**EGR 302 – Engineering Design and Documentation**

**Deliverable 4: Concept Generation And Selection**

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4.1 Concept Generation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Features |  |  |  |  |
|  | option 1 | option 2 | Option 3 | Option 4 |
| sensors | Infrared | Optic Encoder | potentiometer |  |
| LEDs | 5mm | 8mm | 10mm |  |
| Motor Type | DC |  | AC |  |
| Motor | Brushed | Brushless | Synchronous | Induction(squirrel cage) |
| direction of spin | vertical axis | horizontal axis |  |  |
| microcontroller | arduino | PSoC | PiC |  |
| materials | wood | plastic | aluminum | steel |
| Power systems | 9V battery | AA battery | AAA battery |  |

Table 4.1

**Sensors**

Infrared Sensor:

The infrared sensor uses infrared light to time a measure the speed of the rotation. The infrared sensor is also cheap and simple to use. The infrared sensor sends a signal to the microcontroller each time the wand makes 1 revolution. This information can be used with the speed to determine the location and allow the lights to go on at the proper time.

Optic Encoder:

The optic encoder knows the angle at any point in the rotation as opposed to once every revolution. The optical encoder will actually give us the angle that the wand is at, rather than just reporting a revolution has completed. It does this by sending light through cut out sections of a wheel, with each angle having a different cut out. These different light signatures are recorded and translated back into a number that tells the microcontroller what angle it is currrently at. This is nice because then the speed can be unknown and does not need to necessarily be a specific value. The optical encoder however is significantly more expensive and more complicated to implement and combine into our project.

Potentiometer:

The potentiometer can also do what the optic encoder does, but it does it in a very different way. The potentiometer is a variable resistor that changes resistance as it spins. This one is also cheap like the infrared sensor, and would give us an analog output that would be able to be calculated into an angle. However the potentiometer is complicated to implement because we would have to calculate what values corresponded to what angles. We also would need to figure out a way to keep the potentiometer from “maxing.” The potentiometer, after spinning a few times, would have a tendency to stay at the same max value when rotated in the same direction multiple times. This would be a complicated process.

**LEDs**

RGB LEDs:

standard RGB LEDs seem like the optimal choice at first glance. They are cheap, easily manageable and durable. The RGB LEDs can easily be purchased in large numbers and wired to the microcontroller.

SMD LEDs:

SMD LEDs are small but they don’t produce very much light. They also are too small for our purposes. To cover the area we need they would need to be in large numbers, which is expensive.

Triple out high power LEDs:

Triple out high power LEDs are the brightness we are looking for. They are incredibly bright, but also very expensive. They also require a lot of power and are not practical for our project.

Piranha Super-Flux LEDs:

These LEDs are a better, cheaper, brighter version than the RGB LEDs, which are larger than the SMD LEDs, and cheaper than the Triple out high power LEDs.

**Motor**

Brushed Motor:

The brushed motor is a DC motor that is cheap but gets the job done. It performs the task at hand without all the bells and whistles. This motor is also incredibly reliable however It also generates electromagnetic interference that needs to be dealt with.

Below is a table comparing all the motors against one another.

Brushless Motor:

* This motor would be useful because it is low maintenance, has a high efficiency, and is more effective than brushed motor at heat control, noise, and speed or torque. However this prospective concept’s downfall is the expensive control system cost.

|  |  |  |
| --- | --- | --- |
| Pros/Cons | Brushless DC | Brushed DC |
| Maintenance | Low | High |
| Speed/Torque | All speeds | Low-Med speeds |
| Efficiency | High (85-90%) | Low (75-80%) |
| Output | High | Variable |
| Size | Large range of sizes (sm-lg) | Large range of sizes (sm-lg) |
| Noise | Low | High |
| Heat Dissipation | High | Poor |
| Control | Complex & expensive | Simple & Inexpensive |
| Environment needed | Clean | Doesn’t matter (extreme) |
| Life Span | Long | Short |
| Cost | High | Low |
| Other | Needs controller (doubles price) | Creates EMI/no controller |

Table 4.2

|  |  |  |
| --- | --- | --- |
| Pros/Cons | Synchronous | Induction (squirrel cage) |
| Torque | High | Less than synchronous |
| Speed | Constant | Variable |
| Control | Required | Not Required |
| Cost | High | Low |
| Self-starting | No | Yes |
| Efficiency | High | Less than synchronous |
| Maintenance | Low | No maintenance |
| Life span | 10,000 hours (416 days’ worth) – 3 years | Avg: 15 Years |

Table 4.3

From these tables it is evident that induction motors aren’t viable because they are variable speed and have less torque than synchronous. Synchronous would be good because it has high torque and high efficiency, but it is expensive and also has a problem with the fact that it doesn’t self start.

