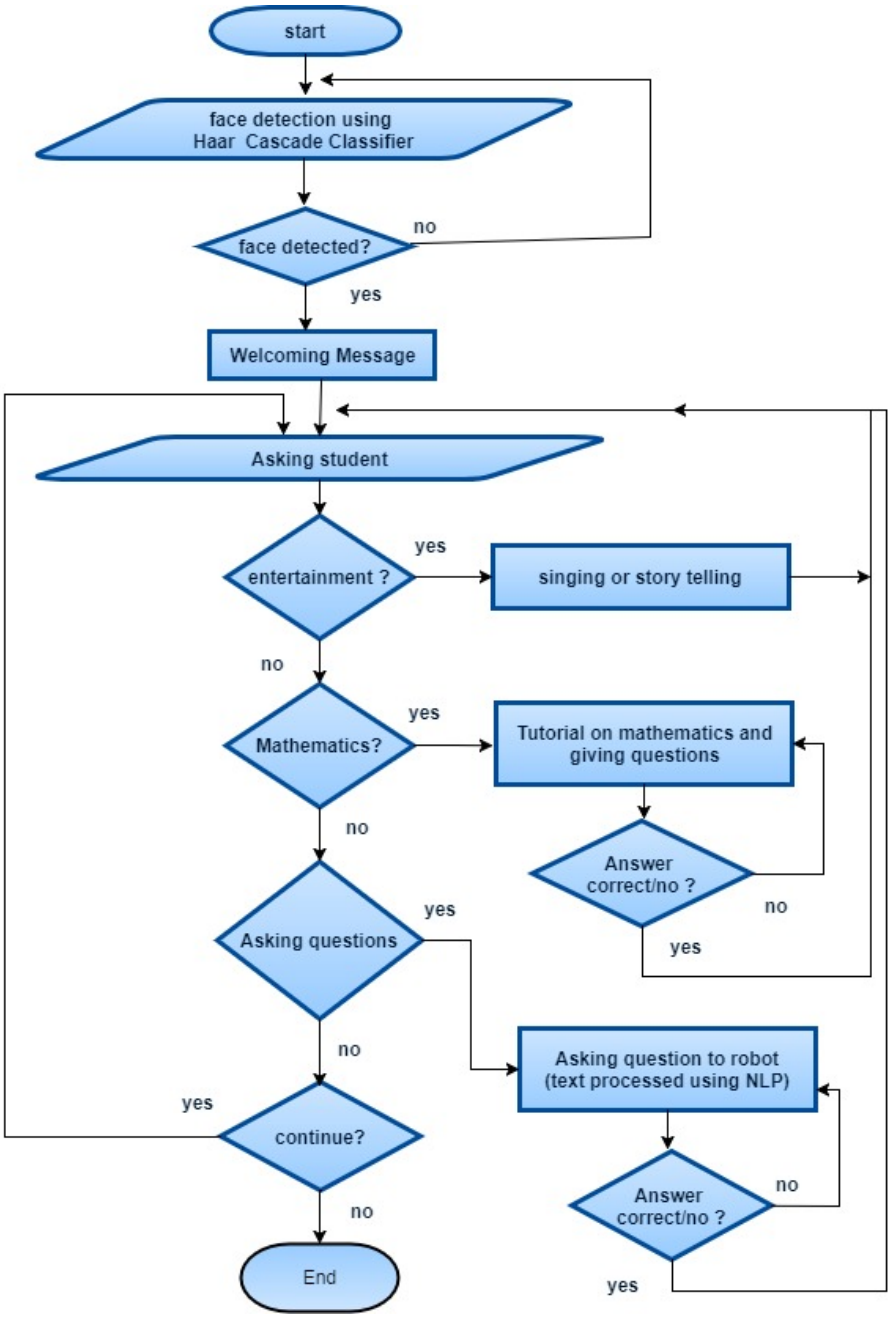

Fig. 2. Proposed flowchart of the systems

4. Experimental Result

The experiment was conducted at our robotics laboratory. We tried to give a 10 requests/questions to robot in Indonesian language with the distance between student and robot about 45cm. It is shown clearly in table 1. It shows that the average accuracy for correct recognition is 73.3% and correct answer is 63.3%.

Table 1. Result of experiments using 10 times for each question

Questions	Correct recognition	Accuracy	Correct answer	Accuracy
Derwin has 5 apples and then he buys 3 apples. How many apples does Derwin have now?	7	70%	5	50%
What is the total 5 multiply by 3?	8	80%	7	70%
What is the total 10 divided by 2?	7	70%	7	70%
average		**73.33%**		**63.33%**

We also make a comparison with NAO Robot for Speech Recognition system using *Coreographe*. The design is shown in Fig. 3. Using *Coreographe,* we can make specific systems for the humanoid robot, such as put some components to set language, face detection, make a movement of body and hand, saying command and recognition of command in sequence. The limitation of this system is only able to accept single word as command, so our proposed system that can recognize command more than 1 word should be better.

