Experiment on the empathic reaction of an animatronic structure determined by a voice command

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Abstract. This paper presents an experiment on the affective reaction of a modified biomimical structure Chimpanzee Alive at a series of commands or vocal dialogues. The experimental structure includes a biomimetic structures Scary Terry Talking Skull which has the possibility, through own development board, to send voice commands to the biomimetic structure Chimpanzee Alive. These voice commands are taken by using a smartphone with android operating system and which has Arduino BlueControl applications installed. After processing of the voice commands by Arduino BlueControl, the smartphone sends control signals by bluetooth, to biomimetic structures controller. This commands the motors of the biomimetic structure (for the movement of the eyebrows, mouth and eyelids), the result being the following expressive states: euphoric, pensiveness, annoyance. After obtain the expressive states, the Chimpanzee Alive structure returns into neutral state by activate a gestures sensor.

1. Introduction

Animatronic structures are in fact those structures that have elements from the domains: computers, mechanical systems, electronic systems and control systems (being considered robots or mechatronic structures). The animatronics are at the junction between electronics and animation [1].

An important contribution in developing animatronic reactive structure consist in studies of human body and reaction, especially dynamic and virtual simulations and experiments [2,3].

Animation induces the optical illusion of motion by running images (pictures or drawings representing animals or objects) at a certain speed. This creates the illusion that animals or objects exposed in photos, pictures or drawings, are continuously moving [4].

Over this movement of the pictures (which creates a visual effect), to obtain an almost real environment, a soundtrack (which creates the auditory effect) can be transposed [5].

The animatronic structures are mechanical structures that present a real element (reproduce real animation by moving the component mechanical elements with the help of driver systems and electronic command and control systems). They are structures that model or mimic the expressions or behavior of animals or humans. These structures are also called biomimetic structures [6].
2. Problem Formulation

Creating an animatronic structure is done using models from the real world (often taking the animal world as a model).

Lately, communication with such structures is done using voice commands (which provide the easiest and most natural way of communication [7]). Thus, can be listed, the following robots / animatronic structures that interact by voice (between many marketed):

- The Puffy robot, which recognizes the voice and has the following facilities: it can hold a discussion, dance, walk and tell stories [8];
- The robot Flash, which can be controlled voice and tactile, which can move, dance, sing, record and speak (as the one it records) [9];

There are also humanoid robots that can be controlled vocally, for example [7]:

- Alpha 1S humanoid robot (the first humanoid robot that helps the family to ensure good mood, telling stories, singing and talking);
- The humanoid robot CrzR, which can be our ideal assistant, can encourage us by hugging us or helping us find the boarding gate at the airport;
- The humanoid robot Pepper, which can interpret the emotional state of humans, being the ideal personal assistant.

Taking into account the ones presented (the tendency and importance of the voice communication in the educational applications) an experimental structure was created that consists of two biomimetic structures: the Scary Terry Talking Skull structure and the Chimpanzee Alive structure, to highlight collaborative interaction activities. In this experiment, the Scary Terry Talking Skull biomimetic structure will have to send voice commands (and at the same time to mimic the utterance of these commands) to the Chimpanzee Alive biomimetic structure, in order to reach different emotional states.

3. Problem solution

The Scary Terry Talking Skull biomimetic structure [10] has the possibility, through its own development board, to send voice commands to the Chimpanzee Alive biomimetic structure [11], to reproduce different emotional states.

From this point of view, the biomimetic structure of Chimpanzee Alive needs to be modified (it replaces its own development board with an Arduino MEGA board, in order to have greater availability for inputs and outputs (analog / digital) and to allow reception and interpreting voice commands or to engage in dialogue). Also, during the experiment, a terminal bluetooth application (with the help of a mobile phone and a Bluetooth module) was developed that offers the ease of voice interaction between the two animatronic structures.

The Arduino Blue Control software application is used through the Android operating system (used by some phones) and allows a user to send commands to an Arduino board via bluetooth. In this experiment, the Voice Control menu of the Arduino BlueControl application interface is used.