**Microcontroller**

Arduino:

The Arduino is an open source microcontroller. What that means is that hobbyists and designers are free to use the source code as they choose without worrying about copyright. This means that the arduino is a cheap and easy to use solution as a controller for our LED wand. The arduino requires an input voltage of 7-12V but the actual wattage it requires is rather low and will not be a large draw on our system. It has 14 Digital I/O Pins (6 PWM outputs), 6 Analog Inputs, 32k Flash Memory and 16MHz Clock Speed. Basically the Arduino is very useful when just building one item or during the beginning of a design to test the product out in a cheap and efficient way.

PIC:

The PIC (or Peripheral Interface Controller) is a micocontroller that is not open source like the arduino, but it is still easy to use and implement. PIC microcontrollers have many different configurations, are very customizable and vary in prices. PIC microcontrollers are cheaper but it costs more to start them off. A programmer and a debugger are required to code and use the controller. A kit with a microcontroller included will cost around $60 but after the initial costs of the program and debug software they drop substantially in price. A big difference between the two is that the PIC can be just a chip while the Arduino is an entire platform.

PSoC:

PSoC microcontrollers are very similar to the Arduino when comparing them to the PIC controller. The PSoC is has more capabilities but also is not as easy to use or have as many easy plug and use products, like the Arduino Bluetooth or wireless Shield.

**Axis of rotation**

X-axis:

* The X-axis spin is a viable option because it rotates around the X axis and presents a flat surface to display the image. The image will be circular and be consistent. However it does have a few problems. The resolution on the outside will be better than the center. Also the image coordinates will have to be converted to polar which is slightly more work than Y-axis rotation. The image also is not as visible because it is limited to only two directions.

Y-axis:

* Rotation around the Y-axis is also a viable option because it presents an image across 360 degrees. It doesn’t require conversion from polar to square and is much easier to code for. The resolution is also consistent on all parts of the image. This image can also be visible from any direction.

**Materials**

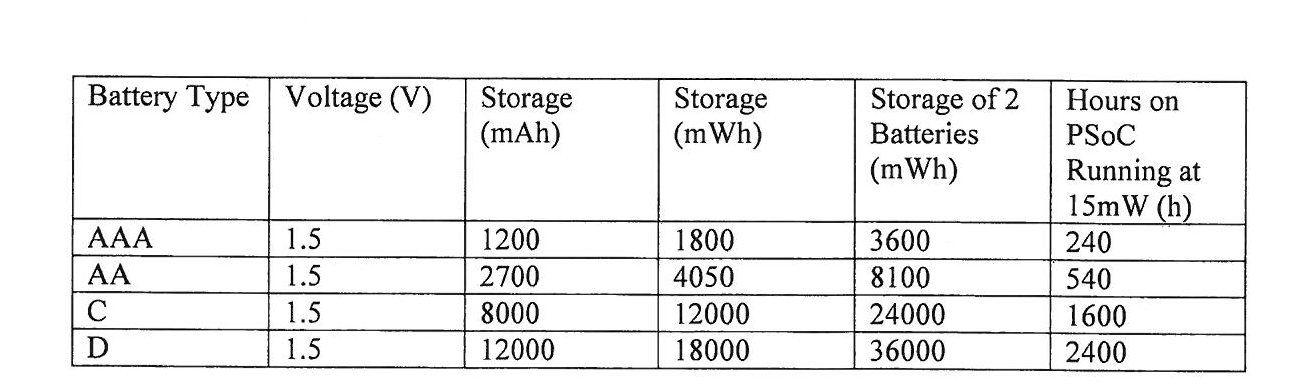
We researched a large number of materials for the structure and settled on a few key choices. The two that looked the most viable were plastic and aluminum. Those two were lightweight, inexpensive, and strong. The structural material had a few requirements. The structure needs to be light, inflexible, and cheap. The lighter the material the less torque the motor requires. The material also needed to be inflexible enough to withstand the torque.

