HEX*FIRE:*

Adjustable Machine Vision Lighting

Project Proposal and Feasibility Study

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Engineering 339

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Appendices

1. Problem Statement

This project is to be completed in conjunction with Opsci Incorporated. The purpose is to design and build a prototype lighting system to be used with a machine vision camera. Machine vision has many diverse applications each having a variety of lighting needs. Several lighting scenarios may be necessary for gathering different information about a single part. For example, uniform lighting can reveal the overall shape of a part, while directional lighting from one side can reveal a specific edge. There are a wide variety of lighting devices available today. They are designed to provide for many lighting needs. However, most current systems focus on meeting only one specific lighting need. HEXFIRE will be a versatile lighting system capable of adjusting to meet a wide variety of lighting needs. Quick adjustments will allow for variation in the angle, direction, and intensity of the light. HEXFIRE is to have six LED panels that are independently adjustable to provide a variety of lighting angles. Each panel will have independent controls used to vary the direction and intensity of the light. HEXFIRE will be a multipurpose lighting device with many applications in the machine vision industry. The design will be intended for small scale production. The prototype will be provided with a carrying case.

2. Project Objectives

The objective of the project is to create a lighting system that has the ability to adapt to changing lighting requirements when used in conjunction with a machine vision system. This system should provide a “hemisphere” of light to be useful in this application. The angle of light provided should be adjustable to a repeatable set of increments. The product should be durable and user-friendly.

2.1 Requirements

There are several production requirements placed on the HEXFIRE design. One requirement of the final product is that it must be appropriate for manufacturing. Opsci intends to produce small amounts of the device. Approximately fifteen to twenty HEXFIREs may be produced at one time. The completed device is to cost less than $500 to manufacture, including all electrical and mechanical components. Standard manufacturing tolerances will be used. The camera will mount to the HEXFIRE with a ¼-20 screw.

There are also several requirements for the finished HEXFIRE product. The device should not be unnecessarily heavy. The weight of the device should be minimized to avoid unnecessarily complicated mounting requirements. The overall size of the device should not be significantly greater than comparable devices that are currently available. It must not be too large for convenient use with machine vision systems. The device must be adjustable. Each of the six petals must adjust separately into one of four to six preset positions. The device must be useable with a variety of cameras. The finished product must be aesthetically pleasing. The design must effectively integrate the electronics, hiding them when necessary. The completed prototype should have cool and appealing yet professional appearance.

Finally, several requirements relate to the system use. HEXFIRE must be durable, having the ability to withstand a two foot drop test. Serviceability is a requirement. Each of the petals should be removable for storage, transportation, replacement or service. Each LED array needs to be removable from the petal for service or replacement. The prototype should be provided with an economical and durable portable storage case.

3. Alternative Solutions

HEXFIRE was divided into several categories, and several alternative solutions were formed for each category.

3.1 Petals

Options of four, six, or eight petals were considered. Several possibilities for petal shapes were discussed including a trapezoid, pie slice, pentagon, cut-off point pie slice, a triangle, or a rectangle. A variety of petal angles were considered as well as a variety of lighting angles to be implemented. The advantages and disadvantages of LEDs versus traditional bulbs and other light sources were considered. The possibility of generating indirect or direct lighting was also taken into account. The use of a reflective background was also considered along with the possibility of including a provision for mounting a diffusion plate.

3.2 Locking mechanisms

Many different options for a locking mechanism were considered. There were two categories of mechanisms: those that would require a separate hinge, and those with an integrated hinge. A spring loaded mechanism was one option. Others included Velcro, friction or snaps. The use of gravity to maintain locked positions was considered. Several ratcheting mechanisms were evaluated. The use of a clutch type device, a locking hinge, or the integration of gears was also mentioned.

3.3 Hinges

Several options for the hinges joining the petals to the collar were considered. A piano type hinge and a ball joint hinge were mentioned. It was noted that it would be desirable to have a hinge with a removable pin. The option to incorporate the hinge into the locking mechanism was discussed. The possibility of accomplishing a hinging action with the use of gears was raised.

3.4 Mounting to camera

The original idea was to use a ¼-20 screw to attach the camera to the HEXFIRE device. Other devices that could be considered include a clamp, a collar with set-screws.

