May-1414

Kinetic Sculpture - The Butterfly Wall

Team Members

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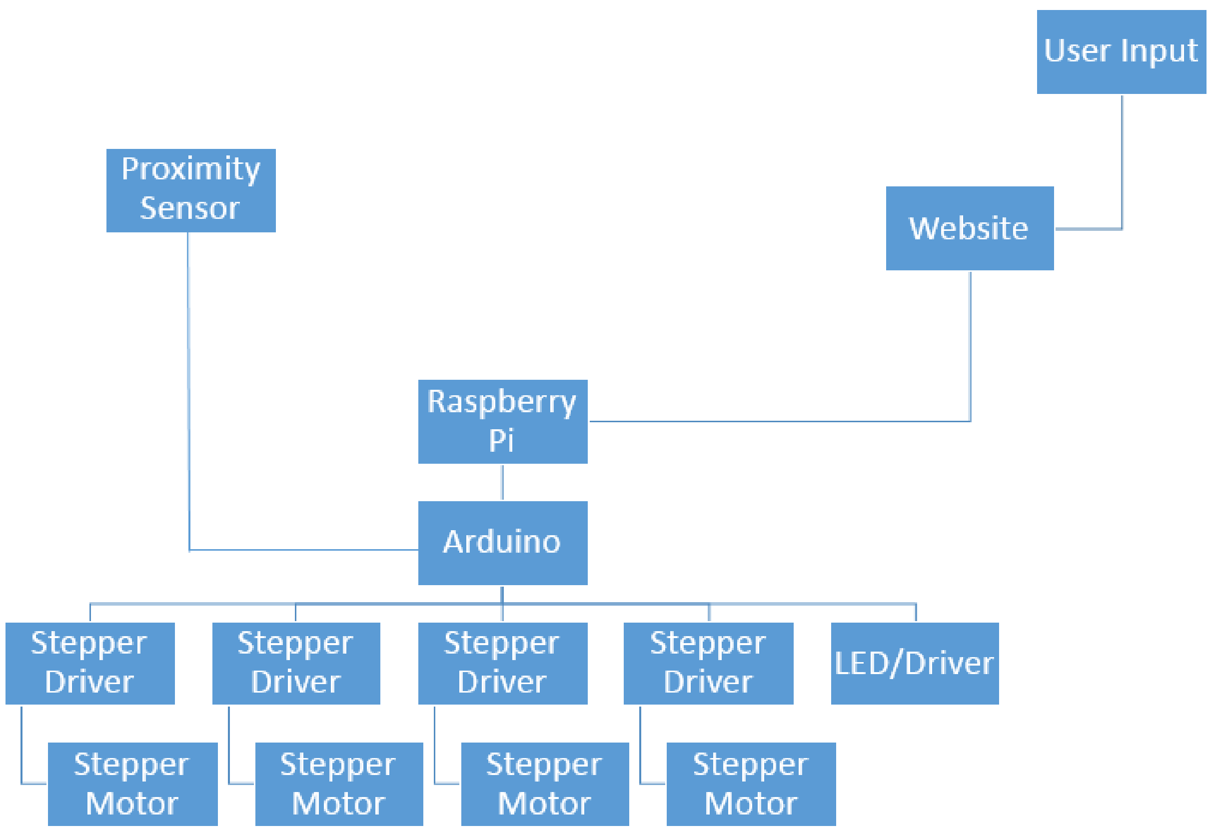
Contents

Description

Inside the San Francisco International Airport is an interactive piece of artwork known as *The Butterfly Wall*. It allows users to control the motion of mechanical butterflies using hand cranks located on the outside of the display. For this project, we will be designing a web interface and an electrical control system for a smaller version of *The Butterfly Wall,* to be displayed in Coover Hall upon completion. Our finished design will allow users to control the motion of the mechanical butterflies by opening a mobile website, which we will design. We will also design a system to process the user supplied input, and control a series of stepper motors and LEDs based on that input. Our final design will accommodate four mechanical butterflies, which will each have its own LED grid.