Aluminum is sleek, sturdy and inexpensive. Aluminum can create a sturdy structure cheaply. Aluminum’s only real issue is the fact that if not properly dealt with the edges can be sharp. It also could be difficult to put pieces together.

Plastic is similar to aluminum but is a bit less sturdy. Plastic is easier to mold and use but less durable.

**Power supplies**

The table below shows the battery power each type of battery has.

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**Table 4.3(B)** Battery power

4.2 Concept Selection

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Concept Selection** |  |  |  |  |
|  | Concept A | Concept B | Concept C | Concept D |
| criteria |  |  |  |  |
| cost(.3) | 0 | 0 | + | 0 |
| weight(.1) | 0 | 0 | 0 | 0 |
| design simplicity(.3) | 0 | 0 | + | + |
| safety(.1) | 0 | - | 0 | - |
| visibility(.2) | 0 | - | 0 | - |
| Sum | 0 | -2 | 2 | -1 |

In the concept selection process we realized that there were so many different ways to combine the different portions of the project that we could never create a biased system. It seems more efficient to compare one concept of each bracket, and then seeing if there are any to mix and match. We measured each concept with a similar scale of cost, portability, design simplicity, safety, and visibility. With the exception of design simplicity, these four things were defined by the client to be important. They are the main 4 objectives from our objectives tree. We felt design simplicity was important because we feel that a simple project is better than a complicated one.

It is important to point out that the criteria are weighted differently for each portion of the project because some things are more important than others, for example the motor is not related to visibility in a very real sense and therefore that can be scaled down.

**4.2.1 Sensors**

The first concept on the chart was sensors. The three sensors are compared in the table below (Table 4.4).

|  |  |  |  |
| --- | --- | --- | --- |
| **Sensor**  **Selection** |  |  |  |
|  | **Infrared Sensor** | Optic Encoder | Potentiometer |
| criteria |  |  |  |
| cost (30%) | .5 | -4.0 | -1.0 |
| weight (10%) | 0 | 0 | 0 |
| design simplicity (30%) | 2 | 2 | 0 |
| safety (10%) | 0 | 0 | 0 |
| visibility (20%) | 0 | 0 | 0 |
| Sum | 0.75 | -0.6 | -.3 |

Table 4.4 selecting the sensor

The table selected the infrared sensor because it has the advantages of cost effectiveness and design simplicity. These two categories are very important to our group and in this case the infrared sensor fulfills those. The optic encoder is too expensive to use, and the potentiometer is

too complex. The Infrared was also our choice just considering everything, and it makes sense to us. Neither of the other options held up and could be viable options.

**4.2.2 LEDs**

After choosing the infrared sensors, we looked into LEDs. The selection matrix is shown below in Table 4.5.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **LED**  **Selection** |  |  |  |  |
|  | RGB LED | SMD LEDs | Triple out high power LEDs | **Piranha Super-Flux LEDs** |
| criteria |  |  |  |  |
| cost (30%) | 1 | 0 | -2 | .5 |
| weight (0%) | 0 | 0 | 0 | 0 |
| design simplicity (30%) | 2 | -1 | 1 | 2 |
| safety (0%) | 0 | 0 | 0 | 0 |
| visibility (40%) | 1 | -1 | 3 | 2 |
| Sum | 1.3 | -0.7 | 0.9 | 1.85 |

Table 4.5 scoring matrix for LEDs

This scoring matrix also fell in line with our own opinions about the LED to choose. We agree that Piranha Super-Flux LEDs are the best choice for LEDs. They are only slightly more expensive than RGB LEDs while being incredibly bright and also easy to use. The SMD LEDs got a lower score in design simplicity because they are smaller and require greater numbers to implement. If we were to choose a runner up to consider we would undoubtably look to RGB LEDs however there is not a significant difference in the implementation step between the two so creating a rival concept using RGB would be incredibly similar.