3.5 Alternate Solutions Already on the Market

There are many available units on the market with non-adjustable illumination angles. Most units on market have no direct way of mounting the illumination system to camera.

4. Feasibility Study

4.1 Preliminary Evaluation of Feasibility

The analysis performed to date lead to the conclusion that the project is feasible. There are no tasks on the preliminary task list that stand out as beyond the limitations of the team. Most of the components are simple machined parts or commercially available, common items. The preliminary budget shows that the project can be kept within $500 budget provided by Opsci Inc. The major tasks necessary to complete the project include housing design, hinging/locking mechanism design, and the integration of the electronics.

The housing will be designed with sheet and machined aluminum in mind. Other options will be investigated, but aluminum is usually light weight, cheap, machineable and durable.

Design of the hinging and locking mechanism will require testing various options to determine the most effective way to vary the lighting. Hinges will either be purchased or designed.

Integration of the electronics will require incorporating control and LED circuit panels. Considerations will be made for the connections required by the electronics. Careful attention will be paid to concealing the electronics and wiring. A power source for the device will also be considered along with connectors.

4.2 Current Developments in feasibility

The hinging and locking mechanism has been investigated. The option of incorporating the hinge and lock in one mechanism was also considered. The preliminary design includes several options for hinging and locking. Three mechanisms have been selected for further modeling and testing. The testing should affirm feasibility while highlighting any modifications necessary. The three mechanisms selected are within the projected price range and are economically feasible.

The uniformity of the light emitted by the LED arrays has become a feasibility concern. The uniformity requirements are being researched. Research is also currently being done into the specifications of LEDs being used. The option of installing a diffuser panel to create uniform light is being investigated. Feasibility obstacles presented by uniformity of light should be possible to overcome without any problematic expenses. Through discussions with the Opsci representative it was found that uniform light is not always desirable. Directional lighting can be useful when attempting to highlight an edge or angle of a part.

5. Task Specifications

5.1 Research – with the goal of developing a knowledge base to work from.

- Research existing Camera lighting systems.
- Research available LED lighting.
- Research machine vision cameras.
    - Select focus applications
    - Determine lighting requirements.
- Research petal adjustment options.
- Research petal locking methods.
- Research prices for budget.

5.2 Design Components

- Petal – Houses the PCB containing the LEDs which is attached to the collar through the hinge/locking mechanism.
    - Design – Determine the shape of the petal with the angles required along with creating as little dead space as possible.
    - Provide petal shape to Opsci for PCB production.
    - Material selection – Choose a material that is cheap, but will also be strong enough to hold everything together without breaking.
        - Machined block aluminum – Entire petal machined from a block of aluminum.
        - Molded plastic will also be considered. i.e. ABS
        - Sheet aluminum – Set thickness determined and cut to appropriate dimensions.
        - Sheet metal – Set thickness determined and cut to appropriate dimensions.
        - Finish – The external appearance to look appealing to the customer.

    - Produce – Once the material is determined and available and the design is set, take it to the machine shop and fabricate a prototype.
    - PCB spacer – Something to keep PCB in the machined petal without moving.
        - Machined into petal.
        - Purchased – Double sided tape, rubber stick-on.
        - Design and mold – The PCB can snap into the petal through a designed plastic mold.
            - Epoxy
            - Polyurethane
- Provision for mounting diffusion plate – In the event that a diffusion plate is needed to provide for more uniformity of light on the product.
    - Extra “PCB slot” – have a machined slot in the petal for the diffusion plate to slide into.
    - Clip to front of petal.
    - Screw to front of petal.
- Camera mount - Designing a way to mount the camera to the collar. Needs to accommodate a variety of different cameras.
    - Research mounting requirements – Determine the most popular cameras and make sure that the mount works for those.
    - Test for location – Is the camera able to move back and forth depending on the part that it is looking.
- Shroud - A device that is able to block outside light from interrupting the uniform LED provided light.
    - Size – The distance between the part and the camera is determines how large of a shroud needed.
    - Design - a box not allowing any outside light in.
    - Material – something light enough but also not going to let light in.
    - Finish – reflective material or black box needs to be determined.
- Collar – incorporates all of the parts of the system together.

