Robot Arm Controlled By Facial Features

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1 Proposed Demonstration Device

For the current demonstration purpose the device consists of a robotic arm that uses a feature control sensor apparatus to control dozens of functions. It is configured to afford the user the ability to control a five degrees of freedom robot arm and a number of associated key functions by using their facial features as the control input. In actual real applications the device would most often be mounted to a motorised wheelchair base that would also be controlled by the feature control interface. For the demonstration however, the interface, arm and associated control circuitry are fitted into a floor mounted base unit that runs off a standard local grounded outlet. For the demonstration the attendees will be the users and as such will be afforded a relatively simple task of stacking a series of blocks. The success of each user's first attempt to properly control the sensors will vary, as training and movement aptitudes can differ depending on a person's initial skill in feature gesturing. Regardless of this factor, first hand testing will be an interesting attribute of the demonstration.

2 Device History

The demonstration device is an interactive model that is part of the fourth prototype in a series of feature control and gesturing experiments created in our shop over the past few years. Each predecessor was configured as a robotic wheelchair with various attributes added according to specific design requirements. These attributes have included devices such as a five degrees of freedom robotic arm with a writing/drawing implement, servo operated steering and main drive

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wheels, basic navigation assist, vital signs monitor and linear actuator seat raising mechanisms. The experiments were aimed at developing the basis for a series of simple interfaces and electromechanical adaptations for individuals with severe paralysis.

3 Controlling the Demonstration Robotic Device

The sensors in the interface are configured to detect changes in facial feature movement and interpret the changes as control input data. To operate the unit, the demonstration device user, or an assistant to the individual with paralysis, selects the appropriate feature input sources by setting a few simple toggle switches which are mounted to a panel on the side of the unit. With the switches the choice can be made as to the type of facial features to be monitored as input source data.

The facial feature control sensors self calibrate with the relaxation of a given facial feature to help prevent false triggering. In effect the unit resets it's zero mark according to the features in their relaxed state. The design of the sensors is comprised of both a mechanical element and an electronic sensor that work in unison. Depending on the type of feature detection, the specific sensor type varies. Most of the sensors consist of a roller, lever or similar apparatus that causes an emitter beam to be broken and the detector to execute an "on state" command. The emitter and detectors are basic IR beam break devices. We have also used a variety of miniature mechanical switches, potentiometers and other devices for various experiments. The simple levers and rollers have mechanical slip assemblies that act as the calibration device. So far the facial features monitored successfully have been the nostrils, eyebrows and the jaw muscles as measured during a broad smile, or the tensioning that occurs during biting action. Naturally other features can be monitored, but we have focused on the easiest to integrate thus far.

The main control circuit for the demonstration device uses a simple logic interpretation format for the data collected from the sensors. In this format the device's movements are individually selected and initiated in sequence by a specific feature movement. Nostril movement, or other movements depending on availability, act as the signal for the sequence control to count through the options. If available, the right nostril is used for the basic sequence selection count. The count is a simple run through of the different degrees of freedom for the arm and accessories. The basic count goes as follows: 1= Hand, 2= Wrist, 3= Elbow, 4= Shoulder vertical, 5= Shoulder UP-Down. A simple display graphic shows the function selected. The left nostril is used for a quick select sequence to choose the primary selection areas. This would apply to selecting the type of device used such as (Select robot arm) or (Select wheels for navigation). Between two nostrils hundreds of functions could, in theory, be accessed in seconds. Next, another set of facial features are used to control the degree of freedom selected. The control is kept simple so that the unit operates as a simple tool as opposed to an automation of movements. For example; features such as eyebrows can be used to activate the appropriate movement once the degree of freedom selection has been made. These actions are basic commands such as open-close, up-down and CW-CCW. The format for the eyebrow control interpretation classifies movements on the left as regressive and movement on the right as assertive. Accordingly the left eyebrow corresponds to such movements as counter clockwise, down, left turn, off and backup. The right corresponds to actions such as up, forward, right turn, clockwise and on. Since only one function is accessed at a time, the types of actions within a specific function are easy for the user to monitor.

For the demonstration the feedback for the choice selection is provided in the form of a display mounted to the unit. In the actual application the display is miniaturised and eyeglass mounted as a digital readout that is fitted with a lens, which focuses the image from the readout into the eye and onto the retina. As the focal length for the readout lens is drastically different from the focal length of regular vision, the patient can simultaneously see the readout while looking across a room.

In a robotic wheelchair application certain automatic functions are also provided to give a wheelchair the ability to avoid tipping and other basic dangers. This is accomplished by the use of inclinometers, linear actuators, limit switches and similar devices that force the unit to remain level or refuse the command to climb overly step inclines. Limits are also used to provide automatic prevention of over travel for each of the robotic arm’s degrees of freedom.

The effectiveness and speed of operation for feature control will increase if more of the patient’s motions are intact, because the patient can input additional control through additional sensors. If fine movements are available sensors such as inclinometers, potentiometers and encoders can be used to obtain fluid movements for handwriting and some detail work.

This technology can also be used with an interface for computer operation, tele-presence control and in other control systems that would ideally be operated on a hands free basis.