DESCRIPTION AND CONTROL OF A BIOMIMETIC STRUCTURE

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ABSTRACT: *This paper presents a control architecture for biomimetic structures, as well as a control structure for obtaining a certain biomimetic state. Obtaining these biomimetic states is accomplished using a negative feedback control structure. Implementation of this adjustment structure is done using an Arduino Mega 2560 board.*

KEY WORDS: PID control, biomimetic structure, architecture, emotion, simulation

1. INTRODUCTION

One of the most popular theories of emotion is the Plutchik American psychologist who proposed a detailed classification of emotional responses. He proposed a set of eight basic emotions, which are divided into four pairs of opposite states: joy-sadness, acceptance-disgust, surprise-anticipations, anger-fear. All these emotions are considered innate. The Plutchik also created a wheel of emotions used to describe the connections between therm (fig.1). [1].

His model is the connection between the idea of emotion circle and a color wheel. Like colors, primary emotions can be expressed at different intensities and can be mixed to from different emotions. Circumplex model is seen as a vertical section of a conical model of emotion [2]. A control structure based on biomimetic transducers and a fuzzy controller is described in the paper [3].

According to Plutchik, people can have opposing emotions at a time. Emotions that are the base of the cone are considered to be the most intense and as the intensity decreases are harder to distinguish [4].

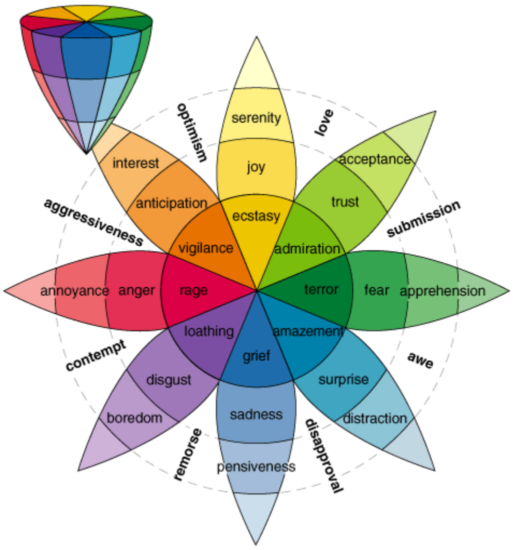


Figure 1. Wheel emotions by Plutchik [1]

2. DESCRIPTION OF A CONTROL ARCHITECTURE FOR THE CONTROL OF A BIOMIMETIC STRUCTURE

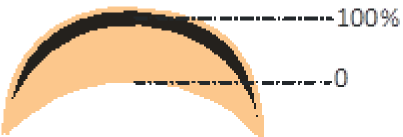
In order to move the eyelids, eyebrows and mouths to a position corresponding to an emotional state, are used mechanisms that are actuated by means of DC motors. The motors, in turn, are controlled by special amplification circuits (because the ARDUINO development board cannot provide the current for powering the motors) called drivers.

2.1. The domains considered for biomimetic expression states

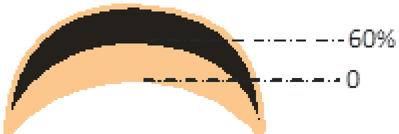
We consider that an expressive state of the human face is mainly given by the actual position of the eyebrow (s), eyelid (p) and mouth (g).
The analysis of the actual positions of the eyebrows (s), the eyelids (p) and the mouth (g) the following figures define the variation scope for these variables.

So, the s-eyebrow variable is shown in figure 2 b1)-b3) and are presented the some positions (minim, maxim and neutral) of the eyebrows.

b1) The minim positions of the eyebrows



b2) The maxim positions of the eyebrows

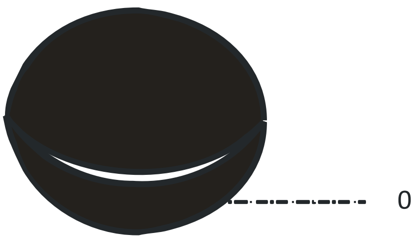


b3) The neutral positions of the eyebrows

Figure 2. The range of the eyebrow

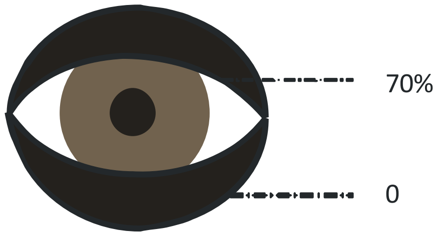
Obs. The eyebrow has the position '+60' [%] in the neutral state, raised (max) for '+100' and lowered (min) for '0' [%] [5].