    - Design – Able to be attached to hinge/locking mechanism with minimal dead space.
        - Hollow for hiding wiring – Able to hide wiring while also being able to plug in petals.
    - Interface with hinges – Collar attaches to hinges easily while also being strong.
    - Interface with camera mount – Able to hold the camera mount that is able to adjust to different cameras.
    - Material – Choose a material that is cheap, but will also be strong enough to hold everything together without breaking.
    - Produce – Once the material is determined and available and the design is set, take it to the machine shop and fabricate a prototype.
- Hinges (petal to collar) – Allows for petal movement with desired range of motion.
    - Connections – electronic – Able to disconnect the petal from the collar easily while incorporating the wiring.
    - Design / select - Determine if we want to purchase a hinge or if we want to make our own.
    - Material – Choose a material that is cheap, but will also be strong enough to hold everything together without breaking.
    - Purchase/produce - Once the material is determined and available and the design is set, take it to the machine shop and fabricate a prototype or locate a company that we could buy the hinge from,
- Locking mechanism – A way of setting the petal to a required angle and a certain number of angles.
    - Design – A way of locking the petal into place with little movement so that angle can be repeatable.
    - Considerations
        - Integrate with hinges vs. independent – Should the hinge and locking mechanism be integrated or separate?
- Petal movement

  - Considerations
    - Individual petal movements vs. uniform – Will all petals move together or each one separately?
    - Actuated petal movement vs. manual adjustment – Is the petal movement done by hand or by electric motor?
- Wiring - Wires will run to power the LED petals with 3 wires – power, ground and signal.
  - Routing – The wires not pinched or worn out with the movement of the petals.
  - Connections – Able to remove petal including wiring easily.
  - Concealment – Wiring will be hidden to look clean and appealing.
- Connection to power source – Where and how will the power source connect to the system?
  - Determine source - What will power the LEDs?
  - Select connection method – Permanent connection or a plug that can be easily unconnected.
  - Acquire parts – Receive power source from Opsci.
- LED – Type and size of LED that will be used.
  - Selection – Talk to Opsci about what LED will be used in conjuncture with the PCB.
- Mounting of HEXFIRE – How will the complete system be mounted to the machine that will be using this machine vision lighting system?
  - Research mounting requirements – Determine distances and ways of mounting our system.
  - Select mounting method – Decide on a clamp, or screwing it to the machine, etc.
- Carrying case – A case that is easily made to transport and store this lighting system without breaking it while also being easy to put together.
  - External design / selection – decide on whether we make our own or find something already in production that will be able to store HEXFIRE.

        - Material selection - If chosen to make our own, what will it be made of to be useful.
    - Interior padding design – Shaped to hold HEXFIRE and keep it in place.
        - Material selection – A cheap material that will protect HEXFIRE.
    - Select source of material – Where can this material be purchased at a cost effective price?
    - Produce interior formed padding – Once material is received and the case is available, create a prototype for the carrying case.

5.3 Testing

- Test positioning of lighting panels to determine desired locking positions.
- Test model panels for range of possible motion.
- Test locking mechanism – Does the devise hold at the correct angles with little movement.
- Test hinging – Does the petal move freely without any interference.
- Test Electronic connections – Do all the LED petals work.
- Test multiple camera mount – Do many different cameras work with the HEXFIRE.
- Test HEXFIRE mount – Does HEXFIRE mount to a machine easily with little movement.
- Drop test – Will HEXFIRE break if dropped from 2 ft (do this after presentation).
- Revisions – After tested thoroughly make any changes to the requirements of project.

5.4 Documentation

- Alternative Solutions
- Preliminary Task Specs
- Preliminary Evaluation of Feasibility
- Preliminary Budget
- Refined Task Specs
- Preliminary Project Schedule

  - Identify components with lead times
  - Identify potential obstacles
- Project Brief for industrial consultant
- Monthly Budget Report
- PPFS Draft Due
- Periodic progress reports to Opsci
- Draft of design report
  - Edit Design report
- Design report

5.5 Presentation

- Prepare website
- Final Design presentation
- Present Final design to Opsci
- Prepare presentation for industrial consultant

6. Preliminary Design

The preliminary design of HEXFIRE centers around the collar. The collar serves as a base for the petals containing the LED arrays. The petals are attached to the collar with a hinging/locking mechanism. The camera will also be mounted to the collar, and the entire HEXFIRE device will mount to an external support which will attach to the collar. The collar will be hollow allowing the wiring connections to be concealed within the collar. The collar will be machined aluminum with an anodized finish. For collar design see Appendix B1.