The mobile phone (which has an Android operating system and has the Arduino BlueControl application installed) takes the voice command from the Scary Terry Talking Skull biomimetic structure and the Bluetooth module ensures the transmission of information from the phone to the ARDUINO board, afferent to the Chimpanzee Alive structure. The processing of voice information is done by Google's voice synthesis.

The Terry Talking Skull Scary structure can be considered a biomimetic robotic structure because it contains a skull with a mobile jaw (drived by a servo motor) for speech simulation (playback) and a ST 400 development board [10], which can process a audio signal and can elaborate commands for the servomotor (jaw movement depending on the audio signal).

The audio signal received by the ST 400 development board, first is recorded in the Audio Shield for Arduino module and then provided by it.

In figure 1 is presented the block diagram of the experiment on how to transmit information for determining the biomimetic expressive states of the animatronic experimental platform, using the voice command.
Figure 1. The block diagram of the experimental structure for the voice command

In figure 2 is presented the physical positioning of the robotic structures for transmitting voice commands from the Scary Terry Talking Skull robotic structure to the Chimpanzee Alive biomimetic structure through the mobile phone and the audio speaker for playing the preset commands.

Figure 2. Transmitting voice commands via mobile phone from the Scary Terry Talking Skull robotic structure to the Chimpanzee Alive biomimetic structure

The experimental system (with the physical connection of the electronic circuits) proposed for the use of voice commands in order to achieve the expressive states by the animatronic experimental platform, is presented in figure 3.
In order to carry out this experiment it was necessary to register the commands as audio files in the internal memory of the Audio Shield electronic board. Thus, through the microphone on the Audio Shield electronic board, the following commands were recorded:

- euphoric monkey, annoyance monkey and pensiveness monkey.

By pressing the "playback" button of the Audio Shield board, the recorded audio file (eg euphoric monkey) is transmitted to the ST-400 electronic board at the "line in" terminal and at the "line out" terminal, a mini audio speaker is connected, which play audio signal "euphoric monkey". Also, at the same time, the audio file will be processed by the ST-400 electronic board which will command the servomotor of the Terry Talking Skull robotic structure. This will cause the jaw to move according to the amplitude of this signal, which will mimic the rendering of the command "euphoric monkey".

The mobile phone will take over from speaker this audio signal and interpret it as a voice command (the "euphoric monkey" command).

The transmission of the voice command "euphoric monkey" from the phone to the Chimpanzee Alive structure, implies the storage in the Arduino BlueControl application (installed in the mobile phone) of a text-type sequence "euphoric monkey" (figure 4.a) and of a character "e" associated with this text sequence (figure 4.b). This application will compare the audio signal taken by the phone with the stored text sequence. If the two information coincide, then the application, installed in the phone, will send the character "e", in the form of a binary code (figure 4.b) (which will be sent via bluetooth.
to the experimental platform) (figure 3), to achieve the expressive state. The same procedure applies for all three emotional states.

Figure 4. Configuring and interpreting the voice command "euphoric monkey" by the mobile phone for the control of the experimental animatronic structure

Chimpanzee Alive biomimetic structure receives voice command from the Scary Terry Talking Skull robotic structure to reach an expressive state. It will remain in the expressive state associated with the received voice command, until, as a human operator, it will activate, with the help of the hand, a gestures sensor.

The gestures sensor used in this experiment is of type APDS-9960. This sensor is capable of detecting certain simple gestures of a human operator without direct contact with it. It uses object detection technology up to 20 cm away and also the object's direction in the domain of sensor's action: left-right / top-down (from a distance up to 15 cm) [12].

It can be said that, in this experiment, there is an interaction between a robotic structure, a biomimetic structure and a human operator, based on a collaborative protocol. By this protocol it was established that, when the gesture sensor is activated, by a movement of the hand, to the left or to the right, the structure of Chimpanzee Alive will be positioned in the neutral expressive state. The neutral state is considered that state that does not express any emotional state - that can be found in Plutchik's wheel. By Plutchik's wheel it is defined that the attainment of an emotional state can be done by associating some emotional basic states [13].