The p-eyelid variable is shown in the figure 3 b1)-b3) and are presented the some positions (minim, maxim and neutral) of the eyelid.



b1) The minim positions of the eyelid

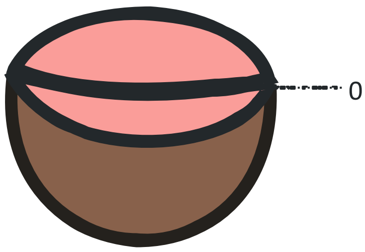
b2) The maxim positions of the eyelid



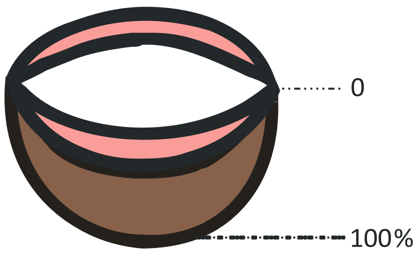
b3) The neutral positions of the eyelid

Figure 3. The range of eyelid variation

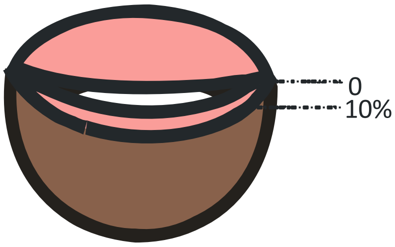
Obs. Eyelid position is '+70%' neutral state, closed (min) '0%' and raised state (max) to '+100%' [5].
The g-mouth variable is shown in the figure 4 b1)-b3) and are presented the some positions (minim, maxim and neutral) of the mouth.



b1) The minim positions of the mouth



b2) The maxim positions of the mouth



b3) The neutral positions of the mouth

Figure 4. The variation range of the mouth

Obs. Relaxed mouth (neutral) the position is ' 10%', mouth fully opened (max) the '+100%' and tighten lips (min) at '0%' [5].

2.2. The description biomimetic structure Robot ELVIS

In Figure 5a) is presented the biomimetic structure Robot ELVIS.
Biomimetic structure Robot Elvis has digital and analog sensors as well as 10 motors. Also has built-in infrared sensors integrated into the jacket that detects motion and sound sensors and vibration in the ear. It can also reproduce unique facial expressions (including upper lip wrinkles) and baritone voice and can sing 8 famous songs by Elvis.

Figure 5 a). The biomimetic structure Robot ELVIS [6]

In Figure 5 b) is presented the mechanical and electronic structure which is controlled by ARDUINO MEGA board.
Its architecture contains ten motors that allow for true replication of its facial movement.

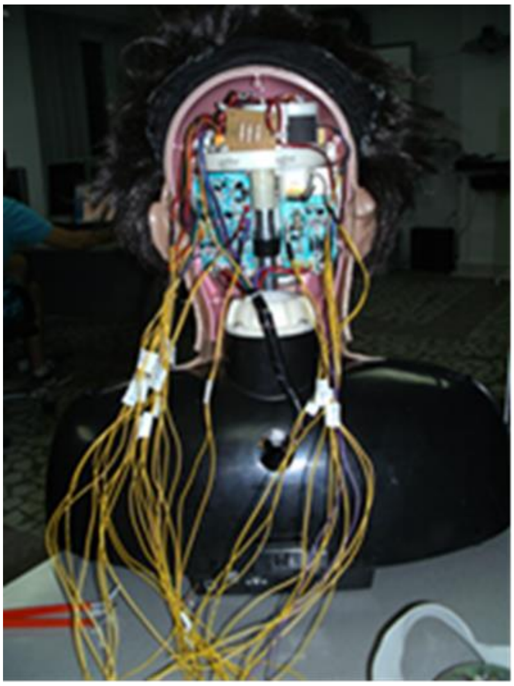


Figure 5b). The mechanical and electronic structure Robot ELVIS

In Figure 5 c) is presented the controlled ARDUINO MEGA board and drivers driving DC motors. In this application, L9110 drivers have been used that can provide maximum currents of 800 mA for an engine (which is sufficient for biomimetic engine engines).

Figure 5c). The electronic structure for control and command Robot ELVIS

2.3. The description ARDUINO MEGA board.

Connecting multiple sensors to a microcontroller development board requires a large number of inputs, of which seven analog input for potentiometers. Therefore, it is used the ARDUINO MEGA board [7] , Figure 6, which has the ATmega2560 microcontroller and the Atmega16u2 microcontroller for USB connectivity.