The petals that house the printed circuit boards containing the LED arrays are the second main component of the design. The petals must securely house the removable PCBs. The PCBs will slide into a slot that is machined into the petal. A plastic or rubber spacer will be included in the slot to ensure that the PCB does not move during operation. The petal itself will be detachable from the collar. The petals will be machined aluminum with an anodized finish that matches the collar. Molded ABS plastic will also be considered for a petal material. For petal design see Appendix B2.

The hinge and locking mechanism is the device that connects the petals to the collar and provides for incremented angle adjustments. Several options for hinging were considered. Several options for locking mechanisms were also considered. Finally, several integrated hinging and locking mechanisms were considered. It was decided that an integrated hinging/locking mechanism would be most likely to provide the simplest solution. Three hinging/locking mechanisms were selected as the best options.

The first is modeled after a mechanism found commonly on drum sets. It contains meshing face toothed gears that are held together with a wing nut (Appendix B3). The gears would be held in the meshed position by a spring loaded clip. If the clip were depressed by the operator, the gear faces would separate allowing the petal to be rotated. When the clip is released the petal would then be locked into place.

The second mechanism is modeled after the armrest senior design project. It is comprised of a spring loaded pin that slides along the back side of the collar. The end of the pin can slide into the teeth of a gear (Appendix B4). When the pin is slid by the operator the petal can be rotated to a new position. When the operator releases the pin it engages in one of the gear teeth, locking it into place. The teeth of the gear would be arranged such that each tooth represents a five to ten degree rotation.

The third mechanism uses a purchased spring loaded ball bearing that can be used with a series of detents. The detents will provide repeatable lighting angles (Appendix B5).

Other design components include the camera mount and the system mount. The camera mount will allow a ¼-20 screw to attach the camera to the HEXFIRE device. The camera mount will be adjustable to accommodate a variety of cameras and to ensure that each camera can be easily centered in the viewing hole. The system mount will be accomplished by providing two ¼-20 threaded holes in the camera mount. These holes can be used to attach HEXFIRE to an external support system (Appendix B6). The camera mount will be purchased or machined from aluminum.

7. Method of Approach

To begin the design process a camera viewing hole size that would accommodate the most frequently used cameras was selected. It was determined that the most appropriate diameter for the camera viewing hole is 2.25 inches. The size of this hole limits the overall minimum size of the collar. The locking mechanism selected will also determine the collar size and shape. The type of locking mechanism determines whether or not a hinge is included in the design. The locking mechanism also affects the options for the electrical connection between the circuit boards in the petal and the wiring and power supply in the collar. An electrical wiring layout will be based on the location of the electrical connectors.

Desired petal angels were determined from conversations with the customers and research of existing lighting devices. The petal angle requirements were incorporated into the locking mechanism and petal size. The petal size was used to determine the size of PCB to request from Opsci. Consideration of uniform lighting requirements leads to discussions with Opsci and lighting experts. It was noted that uniform lighting is not always the goal of the user. Necessary provisions for creating uniform light will be incorporated into the HEXFIRE design. See Appendix C: Flow Chart for Method of Approach.

8. Christian Perspective on Project

It is important as Christens to include our belief in everything we do. This is evident in the design considerations. These considerations are some design norms, ethics, and Christian values.

A few design norms were highlighted as closely related to the project. First, cultural appropriateness is important in the HEXFIRE design. The product is expected to be operated by engineers, and manufacturing technicians. Second, the design must be transparent. It should not require an extensive user's manual. The operator should be able to determine how to adjust the petal angle and lighting intensity by simply looking at the device. The locking mechanism should be easy to disengage as well as engage. The assembled design should not unnecessarily restrict access to the lens. Third, the overall intension of the design exercises stewardship. Resources will be used carefully in the production. Also, having one adjustable device may eliminate the need to purchase several lighting devices to accomplish lighting requirements. Finally, the design will incorporate integrity. By meeting the design requirements and performing acceptably the design will meet customer and operator expectations.