Figure 5 shows the transmission of information within the realized system, by identification the gestures (made by hand movement) use the sensor APDS-9960.
Figure 5. The detecting the gestures for the Chimpanzee Alive biomimetic structure.

The software for the control of the biomimetic structure, which is loaded in the microcontroller of the Arduino board, will interpret the character received through a conditional structure of type "switch" (as shown in figure 6), where the prescribed values for the movement of the eyebrows, eyelids and mouth (bringing the eyebrow, eyelid and mouth variables in a certain position determines one of the expressive states) for the selected emotional state and these values will command the drivers circuit of the biomimetic structure in order to achieve the expressive state.

Figure 6. The interpretation of the voice commands by the Arduino board given from mobile phone for euphoric command.

The attainment of emotional states will be realized according to the positioning of the three elements of the Chimpanzee Alive structure, which influence these states: the eyebrows, the eyelids and the mouth. These elements are driven by means of DC motors and the information about their position being obtained from the attached transducers. Then, the information from the position transducers (which are actually potentiometers attached to the motors) are converted with a 10-bit CAN,
embedded on the Arduino Mega 2560 electronic board, into values within the range [0 ... 1024] CAN units. Table 1 presents the quantified values of the position of the elements, which represent, in fact, the reference values (to be reached) for each expressive state.

**Table 1.** The values quantified by the analog-numeric converter associated with the studied biomimetic expressive states.

| Expressive state | The elements that influence achieving expressive state | The domain of variation associated of the element | The quantified values for expressive state achievement |
|------------------|---------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------|
| Euphoric         | Eyebrow (min: 450, max:650)                            | 610                                              |
|                  | Eyelid (min: 420, max:700)                             | 630                                              |
|                  | Mouth (min: 270, max:510)                              | 430                                              |
| Annoyance        | Eyebrow (min: 450, max:650)                            | 485                                              |
|                  | Eyelid (min: 420, max:700)                             | 330                                              |
|                  | Mouth (min: 270, max:510)                              | 315                                              |
| Pensiveness      | Eyebrow (min: 450, max:650)                            | 580                                              |
|                  | Eyelid (min: 420, max:700)                             | 560                                              |
|                  | Mouth (min: 270, max:510)                              | 330                                              |
| Neutral state    | Eyebrow (min: 450, max:650)                            | 530                                              |
|                  | Eyelid (min: 420, max:700)                             | 615                                              |
|                  | Mouth (min: 270, max:510)                              | 295                                              |

To achieve the expressive / emotional states, a control architecture was used, which has the block diagram shown in figure 7 [14]. As shown in the figure, three PID regulators are used to control the states, one for each element (eyebrow, eyelid and mouth). These elements influences the achievement of the three states.

![Figure 7](image_url)  
**Figure 7.** Block diagram of the command and control of emotional states
As a purpose of the experiment, after generating the voice commands, three emotional states of the Alive Chimpanzee structure will be obtained: euphoric, annoyance, and pensiveness, presented in figure 8.

![Figure 8. The emotional states obtained by the experimental platform: euphoric, annoyance, and pensiveness](image)

a) euphoric  
b) annoyance  
c) pensiveness

### 4. Conclusions

Communication with such structures using voice commands offers the easiest and most natural way of communication. The need to introduce collaborative vocal interaction appears from the social interest (need) to create and develop biomimetic structures close to human behavior, to express expressive states. These structures possess abilities of vocal interaction, as well as capacities of natural and intuitive expression of some expressive states.

The experiment that uses vocal synthesis, for certain commands, allows the interaction between different types of animatronic / biomimetic structures.

A didactic solution can be developed for the purpose of studying a participatory protocol of each structure.

The collaborative interaction of the biomimetic structures within this experiment can also ensure an interaction for a collaborative learning from the students.

The collaborative interaction of biomimetic structures can also be used in order to encourage students to have a participatory attitude to lessons. In this case, the role of robots can be considered as being a social one, as a teaching assistant, to stimulate participatory learning.

Also, using the experimental platform presented in this paper, a commercial solution can be developed for different events (birthdays, Hollween etc).

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