**4.2.3 Motors**

The decision for the motor we chose is shown below in Table 4.6.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Motor**  **Selection** |  |  |  |  |
|  | Brushless (DC) | **Brushed (DC)** | Induction (AC) | Synchronous (AC) |
| criteria |  |  |  |  |
| cost (30%) | -2 | 2 | -2 | -1 |
| weight (15%) | 1 | 0 | 2 | 1 |
| design simplicity (25%) | 1 | 1 | -1 | -2 |
| safety (20%) | 0 | -1 | 0 | 0 |
| visibility (10%) | 1 | 1 | 1 | 1 |
| Sum | -.1 | .75 | -.45 | -.55 |

Table 4.6 motor selection

The Brush motor was chosen because it is the cheapest and most efficient motor of the group. It also is a DC motor which helped considerably. DC motors are considerably easier to implement in design with the power sources we had in mind (DC) and were better suited for this task of rotating at a consistent pace.

**4.2.4 Axis Rotation**

The rotation axis and the essential structure is one of the essential things we needed to evaluate. The table is shown below.

|  |  |  |
| --- | --- | --- |
| **Axis**  **Selection** |  |  |
|  | X-Axis | **Y-Axis** |
| criteria |  |  |
| cost (0%) | 0 | 0 |
| weight (0%) | 0 | 0 |
| design simplicity (45%) | -1 | 1 |
| safety (20%) | 1 | -1 |
| visibility (35%) | .5 | 2 |
| Sum | -.075 | .95 |

Table 4.7 Axis of Rotation

The Axis of rotation is determined to be the Y axis for a number of reasons. One of the primary ones is that the client actually recommended it, but also as shown by the chart it is the best choice for our project. It creates a simpler, more visible product.

**4.2.5 Microcontroller**

The microcontroller table is shown below

|  |  |  |  |
| --- | --- | --- | --- |
| **Microcontroller Selection** |  |  |  |
|  | **Arduino** | PSoC | PIC |
| criteria |  |  |  |
| cost (30%) | 1 | 2 | 1.5 |
| weight (10%) | 0 | 0 | 0 |
| design simplicity (30%) | 5 | 1 | 2 |
| safety (10%) | 0 | 0 | 0 |
| visibility (20%) | 0 | 0 | 0 |
| Sum | 1.8 | 0.9 | 0.7 |

Table 4.8 Microcontroller Selection

This decision for microcontrollers is an extremely easy one. The arduino microcontroller is much easier to use than the other ones. It has a lot of different capabilities and also can be combined with a large number of different options that allow it to be simply and easily configured.

**4.2.6 Materials**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Pros/Cons | Aluminum | Steel | **Plastic** | Wood |
| Weight (30%) | Light (1) | Med – Heavy (3) | Light (1) | Light – Med (2) |
| Cost (30%) | Inexpensive (1) | Moderately expensive (-1) | Inexpensive (1) | Inexpensive (1) |
| Maintenance (0%) | Low | Med – high | Low-Med | High |
| Life Span (0%) | Indefinite and reusable | Depends on weather | - Forever It is not biodegradable  - Unless due to Polymer degradation (weather) | Depends on environment |
| Safety Concerns (10%) | Medium (can have sharp edges if not properly cared for) (1) | Blunt object when spun (0) | It shatters if hit with a car  No other concerns (0) | Can catch fire (0) |
| Strength(20%) | Strong (2) | Very Strong (3) | Strong (2) | Med - Strong (1) |
| Other(10%) | - Requires special welding  - Corrosion - resistant  - Nonmagnetic  - Environmentally friendly (0) | - will rust (0) | - Easily shaped (2) | - Termites  - breakable  - comes in many varieties (0) |
| Sum | 1.1 | 1.2 | 1.2 | 1.1 |

Table 4.9 Material selection

All of these materials came very close in the selection matrix. We had discussed and decided to go with either aluminum or plastic depending on price of each one.

**4.2.7 Power supplies**

The table below shows the power selection matrix.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Battery**  **Selection** |  |  |  |  |
|  | **AAA** | AA | C | D |
| criteria |  |  |  |  |
| cost (40%) | 2 | 1 | 0 | -1 |
| weight (5%) | 0 | 1 | 2 | 2 |
| design simplicity (25%) | 1 | 1 | 1 | 1 |
| safety (20%) | 0 | 0 | 0 | 0 |
| visibility (10%) | 1 | 1 | 1 | 1 |
| Sum | 1.25 | .80 | .45 | .85 |

Table 4.10 power selection

The scoring matrix says we should use the AAA batteries to power our device. We’re not certain that this is such a good idea simply because we may need quite a lot of them to match the power requirements, to keep it going for long periods of time. However it would be nice to have batteries that the consumer could replace easily.