As Christian engineers, Team HEXFIRE has a responsibility to exercise Christian ethics and values throughout the design process. This can be accomplished by maintaining a good relationship with the people that the team comes in contact with. By using resources appropriately and being appreciative of the support received, the team will be able to demonstrate ethics and values. The final prototype and design should clearly demonstrate the ethics and values represented by the team.

9. Task Breakdown and Time Schedule

The first task distribution took place during the research phase of the project. The research topics were divided among the team members so that a knowledgebase could be developed surrounding each relevant topic. Each team member reported the results of their research at the research review meeting and provided a written summary of their results for the record.

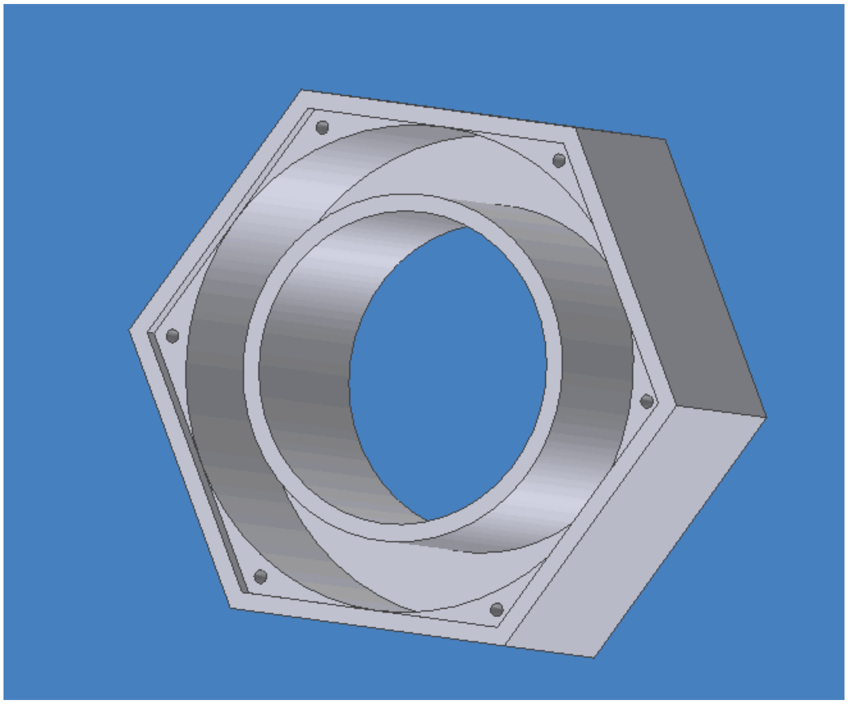
Coordination tasks were also assigned. The project was divided into four categories; design, documentation, website and schedule, and purchasing. The job of each coordinator is to coordinate their task area and delegate the necessary tasks in their area. It was recognized that the amount of work in each area may vary throughout the project. Each team member will be expected to contribute to all areas, but the coordination of those contributions will come from the coordinator.
See Appendix D: Task Assignments.

