International Journal of New Computer Architectures and their Applications (IJNCAA) 8(2): 78-82
The Society of Digital Information and Wireless Communications, 2018 ISSN 2220-9085 (Online); ISSN 2412-3587 (Print)

Interactive Face Robot

Michel J. Owayjan, Fady C. Elias-Sleiman, Hasan A. Ezzidine, and Nourhane H. Haidar
Department of Computer and Communications Engineering
American University of Science & Technology
Beirut, Lebanon
mowayjan@aust.edu.lb, {fady.e.sleiman, hasanezzidine, nourhanehhaidar}@gmail.com

***Abstract-* The interaction between humans and robots has increased and become more personalized in this century. Robots are being used in various fields such as medicine, manufacturing, automation, etc.; however, they lack the interaction capability that is found in a human mainly because more than 60% of human communication is non-verbal, and thus, is hard to replace him. This project presents an interactive face robot which is able to mimic the six universal human facial expressions: happiness, surprise, fear, sadness, anger, and disgust. It can interact with the user using speech recognition in order to mimic a career/major adviser. The Interactive Face Robot is made out of a rubber mask to simulate the skin. Facial expressions are created by moving muscle-like structures based on a facial mass-spring model. Nine servo motors move the different action units in the face to create the different expressions. The Interactive Face Robot mimics a career/major adviser using speech recognition software, the BitVoicer, which recognizes the user's speech and communicates with a LabVIEW™ program that evaluates the answers and calculates the best career/major choice. The LabVIEW™ program, which runs on a laptop computer, also converts the pre-defined questions that the robot asks into voice, and communicates with an Arduino Mega the expression that the face is to generate. Using pulse-width modulation, the Arduino Mega controls the needed servo motors to create the necessary facial expression. The Interactive Face Robot has proven to be user-friendly, and interacted with humans as pre-programmed. Facial expressions provide robots with more capabilities for human-like interactions, making them more adequate for applications requiring interactions with humans. This Interactive Face Robot can replace a career/major adviser, and can be programmed as a receptionist, front-desk operator, or can be used in therapeutic applications.**

Keywords—HCI; Facial Expressions; Interactive Robot

I. INTRODUCTION

As the use of service robots continues to grow rapidly, an increase in the human-robot interaction (HRI) is required [1]. More than 60% of the human interaction is inducted nonverbally [2]. Thus a human-friendly interface should be developed to communicate information the same way we do with humans. For a robot to be effective in the human world, it must respond to the human emotional state by generating back humanlike expressions.

This Interactive Face Robot is able to mimic five universal expressions that benefit users in traditional roles such as servants, assistants, or companions. In a typical work day, an employee might face certain personal issues or might be exhausted; a state that is reflected on the individual's facial expressions. Since facial expressions play a major role in communication, this might send the wrong signal to the other person. Interactive robots have been proved to play a major role in improving the users' relaxation and motivation levels by reducing stress [2]. Moreover, it was found very efficient in helping children with autism by engaging them in social interaction interface [1]. The proposed robot face is a user friendly system. However, its true worth is in the therapeutic characteristics.

The significance of this project is to infer a broad scope of uses in the field of HRI. The system is a fully automated real-time one. The objective is to deliver a complete system that generates facial expressions, recognizes speech, and generates speech in real time. The proposed technique is made up of three primary key points: artificial expressions generation, speech generation, and speech recognition. The proposed scheme can be applied in different industries and circumstances and for different purposes. The goal proposed in this paper is to make the face robot an administrator at a university. Students usually have a hard time deciding what major they should go into. Therefore, the face robot will undertake a career test with the student to find out what the student likes and what not, and accordingly tells the candidate the major that most fit him/her.

