Blinking Orbital Prosthesis

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Introduction

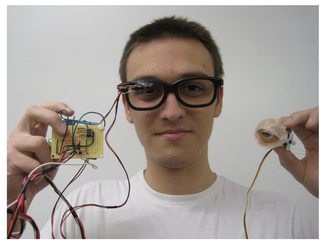
A blinking orbital prosthesis is a specific type of prosthesis of the eye and surrounding tissues that is connected to an apparatus which rapidly opens and closes, mimicking a life-like blink. Current orbital prostheses consist of a custom made, facial reconstruction surrounding a static eyeball-eyelid analogue. The eyepiece itself is often made out of a transparent thermoplastic called polymethyl methacrylate (PMMA) [5] and is encased and surrounded by a biocompatible, silicone based material which works well for imitating facial tissues. Although they have an incredible resemblance to a normal looking eye, current orbital prostheses cannot move. It is this limitation that has led to the need to design a mechanism that emulates the movement of a normal eye. Having an additional blinking feature creates a more natural appearance than current static prostheses. Any possible way to make the replacement eye look and function like the patient's natural eye helps the individual regain confidence, which is a major part of any recovery effort.

Design Requirements

- Performance: The device must operate with minimal noise, vibration, and heat.
- Size: The designed mechanism must be small enough to fit into the eye socket.
- Maintenance: The design should be easy to fix/maintain.
- Accuracy: The design should be able to create a lifelike blink in both speed and appearance while synchronized with the healthy eye.
- Biocompatibility/Safety: The device materials and construction must not be hazardous to the individual.
- Ergonomics: The device must be easy to use.

Previous Work

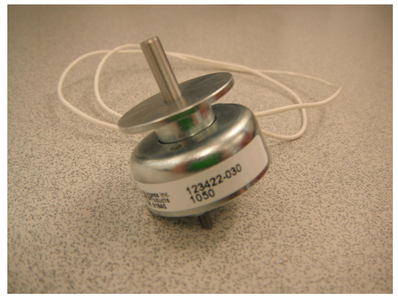
- IR LED/photodiode mounted on glasses
- IR LED emits light onto eye, reflection detected by photodiode
- Eyelid reflects more than open eye, causes increased photodiode voltage
- Op-amp magnifies the photodiode voltage output
- Output signal sent to Arduino
- Detects light levels every 15 ms
- Accommodates changes in the environment

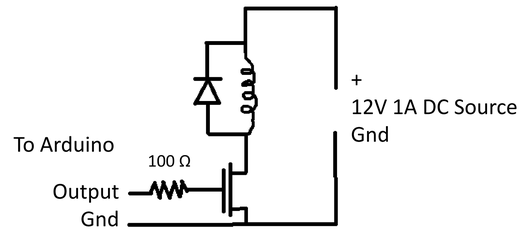


Final Design - Solenoid

LEDEX Push- Pull Solenoid

-Solenoid activated by current, peg extends
-Extended peg releases tension on 'open' line and increases tension on 'close' line
- 'Close' line pulls eyelid shut
-Current to solenoid cut, peg returns
-Returned peg releases tension on 'close' line and increases tension on 'open' line
-'Open' line pulls eyelid open



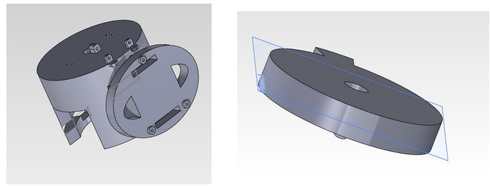


Circuitry

- Utilizes a 45V 3A Mosfet
- Diode prevents backflow of current
- 12 V 1A power supply
- Arduino activates the fet
  - Causes current to flow through the solenoid
- Solenoid rated for 50% duty cycle
  - runs at about 10% duty cycle

Bracket

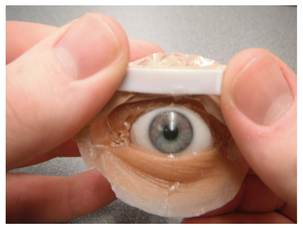
- Provides a mount for the solenoid and the prosthesis
- Allows for the use of gravity to open the eye
- Includes rotary lock to contain the solenoid peg



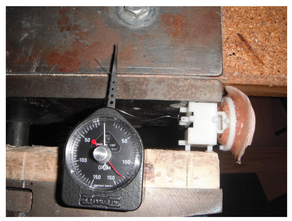
Final Design - Polytetrafluoroethylene (Teflon)

Teflon

- Carbon-Fluorine polymer
- Extremely low coefficient of friction
- Resolves lubrication issue
- Etched sheet adhered via silicone gel



Force Testing



- Without lubricant the force for closing the eye was too large for the scale
- Teflon creates lowest force necessary to open eye
- Teflon force to close eye was higher than with lubricant
  - May be due to the added thickness of the eyelid with Teflon

	Without Lubricant (N=3)	With Lubricant (n=3)	With Teflon (N=10)
Opening	≈1.53 (± 0.04) N	0.23 (± 0.06) N	0.19 (± 0.02) N
Closing	>>1.4710 N	0.5 (± 0.2) N	0.87 (± 0.07) N

Conclusions

- The final design decreases noise and vibration associated with the prototype. This allows the prototype to be used with patients as there is minimal discomfort associated with the sound of the solenoid.
- The final design maintains the speed of the servo motor. As a result, the eye can still blink at a lifelike speed, about 200-300 ms.
- The final design remains easy for the client to replace if necessary.
- The solenoid is fairly cheap, around $50 for one; therefore, the solenoid can be replaced instead of requiring repair.

Future Work

- Detection accuracy
- Separable halves
- Power source
- Wire concealment
- FDA approval

Acknowledgements

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- Professor Thomas Yen
- Professor Mike Morrow

References

A. V. Gregory Gion. *The Medical Art Prosthetics Clinic - Orbital Prosthesis. Available: http://www.medicalartprosthetics.com/content.php?page=prostheses&sec=orbital*

e. a. Eugene P. Goldberg, "Biofunctional Surface Modified Ocular Implants, Surgical Instruments, Medical Devices, Prostheses, Contact Lenses and the Like," US Patent 6387379 B1, May 14, 2002, 2002.

J. G. Justin Cacciatore, Mike Konrath, Blake Marzella, Michael Musser, "Blinking Orbital Prosthesis," 2010.