System Block Diagram



The website will contain the user interface and will be responsible for telling the Raspberry Pi what signals to send to the Arduino. The user interface will have some simple, intuitive action for the user to perform which will trigger the butterflies to act. The Raspberry Pi will send a stream of bits via a USB serial port which will encode the user interaction from the website. There will be one Arduino to handle all of the processing of the user input. It will interpret the signals from the Raspberry Pi and translate them to appropriate signals to send to the stepper motor drivers. Each stepper driver will then drive its own stepper motor. The same Arduino will also handle the control of the LEDs by changing the color and intensities of the LEDs. The Arduino will also receive input signals from eight different proximity sensors that will detect whether one of the butterflies approaches too closely to the top or bottom of the enclosure. If one of the proximity sensors is tripped, the Arduino will stop the acceleration of the stepper motor for that particular butterfly.

Deliverables

December 2013

In December of 2013, we will have finished our design work and assembled one complete butterfly prototype. We will also deliver a fully integrated communications network that will allow us to completely test one-fourth of the final project. We will also develop a presentation to provide an update on our progress and designs.

May 2014

In May of 2014, we will complete our project. We will make any necessary amendments to the design from December, we will assemble four implementations of it, and we will integrate the communications network. We will also build a display enclosure to house our finished product.

Operating Environment

The operating environment of the sculpture will be very stable. We plan on having the sculpture be indoors at all times. So the temperature should always be around room temperature. Therefore we will not have to consider how the sculpture will operate in adverse conditions such as those found if the sculpture was being placed outdoors.

Risks

There may be some risks that we may have to deal with with when working on this project. These risks could include problems with the website and the hardware. These problems could be related to the security of the site. Another way we may encounter risks while working with this project is with the availability of the parts that we require in order to assemble the electric components. We may have risks regarding the butterflies themselves. We will have to make sure that the butterflies do not collide with the top or bottom of the sculpture and fall off their lines.

Requirements

System Requirement Specifications (SyRS)

List of high level system requirements.

1. Smart phone control
    a. Butterfly shall react to user input via a mobile website accessible by smartphone
2. System timeout
    a. If a preset idle timer expires, the butterfly and LED's shall act according to a preset routine
3. LED display
    a. Twenty-four LEDs per butterfly shall create a light display that corresponds but is not directly controlled by the user input
4. Butterfly
    a. The butterfly shall be suspended on a wire
    b. The wire shall allow movement of the butterfly
5. Collision avoidance
    a. The butterfly shall not be able to collide with the top or bottom of the enclosure
    b. The butterfly shall not collide with any other butterflies in the enclosure

Functional Requirement Specifications (FRS)

List of technical requirements.

1. Mobile access
    a. To satisfy SyRS-1, a mobile user interface shall be available
    b. The mobile interface shall be accessible by up to 4 simultaneous users
    c. The mobile interface shall be cross-platform and accessible by most smartphones
2. Controller
    a. To satisfy SyRS-1, a controller shall be used to process input from the mobile interface
    b. To satisfy SyRS-2, the controller shall provide a predetermined input in the case of an idle timeout
    c. To satisfy SyRS-3, the controller shall have pulse-width modulation capability
3. Butterfly movement
    a. To satisfy SyRS-4, a motor shall spin a loop of wire, moving the butterfly up or down, in accordance with the user input
    b. The wire shall be seamless to ensure the wire does not get tangled in the pulleys
    c. To satisfy SyRS-5b, the stepper motors shall be separated by enough space to eliminate the possibility for butterfly collisions
4. Proximity sensor

a. To satisfy SyRS-5a, a proximity sensor at the top and bottom of the enclosure will alert the controller of an impending collision so that the microcontroller can modify the butterfly's motion to avert the collision

Non-Functional Requirement Specifications (NFRS)

List of miscellaneous requirements.