II. STATE-OF-THE-ART

A Japanese teacher called Hiroshi Ishiguro developed his own robotic doppelgänger. The doppelgänger can act as the teacher by explaining lessons and answering questions. [3] Also, Hisashi Ishihara, Yuichiro Yoshikawa, and Prof. Minoru Asada of Osaka University in Japan developed a child robot that can generate realistic facial expressions. [4]

Within the recent decades, many researches have been trying to compose strategies to automatically classify facial expressions. Various methods have been used. The representative research-work based on this approach includes the work done by Hanson Robotics [5]. The newest addition to their family was Han, a face robot that can engage in conversation and generate facial expressions and make eye contact [5]. On the other hand, the Einstein robot head used 31 servo motors, 27 of them are used to generate facial expressions [5]. What remarks this project from others is that the facial expressions are detected by the movement of the muscles under the skin; these are learned by the robot and then generated when necessary. The project describes how each servo motor is used with every particular expression [5].

Moreover, Karsten and Jochens constructed a robotic head ROMAN. The paper delinates the three major steps in this project: first how the robot is able to realize facial expressions, then the mechatronic system of this robot including the neck and eye construction, and finally the software architecture of ROMAN [6].

International Journal of New Computer Architectures and their Applications (IJNCAA) 8(2): 78-82
The Society of Digital Information and Wireless Communications, 2018 ISSN 2220-9085 (Online); ISSN 2412-3587 (Print)

III. Materials and Methods

The project's design can best be described in three parts: hardware, model construction, and software. Figure 1 shows the block diagram of the project, detailing the interaction between the hardware and the software parts which will be described in more details hereafter.

A. Hardware

Every step that went into the construction of the hardware is presented in Figure 2. To begin with, the face was divided into three parts: the upper, middle, and lower. The upper part contains the eyebrows and their corresponding mechanism. The middle part contains the eyes, the upper lip, and the fixed upper jaw. Finally, the lower part contains the lower lip and moving lower jaw, and rotates to model the mouth as it opens and closes.

The eyes are ping pong balls that have been reshaped and colored to look like the human eyes. The position of the eyes required several calculations. The human eyes are positioned at the same distance from the right and the left nostrils, and to the line perpendicular to the mouth. Moreover, when looking from the top plane of the face, the distance in which the eyes are pushing forward or backwards should be taken into consideration. After fixing the eyes, the back of every eye is attached with an L shaped plastic, as shown in Figure 3, that was fabricated using a 3D printer. The end of the L shape is connected to a joint, as shown in Figure 4, attached to the servo motors arm. This allows the eyes to move right and left simultaneously. To apply a real lips movement, a guitar string is fixed around the lower and upper teeth. Other guitar strings are fixed at two points on the lower jaw and three points on the upper jaw with a round string connecting each part to model each lip. Every fixed point is tightened by a servo motor.

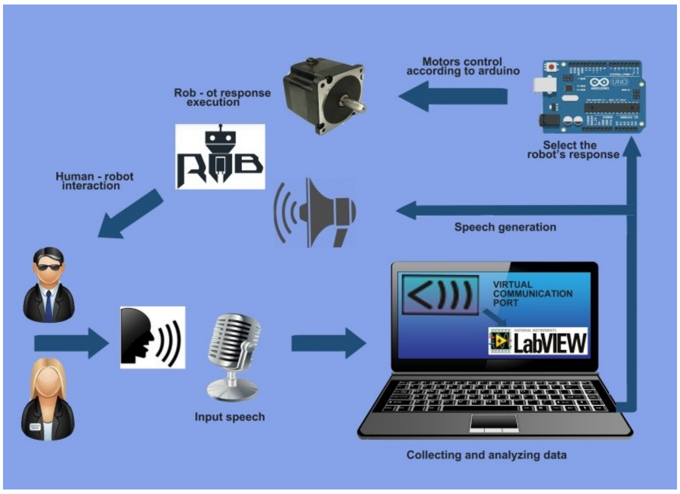

Figure 1. System's block diagram.

Figure 2. Making of the hardware.