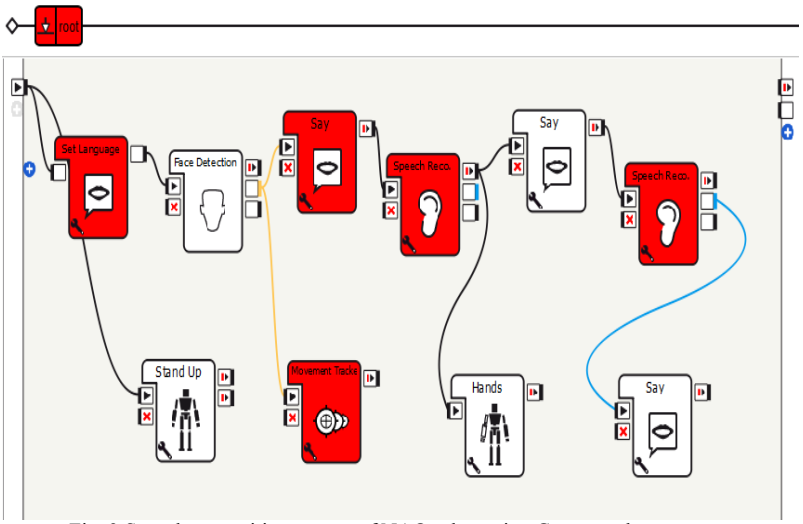

Fig. 3 Speech recognition system of NAO robot using Coreographe.

We develop a curriculum for teaching basic mathematics to student by considering psychological aspects that consists of tutorial of addition, multiplication, subtraction and division with some questions and answers. This system must be very useful in school as shown in table 2 in Indonesian language and translation in English.

Table 2. A part of curriculum for teaching basic mathematics

Activities	Robot	students
Lesson 1, Basic calculation **Class 1, elementary school**		
Introduce the self	Selamat pagi anak-anak, **saya Robot** bernama EduRobot yang **akan membantu** Ibu/Bapak Guru kita mengajari Matematika yang asik. **Bersediakah** kamu belajar Matematika dengan saya? (Good morning students, I am a Robot, my name is EduRobot. I will help your teacher to teach Math in a fun way. Would you like to learn Math with me?)	Yes, we are ready, EduRobot.
Describing theory of mathematics	Apakah kamu semua **suka makan buah**? **Senangkah kamu** menghitung buah ? Robot punya mainan berhitung yang menarik. **Berapakah total** jumlah 2 buah Mangga ditambah 5 buah mangga? (Do you like to eat fruits ? Do you like to count fruits? I have interesting counting game. How many mangoes in total if I have 2 mangoes and I add 5 more?)	Total are 7 mangos
Response the answer	**Benar** anak-anak. **Jawaban yang tepat.** (Correct, right answer!)	Thank you very much robot.
Asking question to the robot	Total 8 buah (Total is 8 apples)	Derwin punya 5 apel dan membeli lagi 3 aple, berapa total apel Derwin ? (Derwin has 5 apples and then he buys 3 apples. How many apples does Derwin have now?)
Lesson 2, Basic Calculation **Class 2, elementary School**		
Describing theory of mathematics	Berteman dengan teman di sekolah dan tetangga merupakan hal **yang mengasikkan dan penting bagi kita**. Jika kamu memiliki 30 teman sekolah, dan 12 teman di sekitar rumahmu, berapakah total semuanya ? (Making friends with friends at school and neighbourhood is fun and important. If you have 30 school friends and 12 friends around your neighbourhood, what is the total of everything?	Total are 42 friends

The result of our humanoid robot that controlled using laptop and Arduino UNO shown in Fig. 4:

Fig. 4. Our intelligent humanoid robot with elementary student

5. Conclusion

The development of intelligent humanoid robot for education is quite a challenging task. Natural interaction is an important aspect in developing intelligent humanoid robot for education. We successfully propose the speech recognition using stemming and tokenization for humanoid robot. Fun aspect is given as well, because kids learn best when they are relaxed and focused. They can give good impact on student learning, and the system is better

than Coreographe. For the future work, our robot will be challenged with more complex spoken interaction due to more variation of actions to do and the ability for recognizing emotions and long speech should be proposed.

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