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Human Interaction with Humanoid Robot

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Abstract: This paper describes the interactive functionalities of NAO humanoid robot with human activities. It demonstrates the face recognition, voice recognition and various human activities using sensors. The above tasks are carried out in Choregraphe based Graphical User Interface (GUI) module. It helps to connect the various modules connect with the hardware and software components. The intuition of this project is to train and validate NAO humanoid robot for human interaction in voice, face and movement activities with emotions.

Keywords: NAO, Voice and face recognition

1. INTRODUCTION

This paper discuss about the operating principles of NAO humanoid robot which are experimentally demonstrated with the prototype model. This section explains the salient features of the NAO robot. The humanoid Robot NAO is an humanoid robot developed by a French Company called Aldebarans-Robotics [1]. It is an open platform where the user can change all the embedded system software or just add some applications to make the robot adopt specific behaviors. NAO robot is 23 inches tall and walk on various varying slope surfaces and recognize faces & voices and even react to touch with emotions. The appealing appearance and features of the NAO robot is shown in Fig.1. It has sophisticated sensor network, including two cameras, four microphones, a sonar range network, including two cameras and receivers, one mother board in head location, nine tactical sensors and eight pressure sensors. The technical specifications of NAO [1] are given in Table 1. NAO is a combination of hardware and software product interfaced with choregraphe program with GUI tool. The program facilitates with simple drag and drop boxes with coding to perform various tasks. The data is captured by the sensors and controlling the robot by the movement of libraries. It consists of 25 motors makes it to move freely in all directions. NAO consists of two cameras which are helpful to see in the left and right directions. It has one inertial navigator makes it to move in an upright position or falling position. It consists of touching sensors at chest, foot and head enables to feel the pressure-based touches. It consists of four directional microphone enables to hear the interactor voice.

It is built up with two sets of receivers and transmitter which helps to easily adapt to automation applications.

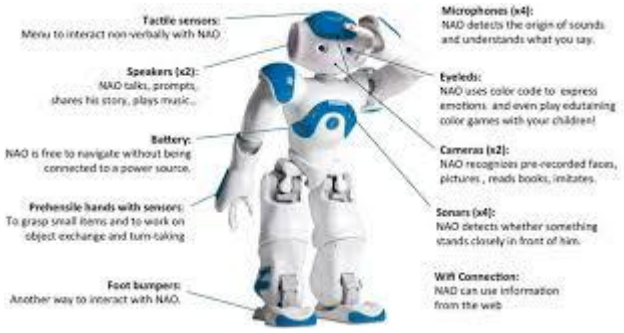

Figure 1. Appearance and features of NAO robot

Table 1. Specifications of Nao Robot

Nao Next Gen (2011)	
Height	58 centimeters (23 in)
Weight	4.3 kilograms (9.5 lb)
Autonomy	60 minutes (active use), 90 minutes (normal use)
DOF	21
CPU	Intel Atom @ 1.6 GHz
Built-in OS	Linux
Compatible OS	Windows, Mac OS, Linux
Programming languages	C++, Python, Java, MATLAB, Urbi, C, .Net
Vision	Two HD 1280x960 cameras
Connectivity	Ethernet, Wi-Fi

NAO has 25 degrees of freedom (DOF). It has two DOF at the head, five DOF in each arm, one DOF in pelvis, five DOF in each leg and two DOF at each hand. This enhanced DOF feature is used by NAO for free

movement. A variety of communication equipment, including voice synthesizer, LED lights and two high fidelity loudspeakers are in the body of NAO. NAO uses 1.6 GHz intel processor located in the head for running in the LINUX kernel. It consists of a second CPU on the trunk. The power for the operations is provided from 48.6 KWh battery. The major merit of NAO than other robots is its pelvis kinematics design. Only one motor is required to drive the pelvis of NAO. Three motors are used to perform various pelvis actions by its peers. This feature reduces the building cost and save space in the lower part of the trunk. It enhances the flexibility of NAO for the free alignment of spine, head and limbs.