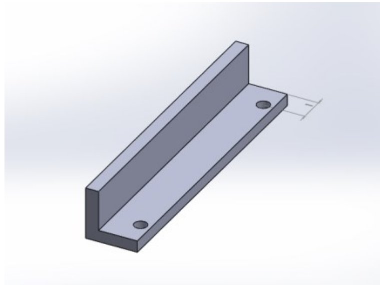

Figure 3. L-shape 3-D CAD design.

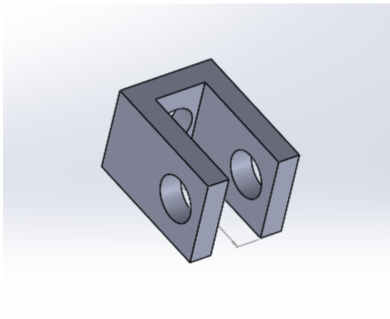

Figure 4. Joint 3-D CAD design.

Influenced by the idea behind the bicycles' brakes, the guitar strings are navigated through plastic pipes that are fixed on the mannequins head. The end of the pipe is immobile, allowing that end of the steel string to be tightened using servo motors.

The lower jaw needed two servo motors to allow easy movement. Moving to the upper jaw, knowing that there are three fixed points on the round guitar string bridge that modeled the upper lip, three servo motors are used. Due to lack of space, a polyamide body was designed to hold the three motors as seen in Figure 5. The motor wings hold a plastic rod that fixes the guitar strings on it in order to move the lips. In addition to that, a cable conjunction is fixed in front of the polyamide body in order to fix the plastic pipes with a screw. The conjunction itself is fixed by a screw so that the pipe, the rods on the motor end, and the openings above the lips are on the same line of sight.

International Journal of New Computer Architectures and their Applications (IJNCAA) 8(2): 78-82
The Society of Digital Information and Wireless Communications, 2018 ISSN 2220-9085 (Online); ISSN 2412-3587 (Print)

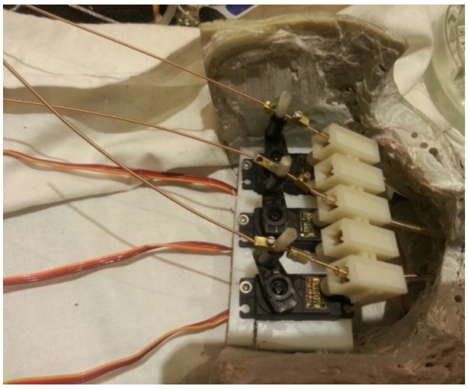

Figure 5. Upper jaw.

The lower jaw and the upper jaw are connected in such a way that allows the mouth to open and close. Therefore, the two parts are fixed using an iron joint as seen in Figure 6.

To allow rotation, first the lower jaw is connected with a loosened screw, and smoothened from its back-right and beck-left to make an angle of approximately 30 degrees with the upper jaw. The movement mechanism is done using two steps. The first is to fix three springs from the front end of the lower jaw to the upper jaw. While the second is to connect the back end of the lower jaw to a servo motor fixed on the back of the head, using a plastic thread. This will pull the jaw and make the required rotation. A spring is attached to pull the jaw back to its initial position.

The next step covers the eyebrows. The eyebrows are fixed 2 cm above the eyes. They are made up of fiber masked by a nylon sheet. The edges are smoothed. They are later drilled and fixed by their middle to be able to rotate easily to perform happy, angry, and neutral emotions. This mechanism is made up of plastic threads that are connected from the center of the eyebrows, up to the upper part of the head, then into the head where they are connected to the servo motors. This will allow the eyebrows to move up to 60 degrees anti-clock wise.

As for the neck, an iron rod is attached on a base platform that is connected to a rotating disk around a fixed axis. The base can be adjusted to the left and right using a servo motor. Such a mechanism will not be affected by the robot's weight.

