Blinking Orbital Prosthesis

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Abstract

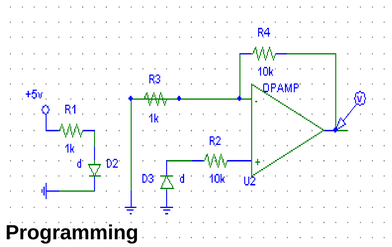
At the Medical Art Prosthetics Clinic in Madison, Greg Gion and his associates make prosthetics for those who have lost their eyes due to an accident, disease, or genetic disorder. Mr. Gion's goal is to help the thousands of people who have an absence of facial tissue by restoring their appearance and giving them greater self-confidence. The problem with the current prosthetics is that they are completely static, which breaks the illusion of realism every time the patient blinks. Previously, we were able to create the mechanism for a blinking prosthesis. Our goal is now to be able to synchronize that mechanism to blink at the same time as a healthy human eye. This will further increase the realism of the prosthesis, helping Mr. Gion to better achieve his goals. Through our research, we were able to find methods of detecting blinking and incorporate them into our design. From this we have device a blinking orbital prosthesis which can be synchronized with a healthy eye using an LED/photodiode system due to its safety and ease of use.

Client Requirements

- The mechanism, excluding the circuitry, must be able to fit inside the eye cavity
- A single solid piece should hold the mechanism
- The motor should be detachable from the prosthetic
- The blink of the prosthesis should be synchronized with the blink of a patient's healthy human eye
- An overall aesthetically appealing appearance
- A budget of $500

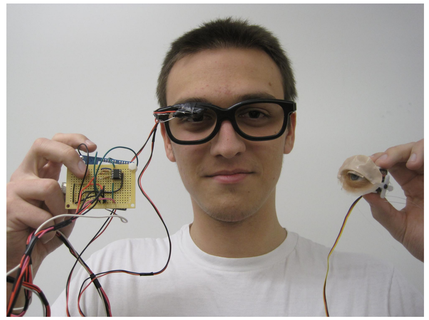
Final Design

Synchronized Blink
- IR LED emitting light on eye
- Reflection detected by Photodiode
- Increased reflection from eyelid during blink
  - Leads to increased voltage in photodiode
- Op-amp increases voltage output of photodiode
- Output signal sent to Arduino
  - Signal sent to servo motor triggering prosthesis to blink

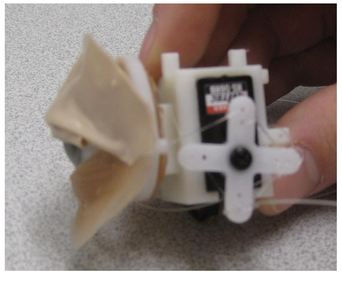


Programming
- Voltage output fed to Arduino, 10 bit A/D
- Running average of 10 input values
  - Measured every 15 ms
- Difference exceeding average by 20 values = Blink
- Accommodates changes in environment

Bracket
- Reduces prosthesis total volume
- Removes structural burden from silicone
- One solid piece allows for constant tension on cords
- Detachable motor box provides for different motor options



Circuitry
- Two independent circuits
- IR LED in series with 5V supply and resistor
- Photodiode/op-amp circuit
  - Gain of +11V
  - Mcp-6002 op-amp
  - Photodiode - source of voltage



Prosthesis Testing

		Actual Eye				
	Head Steady					
		Positive	Negative		Sensitivity	PPV
Prosthesis	Positive	204	73		0.985507246	0.736462
	Negative	3				
	Head Moving Side-to-Side					
		Positive	Negative		Sensitivity	PPV
	Positive	186	54		0.877358491	0.775
	Negative	26				
	Head Moving Up and Down					
		Positive	Negative		Sensitivity	PPV
	Positive	114	233		0.850746269	0.32853
	Negative	20				

- Tested for three outcomes:
  - True Positives (real eye and prosthetic blink)
  - False Positives (prosthetic blinks and real eye does not)
  - False Negative (real eye blinks and prosthetic does not)
- Testing for LED/photodiode positioning
  - 15˚ between the two diodes
  - Attached on bottom of the upper rim of the glasses (angled downwards towards the eye)

Future Work

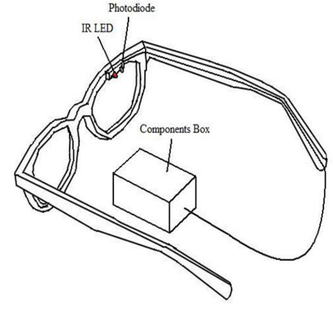
Motor
- Finding a motor that creates less heat, noise and vibrations.

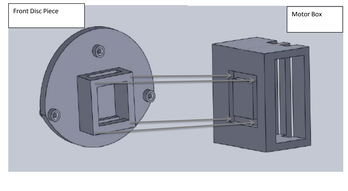
Aesthetic Adjustment
- Design glasses that fully conceal the IR LED, photodiode and wire from the circuit. They must also fix the IR LED and photodiode in the optimum position and angle for blink detection.
- Conceal wire from prosthesis motor to look like skin and hair.

Portable Power Supply
- Power the system with batteries instead of a wall plug.

Additional Size Reduction
- Perfect bracket design to shave off every possible piece of unused material for patients with smaller eye sockets.

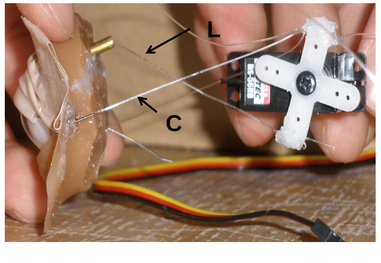
Refine Synchronization System
- Work on improving the positive predictive value of blink detection system.
- Improve synchronization by adjusting prosthesis blink speed/adjust for delay.





Orbital Prosthesis/Previous Work

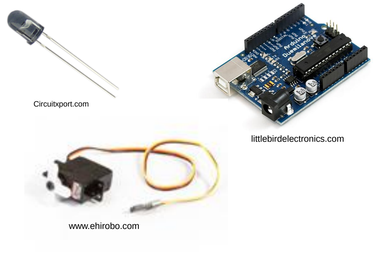
- Feather Hitec HS-56 servo motor controlled by an Arduino microprocessor.
- Two pieces of fishing line to mimic eye muscles.
  - Closing cord (C) – orbicularis oculi muscle
  - Levator cord (L) – levator palpabrae muscle
- Button triggers servo to make one back/forth cycle of 90°.
  - Closing cord tension = lid closes
  - Levator cord tension = lid opens



Cost Analysis

Item:	Cost:
Arduino USB Board	$29.95
ICB88 PC Board	$1.99
IR LED/Photodiode Pair	$3.49
HS-56HB Servo Motor	$30.94
Fishing Line	$2.84
Detector Plug	$3.29
Glasses	$5.00

Total Cost: $77.50



References/Acknowledgements

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