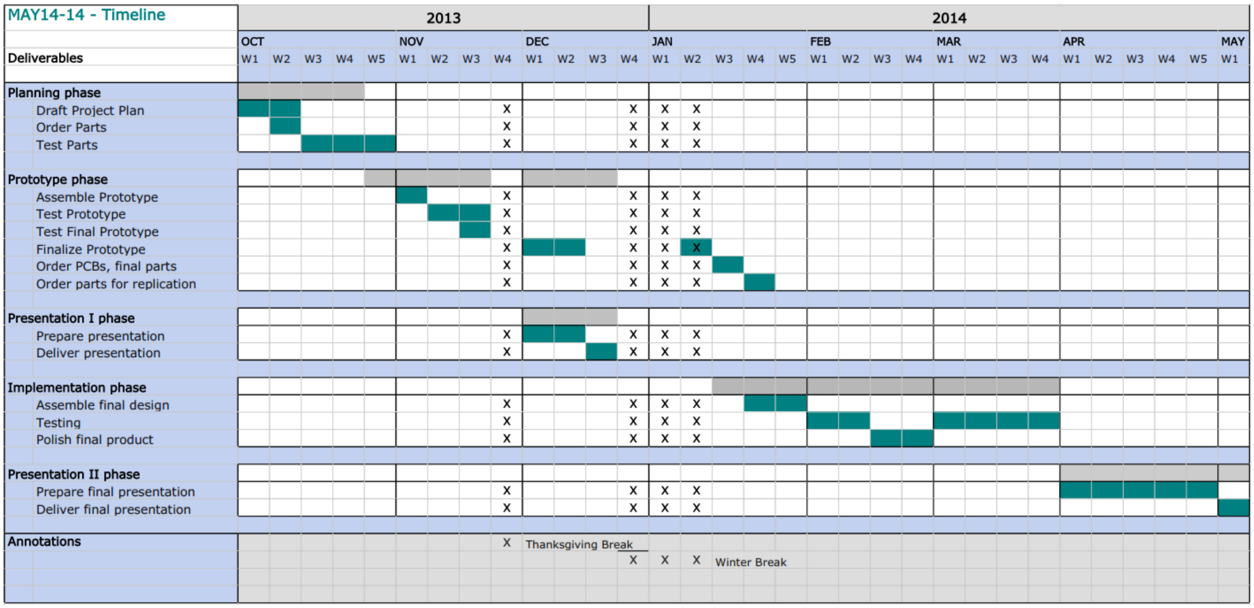
1. Enclosure
    a. Enclosure shall be 8ft long by 1ft wide by 8ft high
    b. Enclosure shall be of clear plexiglass
    c. Plexiglass shall be joined with aluminum extrusions
    d. A QR code shall be on the exterior of the enclosure to take users to the mobile interface
    e. Enclosure shall have a void for a power cable to enter the system
    f. All components shall be inside the enclosure and secured in a manner which will allow the enclosure to be moved easily
2. Butterfly
    a. Butterfly shall be clear plexiglass
    b. Butterfly wings shall flap to emulate flying at a rate proportional to the vertical movement
3. Aesthetics
    a. The hardware required to implement the System Level Requirements shall be exposed in the final design
    b. The hardware shall be installed in a neat, professional, and aesthetically pleasing manner

Work Distribution

Work is distributed in a way that allows for maximum efficiency within the group based on each group member's individual skills and past experience. Each group member will have a specialized responsibility, but will also assist as necessary with any other portion of the project. The user interface of the project is the mobile website which is handled by Matt. The website will indirectly communicate with the stepper motor controllers, which are handled by Azmir who also be leading the mechanical design of the butterfly. The control of the stepper motors will require several different components which will be integrated together in custom PCB's which will be designed by Josh. In addition to the butterflies, there will be rings of RGB LED lights near the top of each butterfly which will provide some reaction to the motion of the butterfly, and will be handled by Craig.

- Crag
    - LED ring construction
    - Communication between arduino and Led driver
    - Enclosure assembly
- Josh
    - PCB Layout
    - Communication between proximity sensor and arduino
    - Enclosure assembly
- Matt
    - Mobile Website / User Interface
    - Communication between user interface and Arduino
    - Group Webpage
- Azmir
    - Stepper Driver
    - Communication between arduino and stepper driver
    - Design of butterfly