B. Model Construction

After assembling all the parts together, there comes the binding stage between the rubber face and the skull. This was too risky because of the incompatibility between them. Knowing that facial expressions are produced due to fixed AUs and flexible ones, the mask is secured in some places, and left loose in others. Also, the cheeks are filled with sponge to achieve the smooth touch of the face and give it a realistic form. The nose is also thickened by sponge and compressed to have the desired shape. After fixing all the face, the motion of every motor was tested. You can see the before and after of the Interactive Face Robot in Figure 7.

C. Software

The project's system is based on three software: LabVIEW™ (National Instruments, Austin, TX, USA), Arduino™ (Arduino, Northern Italy), and BitVoicer™ (BitSophia, So Paulo, Brazil) which are connected via a serial communication (Figure 8). The LabVIEW™ program is called the decision maker since it connects the BitVoicer™ to the Arduino™. The LabVIEW™ program gets its input from the BitVoicer™, and then according to a predefined algorithm, it will send a command to the Arduino™ microcontroller which will drive the corresponding servo motors.

Figure 6. The connection of the jaws.

Figure 7. Before and after of the interactive face robot.

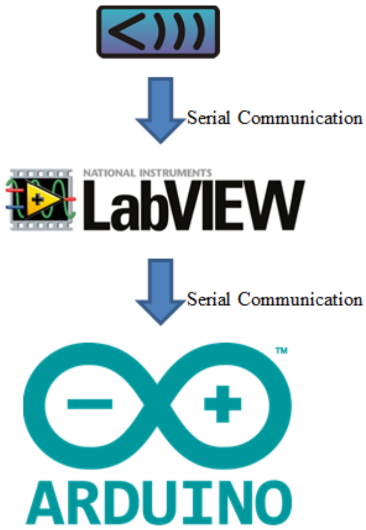

Figure 8. Software block diagram.

The face robot can be used in a variety of fields. One of them is to act as a university administrator. One of the hardest things that a student encounters when moving from the school phase to the university phase is to choose the right major. That is why, the previously mentioned program was edited to be able to do a career test with new students. A sample career test was performed. Eleven majors were taken into considerations, which are: Radio TV, Interior Design, Journalism, Public Relations, Computer Science and Informatics, Finance, Management, Marketing and Advertising, Computer and Communications Engineering, Biomedical Engineering, and Clinical Laboratory Sciences. The sample career test displayed in Table. I consists of eighteen questions. The users' answers are a simple yes/no answers. Whenever the user answers yes on a certain question, the majors related to the question should increment once. The increments are distributed between the majors equally with no favor of one over the other. Finally, when the test is over, the program should be able to know the major with the highest score and relay the information as speech to the user. The Arduino code controls the motors in the face to produce an emotion. Table II displays the angles that the ten motors rotate to create every emotion. There are one motor for the eyes, one for the neck, one for every eyebrow, one for the jaw, three for the upper lip, and two for the lower lip.

TABLE I
SAMPLE CAREER TEST

	Question	Incremented Majors
1	Do you like mathematics?	Computer and Communications Engineering Computer Sciences and Informatics Biomedical Engineering Finance Interior Design
2	Are your communication skills good and do you like to meet new people?	Journalism Marketing and Advertising Public Relations
3	Do you find out-of-the-box solutions for your problem?	Computer and Communications Engineering Computer Sciences and Informatics Marketing and Advertising
4	Are you confident and do you like to show yourself to the public?	Journalism Radio TV Public Relations
5	Do you like to learn about living things?	Biomedical Engineering Clinical Laboratory Scientist
6	Are you good in analyzing and interpreting data?	Finance Management
7	Do you have an analytical mind and do you organize your responsibilities?	Finance Management
8	Are you interested in acting, film making, or media production?	Journalism Radio TV
9	Did you spend most of your high school time in laboratories?	Biomedical Engineering Clinical Laboratory Scientist
10	Do you have the ability to recognize general principles in certain situations?	Clinical Laboratory Scientist
11	Do you need the freedom to create and be creative?	Interior Design
12	Do you like designing and artwork?	Interior Design
13	Are you appealing?	Public Relations
14	Do you like tinkering with electronics and robots?	Computer and Communications Engineering
15	Do you like to sit in front of your laptop?	Computer Sciences and Informatics
16	Do you interact with people in patience and congeniality?	Public Relations
17	Do you have the ability to link things together?	Management
18	Do you like to do heavy researches?	Marketing and Advertising