2. RELATED WORKS

This section summarizes the research of published works relevant to various activities of NAO by eminent researchers. Gouaillier et al., modeled NAO with comprehensive and functional design to carry out many tasks smoothly when compared with its peers in the market [2]. This paper described the detailed kinematics and characteristics of NAO. The motion module (ALMotion) was designed to facilitate the control of NAO with simple joint space commands to allow direct control of end effectors. It helps to manipulate the center of mass and request high level straight walk motions [3]. Eminent researchers demonstrated the omni-directional walk of NAO against small obstacles [4].

The research paper [5] reported a successful hardware implementation of NAO with fall strategy which is critical in humanoid robot technology. It uses Locomote software for simulations for the control strategy. It braces his hand during the fall which is the distinct characteristics. Ismail et al. described the functionalities of NAO by understanding the facial expressions of autistic children with emotion pattern [6]. It estimates the understanding level of autism children and recommends the kind of medical therapy.

Nguyen et al. demonstrated the capability of NAO to recognize the coloured objects and improve the intelligent the interaction between humans using information fusion using states transition diagram [7]. In this paper, fuzzy logic technique was used to identify the colour of the objects and rules were described to discriminate among various colours. Dalibard et al. explained the walking behavior of NAO commanded with different emotions [8]. This paper described the cautious behavior of humanoid robot with high and low levels of the ground, proud and sad walk like human emotions. Le et al. explained the facial expressions and response behavior of NAO while telling the story in [9]. It completes the facial texture of the human during storytelling and responds accordingly. Keizer et al. presented a research article which supports social engagement and interaction with multiple customers [10]. Selene et al. developed an intelligent system which manages hierarchical behaviors using a NAO robot for different personality traits. The report explained an intelligent system to identify the behavior and personality of the humans by conducting interviews. It developed a five-factor model to determine the reaction and personality of humans. The dataset was trained and validated with number of trials. Reinforcement learning based intelligent was proposed to learn from the unknown and predicted dataset [11]. This technique is used to predict the behavior of the unknown system with previous experiences.

3. PROPOSED METHEDOLOGY

Computing languages are used to program NAO robot. This project utilizes Choregraphe based GUI tool boxes connecting for various functions of NAO and the outputs are connected to hardware interface of NAO. The toolboxes of Choregraphe GUI are written using Python and the coding is displayed, if the toolbox is double clicked. Windows and Linux platforms are compatible with NAO programming. The robot can be connected to a computer or laptop by using an Ethernet connection or WIFI connection. NAOqi is the embedded software designed to drive the activities of NAO. This software is used to integrate all the modules through operating system and communicate to NAO about the commendable operations. It consists of five interactive modules namely NAOqi Core, NAOqi Audio, NAOqi Motion, NAOqi Vision and NAOqi Sensors. The primary functions of the NAO robot operation such as initialization and parts movement are carried out using NAOqi Core module. The audio features of NAO are performed by NAOqi Audio module. It uses various wavelength of sound wave to recognize the trained voice for its operation. The motions of NAO are performed by NAOqi Motion module. The accurate movement of the parts has been done various stepping angles to provide precise movement. The parts movements are programmed in forward, reverse, number of stepwise to carry out the stepwise movements of the NAO robot. The vision process is carried out using NAOqi Vision toolbox. It is used to visualize the object using its LED based visualization. The emotions of the robot is carry out using the different colour reflection of the LED lights in various planes. The touching and pressing actions are realized by

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robot using NAOqi Sensor tool box. But the limitation of this tool is found that the pressure is realized after certain pressure only.

Choregraphe software is a user-friendly graphical programming environment which is used display various command boxes on the screen for interfacing. The application window which displays the command boxes is majorly divided into three different zones as shown in Fig. 2. The First zone in the application window displays details about project file and project object libraries. The project file library consists of animation, speech, LED, multimedia, movement, sensing and programing options. In the second zone, the command boxes from the fist zone are dragged and are linked with one another to perform a specific task defined by the user. The third zone consists of a video monitor section and a virtual robot section. The video monitor section is generally connected with the cameras of the NAO which is majorly exploited for learning the face and for face recognition. The virtual robot section consists of a virtual bot resembles the action to be performed by the NAO. It is the execution section of the action modeled by the building blocks in the second zone.

