Blinking Orbital Prosthesis

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Abstract

An orbital prosthesis is an artificial eye that closely mimics a person's natural eye. Although they provide the patient with a more natural appearance, the prosthesis is easily noticed because it cannot blink. The goal of this project is to create a mechanism that allows an orbital prosthesis to blink. The two major parts include the mechanism for movement of the eyelid and the use of an infrared sensor for an automated system that relies on the movement of the naturally blinking eye. The focus of this prototype is devoted to the mechanics of the blink, and not the synchronization. Through designing and testing, a final design was chosen, which envelops the use of a motor to move a lid up and down.

Problem Statement

Motivation

Patients have requested that orbital prostheses impart more life-like qualities, including the ability to blink. Each year 11,000 accidents occur in the United States alone that leave patients with a large facial gap where the eye had been previously located (Lee, 1988).

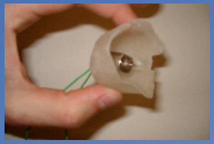
Background

Orbital prostheses are used when a person suffers from a tragic circumstance (injury or disease) that damages the eye beyond repair to make the patient appear more normal. They do not serve the same function as a healthy eye meaning the prosthesis can never be used for sight. Currently, orbital prostheses do not blink.

Client Requirements

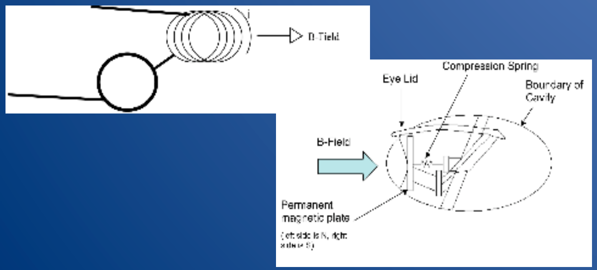
- The size of the orbital cavity is limited to approximately 16.5 cm^3
- The prosthesis must be able to operate at 37°C and at atmospheric pressure
- It must be safe for everyday patient use
- Any external components must be small enough so future researchers can work on a complete enclosure

Final Design



- Super high-speed motor that runs at 0.3A and 6V DC
  - Mounted within a PMMA cavity with the wires protruding from the backside
- Power source is a 1.5V calculator battery
- Circuit is switch operated
- PMMA arm 1.75cm in length is attached to the rotary shaft of the motor
  - Rotates in the clockwise direction
- Two metal rods are attached to the back of the eyelid
  - Arm on rotary shaft forces rod that is angled upward up, which causes the eyelid to close
  - Arm on rotary shaft forces rod that is angled downward down, which causes the eyelid to open

Alternative Design

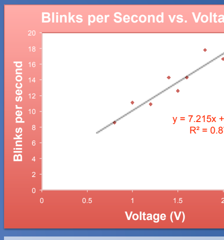


Repelling Magnetic B-Field

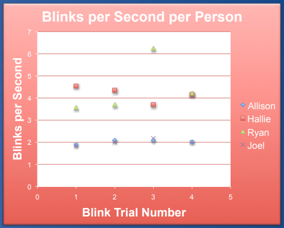
- Utilizes a repelling magnetic field to close the eyelid
- Magnetic field is generated by a glasses frame in front of the prosthetic eye
  - The glasses use multiple coils of wire for generation of the field, called a solenoid
- The magnetic field is oriented so that it repels a neodymium magnetic plate located behind the globe
  - The plate is connected to a compression spring that will return the plate to its initial position after the electromagnetic field has been turned off
- Initial motion of the plate will cause the eyelid to close, while the returning motion will cause the eyelid to reopen
- Testing proved too dangerous to validate design
- Large amounts of current are necessary to generate a magnetic field large enough to move the neodymium plate a usable distance

Testing

To quantitatively measure the speed of the blink, a 30 frames per second camera captured the movement at varying voltages. The videos created were then slowed down to 100 milliseconds in order to count the number of blinks in the specified time period.



This data provides quantitative evidence that amount of blinks per second changes linearly with respect to voltage.



Real-life blinking data can be used to determine the necessary voltage to mimic the blink of a healthy eye.

Future Work

Now that the orbital can blink, a future team can start to develop the infrared system to coordinate the prosthetic eye with the naturally blinking eye. The patient would have to wear a reflective contact lens in their naturally blinking eye. Then, an infrared sensor would be mounted on a pair of eyeglasses that would detect when the natural eye is open through this reflective contact. When the natural eye closes, the sensor would send a different signal to an infrared receiver within the pupil of the prosthetic eye. After triggered, the pupil receiver would initiate current flow to the motor, activating the blink. This infrared system would, in effect, replace the switch and completely automate the system. Another future improvement would be minimizing noise associated with the blink. Placing foam or some other material on the end of the motor arm would decrease noise, and potentially slow the speed of the blink.

Cost Analysis

SPDT Micromini Toggle Switch	-	$3.99
Calculator Silver-Oxide 1.5 V Battery	-	$4.99
6VDC Micro Super High Speed Motor	-	$3.99
Poly-methyl-methacrylate	-	$2.99
Total		**$15.96**

References

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