TABLE II
EMOTIONS VS ACTION UNITS

Emotion	FACS Code	
	Muscle Description	*Associated AUs*
Normal	Poker face	Neck : 50° Left eyebrow: 120° Right eyebrow: 30° Eyes: 180° Jaw: 130° Left lower lip: 150° Right lower lip: 90° Left upper lip: 170° Middle upper lip: 170° Right upper lip: 170°
Surprised	Eyebrows raised Mouth open Eyes open Lips protruded	Neck : 50° Left eyebrow: 90° Right eyebrow: 0° Eyes: 180° Jaw: 50° Left lower lip: 120° Right lower lip: 130° Left upper lip: 170° Middle upper lip: 170° Right upper lip: 170°
Angry	Nostrils raised Mouth compressed Furrowed brows Eyes wide open	Neck : 50° Left eyebrow: 140° Right eyebrow: 40° Eyes: 180° Jaw: 130° Left lower lip: 150° Right lower lip: 90° Left upper lip: 170° Middle upper lip: 170° Right upper lip: 170°
Frustrated/Contempt	Lip protrusion Upper lip raised Eyebrows raised	Neck : 50° Left eyebrow: 90° Right eyebrow: 0° Eyes: 180° Jaw: 130° Left lower lip: 150° Right lower lip: 90° Left upper lip: 170° Middle upper lip: 170° Right upper lip: 170°
Sad	Mouth depressed Eyebrows partially raised	Neck : 50° Left eyebrow: 115° Right eyebrow: 10° Eyes: 180° Jaw: 130° Left lower lip: 120° Right lower lip: 90° Left upper lip: 170° Middle upper lip: 170° Right upper lip: 170°
Happy	Upper lip raised at corners Eyebrows partially raised Jaw partially opens	Neck : 50° Left eyebrow: 100° Right eyebrow: 0° Eyes: 180° Jaw: 100° Left lower lip: 150° Right lower lip: 90° Left upper lip: 100° Middle upper lip: 170° Right upper lip: 100°
Move left	Turn neck to the left	Neck: 130°
Move right	Turn neck to the right	Neck: 30°
Move eyes	Move eyes left then right	Eyes: from 0° to 180° with delay 50ms for every 5°
Talk	Open and close mouth	Neck : 50° Left eyebrow: 120° Right eyebrow: 30° Eyes: 180° Jaw: 130° Left lower lip: 150° Right lower lip: 90° Left upper lip: 170° Middle upper lip: 170° Right upper lip: 170° Delay (200ms) Neck : 50° Left eyebrow: 120° Right eyebrow: 30° Eyes: 180° Jaw: 90° Left lower lip: 120° Right lower lip: 120° Left upper lip: 150° Middle upper lip: 150° Right upper lip: 150°

IV. Testing and Results

This project presented results for a fully automated real-time expression generation system that has been proven to be able to generate the five universal expressions: normal, happiness, sadness, surprise, and anger (Figure 9).

The primary goal of this work is to solve an engineering problem: how to make the robot's interaction be as humanly as possible. Facial expressions play a major role in this interaction. Therefore, the appearance of human facial muscles was approximated with available motors. The career test was experimented on several graduate friends, and almost all of them got the result of their university major or something that they have always wanted to do, but never got the chance to. Moreover, they enjoyed taking the test since the robot was interacting with them non-verbally. The robot was smiling and making funny expressions so that the user felt comfortable and happy. It was observed that users interacted more with the robot than with either a laptop or with a human.