Choregraphe software performs four functions which is used in desktop application. Choregraphe is used for creating animations, new behaviors and adding dialogues. It is used to test the designed module on the virtual robot or even on the real NAO by establishing a connection between the Choregraphe software and the NAO through WiFi or ethernet cable. The major application of NAO is that it provides a complete control over the NAO and to monitor it. The Choregraphe software is used to establish various complex behaviours such as interaction with human, dance like human, sending emails and many actions. The modules can be designed even by writing python codes.

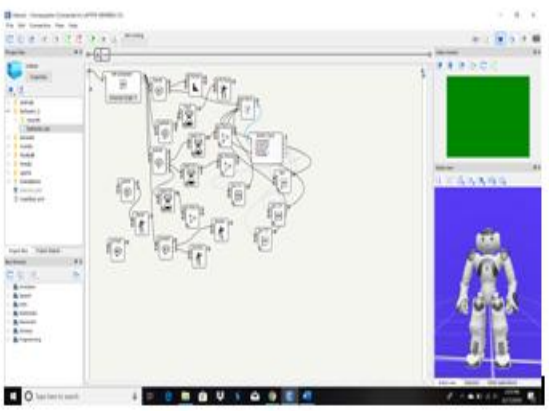

Figure 2. Application Window of Choregraphe GUI

4. EXPERIMENTAL RESULTS AND DISCUSSION

This section presents the approach proposed for the behaviors NAO model applied to various human interaction processes. The following illustrations describe what was technically done to implement and the components that were created to provide a bridge between the human and the robotic control software. In the third zone the picture of the NAO robot was displayed to ensure the execution of the Choreographe software tool. Fig. 3 describes the general information about the institution. The questions are given below the figures and answers are given within parenthesis.

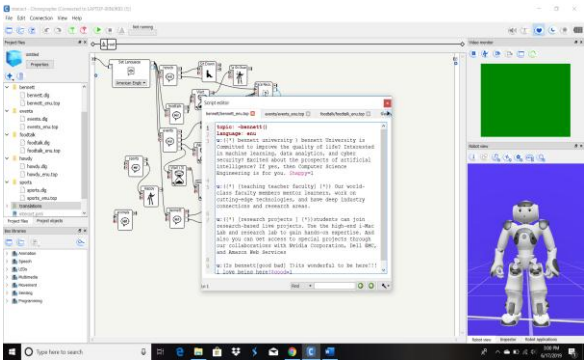

Figure 3. General talk about Organization

*Selection of CSE at Institution (happy/unhappy)
*Quality of faculty (cutting edge technology/outdated)
*Type of research projects (sponsored/unsponsored)

NAO exploits the voice play back option available in the Choregraphe software and thus it is playing a vital role in human interaction and voice recognition. The interviewer model sends the input to dialogue in various forms such as text. Thus, the input of the modules is a text string block. When the robot completes it's designed task the box sends a signal as the output usually indicated by a command. The output of the box is of Boolean datatype. Figures 4-6 illustrate the talk activities relevant to formal version, food and sports relevant conversation. The probable questions to which the NAO was trained, and the answers are given bellow the following figures. It is observed that the outcome of the NAO matches perfectly with the trained modules. The Python script for the interaction with NAO is given in Appendix.

Fig.7 illustrates the performance of the sensors located at the different parts of the NAO. It also interacts with the user about the location of the touch movement and the impact of the pressure given by the user. The robot is able

to identify and track the faces of the humans who are being training using recognition tools of the Choregraphe face detection box. Fig.8 shows the face recognition module output in which the NAO was trained. It recognizes the human face as 3-D object which is displayed as a ball. In the above trails, it is inferred that the output of the trained NAO through Choregraphe tool box gave the good results and the python script of the training events of NAO is given in Appendix.