ARDUINO MEGA is an ideal development board for applications that need multiple communication pins, analogs and PWMs.

Figure 6. The ARDUINO MEGA board

3. PRESENTATION OF THE COMMAND AND CONTROL STRUCTURE FOR ROBOT ELVIS

In Figure 7 we designed a control architecture for commandig a biomimetic structure using three classical PID regulators (proportional-integrator-derivative), three execution elements and three transducers positioned on the reaction path, one for each input variable, eyebrow-s, eyelid-p, mouth-g for ELVIS Robot.

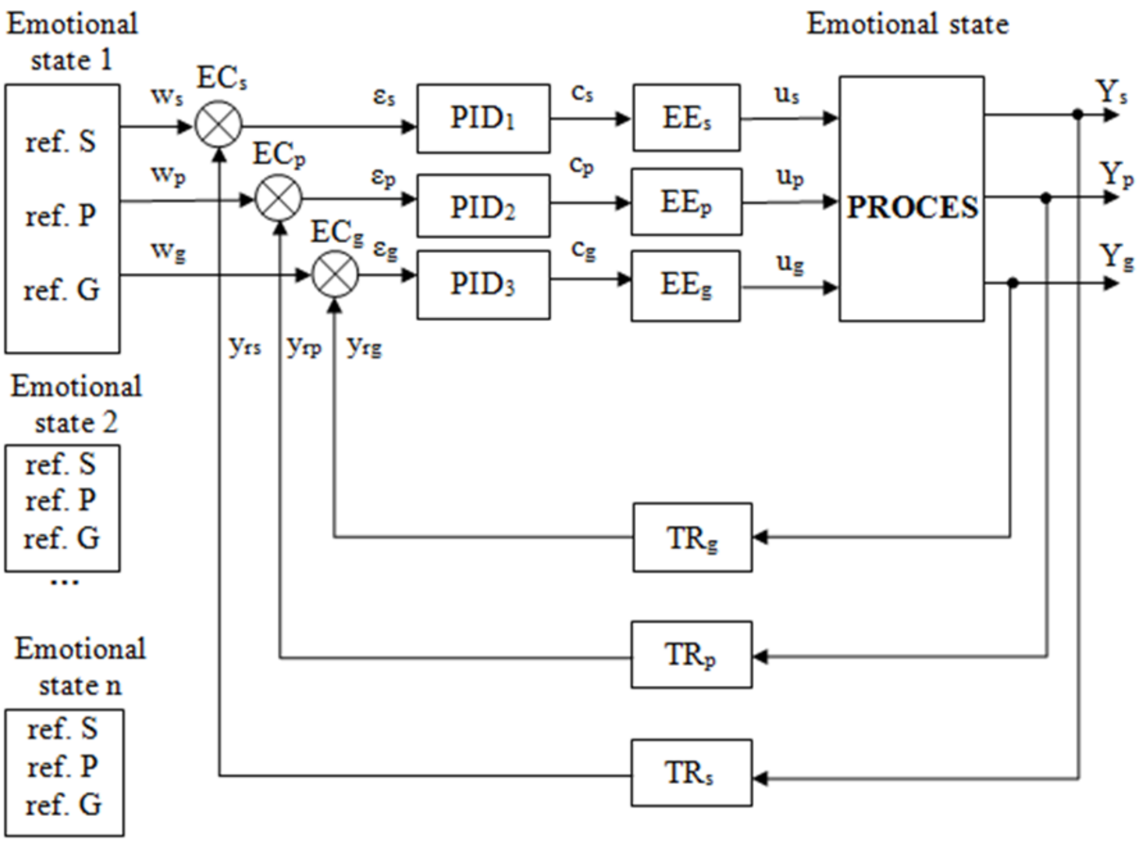


Figure 7. Block diagram for command and control of the biomimetic structure

4. CONCLUSIONS

The aim of this paper is to present the principle of control of biomimetic structures by using classical regulators. The biomimetic structure control technique studied uses PID algorithms and is an attempt to cover the basic principles and intelligent control concepts in humanoid robotics. From the simulation results for the studied expression state it results that the eyebrow variable (yellow) having the range of variation between the highest and lowest positions has the response time till the point of reaching the highest reference value.

In general, this paper refers to a wide selection of examples that serve to demonstrate the benefits of applying this techniques in order to control these types of biomimetic structures.

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