V. Conclusions and Future Work

Because of the demand to study human robot interaction, a robot platform was produced to meet this requirement. The exact task of this project is to have a robot face that is human-like and produces facial expressions similar to those in humans. The methodology followed is simple. The robot takes as an input the users' speech. Then, the robot interacts while generating facial expressions by feeding the Arduino with specific command that will thus move the servo motors to generate the desired expression by stretching and releasing the rubber face on the AUs that were generated in the testing phase. Moreover, in order to make this interaction more realistic, speech was added for the robot to talk back with the user. The main task of the robot is as an administrator at a university. It asks new students questions to conduct a career test. According to the students' responses, the robot will tell him/her what major he/she should get into.

The scope of this project is promising. It is accurate to say that such a scheme can be used for different purposes easily. For example, the project can be used in the therapeutic domain to help people with autism; also, it can be useful in the education application or even in the care of the aged people. For this project to reach its foremost goal, we should allow it to interpret the facial expressions of the human facing it and act accordingly. Also, artificial intelligence should play a role so that the robot will know how to act without predefined scenarios. Moreover, the speech domain should become broad enough to make sure that the robot can reply to most of what he is receiving.

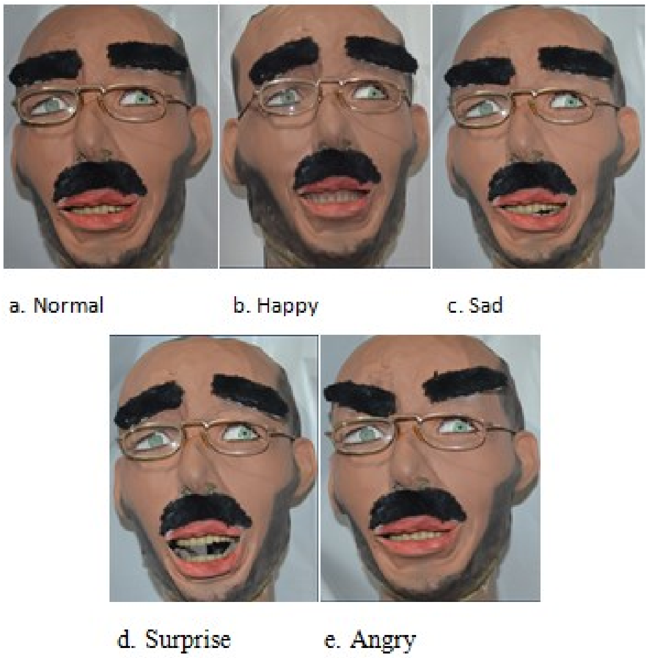

Figure 9. Results.

Acknowledgment

The authors thank Mrs. Henriette Skaff in the Department of Languages and Translation at AUST for her help in editing this article.

References

[1] M. A. Goodrich1 and A. C. Schultz, "Human–Robot Interaction: A Survey," *Foundations and TrendsR in Human–Computer Interaction,* vol. 1, no. 3, pp. 1-20, 2007.

[2] D. Feil-Seifer and M. J. Matarić, "Human–Robot Interaction," *Encyclopedia of Complexity and Systems Science,* R. A. Meyers (eds.), Springer New York, 4643-4659, 2009.

[3] E. Guizzo, "Hiroshi Ishiguro: The Man Who Made a Copy of Himself," April 2010. [Online]. Available: http://spectrum.ieee.org/robotics/humanoids/hiroshi-ishiguro-the-man-who-made-a-copy-of-himself.

[4] N. Kageki, "Meet Affetto, a Child Robot With Realistic Facial Expressions," Feb 2011. [Online]. Available: http://spectrum.ieee.org/automaton/robotics/humanoids/meet-affetto.

[5] Hanson Robotics. "Face Robot," 2015. [Online]. Available: http://www.hansonrobotics.com/robot/han/

[6] K. Berns and J. Herth, "Control of facial expressions of the humanoid robot head ROMAN," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 3119-3124, 2006, October 9-15, Beijing, China.