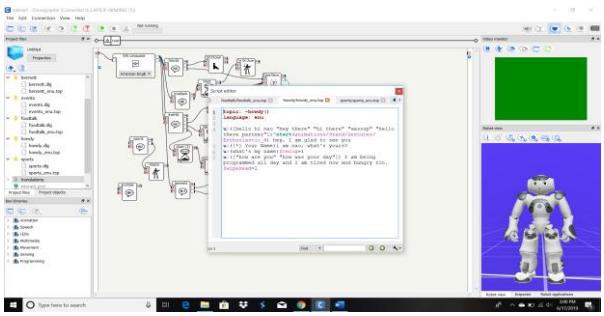

Figure 4. Formal talk

*Greetings (happy/sad)
*Interaction (correct/incorrect)

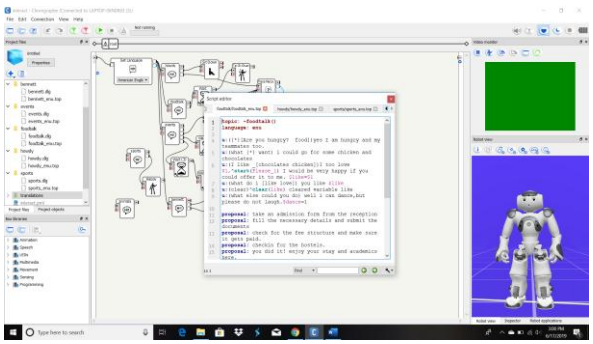

Figure 5. Talk about food interest

*Choice of food (chicken/no thanks)
*Choice of candy (chocolate/dislike)

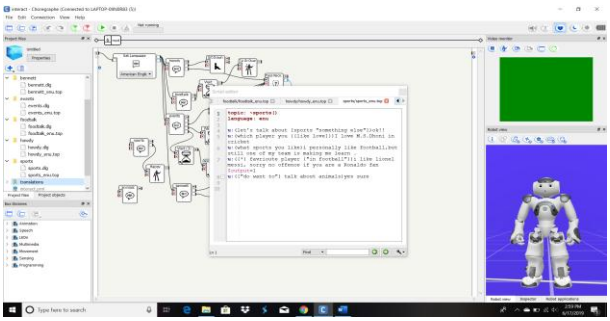

Figure 6: Sports interest

*Favorite sports (cricket / football)
*Favorite sports player (Dhoni /no one)

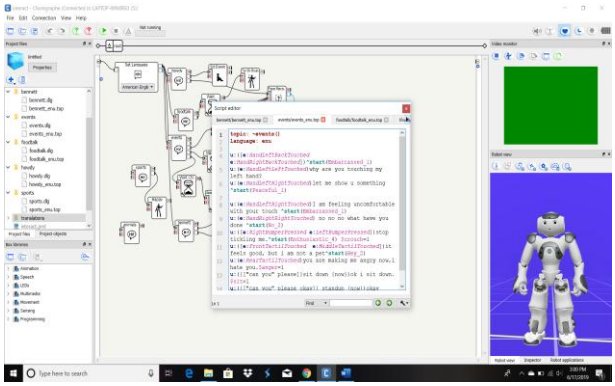

Figure 7. Sensor response

*Right bumper press (response/no response)
*Front tactile touch (response/no response)

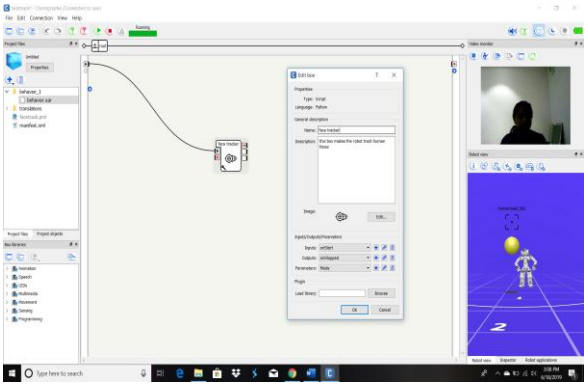

Figure 8. Face recognition*

*Face (recognized/not recognized)

5. CONCLUSION

The humanoid robot NAO was trained to recognize face, voice and do actions according to the human commands. The program for the robot is written using Choregraphe GUI tool. The project team trained the robot for different samples and demonstrate the outcome. It is observed that the robot has carried out the task exactly and the happiness index of the team was exemplary. It is a model hands on project for the demonstration of humanoid robot for day to day activities. It is observed that the robot senses may be improved like ant biting, heat sensing, and emotions without texture as the future case studies. It is suggested to incorporate reinforcement learning for the random unknown trained samples and observe its performance.

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BIO GRAPHIES

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