Timeline



Cost Estimation

Part Number	Name	Unit Price	Quantity	Total
ROB-10267	Easy Driver	$14.95	4	$59.80
SEN-00242	Infrared Proximity Sensor	$13.95	8	$111.60
ROB-10847	NEMA 23 Stepper Motor	$23.95	4	$95.80
	AC/DC Converter 12V	$15.50	1	$15.50
DEV-11021	Arduino	$29.95	1	$29.95
EW-7811Un	150Mbps Nano Size Wireless USB Adaptor	$9.99	1	$9.99
COM-11821	LED-RGB with driver	$.45	96	$43.20

DEV-11546	Raspberry Pi	$39.95	1	$39.95
47-25x48 Notched	Plexiglass 25x48	$50.00	2	$100.00
47-25x48	Plexiglass 25x48	$50.00	2	$100.00
8020-1517x96	Extrusion 96	$10.00	4	$40.00
8020-1517x47_25	Extrusion 47_25	$12.50	2	$25.00
8020-4441	Rounded tri-corner	$5.00	4	$20.00
8020-2141 3x3 15S	Baseplate	$4.00	4	$16.00
8020-2189	Econ Furniture Glide	$1.50	4	$6.00
8020-1517x11_25	Extrusion 11_25	$5.00	2	$10.00
8020-1503x47_25	Extrusion 47_25	$5.00	4	$20.00
8020-1503x11_25	Extrusion 1503	$5.00	2	$10.00
95_25x12 Notched	Plexiglass 25x12	$50.00	1	$50.00
89_25x12 Notched	Plexiglass 25x12	$50.00	1	$50.00
12x6x0_25 (¼”)	Aluminum Panel	$20.00	1	$20.00
48x12 Notched	Plexiglass 48x12	$50.00	1	$50.00
A-6M-9-00804	Butterfly Pulley .5 inch	$2.62	4	$10.48
A-6Z-9-00804	Butterfly Pulley .5 inch with ball bearing	$8.30	8	$66.40
A-7Y55-F3112M	Ball Bearing with .125in bore	$7.66	8	$61.28
A-6M-9-06412	Motor Pulley .5 inch	$10.81	4	$43.24
N/A	PowerPro Hollow Ace - 40lb - 100yd Fishing Line	$20.39	1	$20.39
Total				$1124.58

Resources

Part Description

Raspberry Pi

This platform was chosen to host the web server because of its size, cost, portability, and power. The Raspberry Pi model B boasts 512MB SDRAM, 2 USB 2.0 ports, 700 MHz ARM1176JZF-S core processor, and an onboard 10/100 ethernet adapter. The Raspberry Pi is able to offer all of these features, capable of running a web server, at a cost of only $35.

Arduino Uno Microcontroller

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins(6 of which can be used as PWM outputs), 6 analog inputs, and a 16 Mhz ceramic resonator. The image below shows the schematic for the Arduino Uno Microcontroller.

Stepper motor driver (easy driver)

The EasyDriver is a stepper motor driver that is compatible with anything that can output a digital 0 to 5V pulse. It requires a 7-30V DC power supply to power the motor and has an on board voltage regulator for the digital interface which can be set to 5V or 3.3V. Features include: a A3967 microstepping driver, MS1 and MS2 pins enable adjusting of microstepping resolution, compatible with 4, 6 , and 8 wire stepper motors, adjustable current control from 150mA/phase to 750mA/phase. The image below shows the schematic for the driver.

LED part number WS2812

This is a breakout board for the WS2812 RGB LED. Several of these breakout boards can be chained together in series to form a display or an addressable string.

Market Research

Because this is a non-commercial project, we were limited in the amount of market research we could do. However, there are some resources that we were able to draw on for this project. The first thing we did was contact the artist who designed the original Butterfly Wall for the San Francisco International Airport. Since he has already completed a working version of the project, we hoped he would be able to give us some part recommendations. Unfortunately, after an initial positive response, we have not heard anything back from him. We also researched using microcontrollers to control stepper motors. We found various Youtube videos that convinced us the Arduino system would be the most robust solution. We also investigated other projects, both here at ISU and on Youtube, that created an LED light display. Originally, we were going to use an LED driver that was used in a previous senior design project at ISU. Ultimately, we decided to scrap that idea because we found LEDs with an addressable microprocessor built in. We will continue attempting to contact the original artist in the hope that he can help us avoid any problems that he had while designing the original Butterfly Wall.

Contact

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