10. Cost Estimates

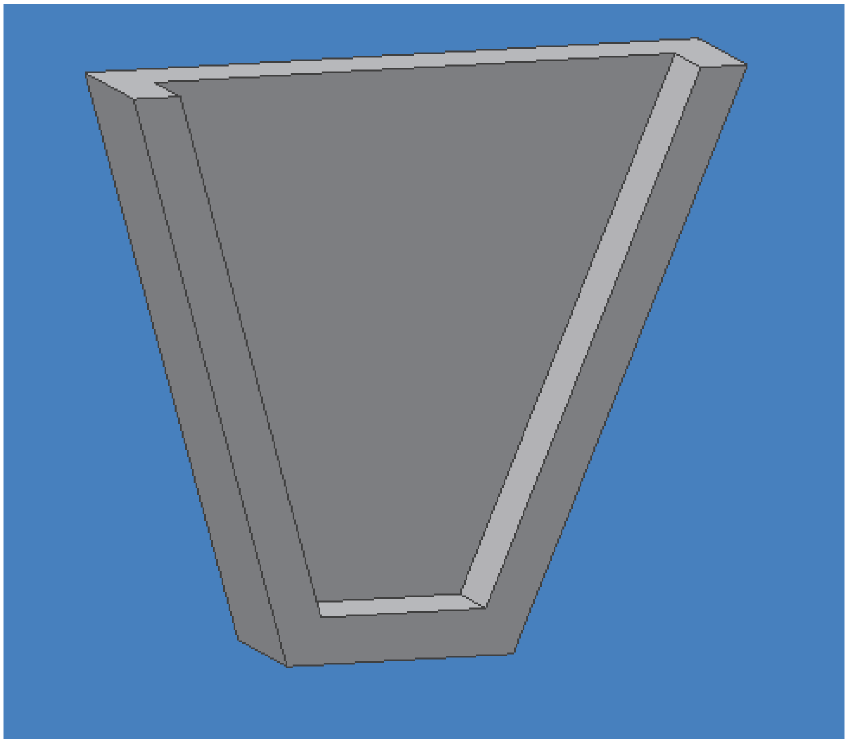
The preliminary budget indicates that the HEXFIRE prototype can be built for approximately $370.00. This is safely within the limit of the funds provided by the team budget combined with the funds provided by Opsci. It also falls below the target production price set by Opsci. See Appendix E: Budget.

Appendices

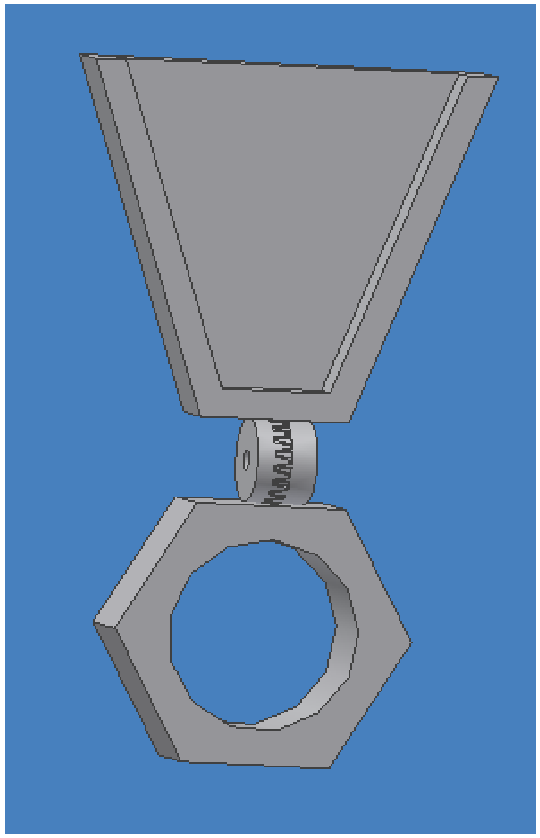
Appendix B1: Collar Design



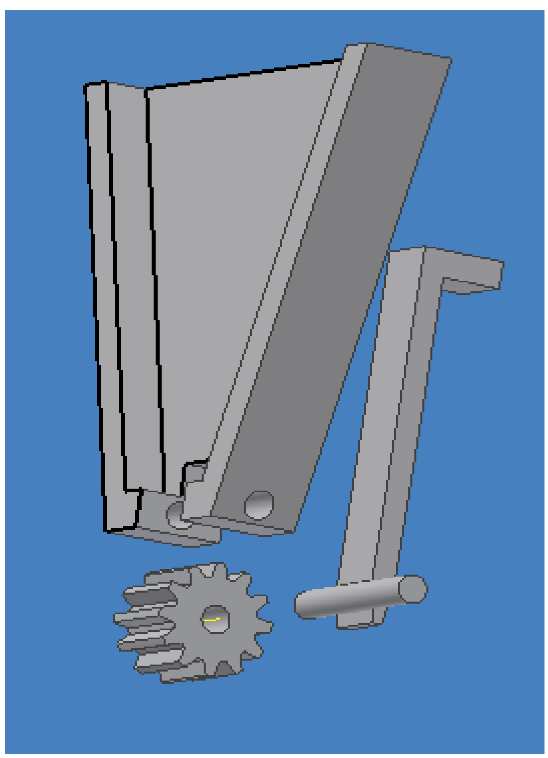
Appendix B2: Petal Design



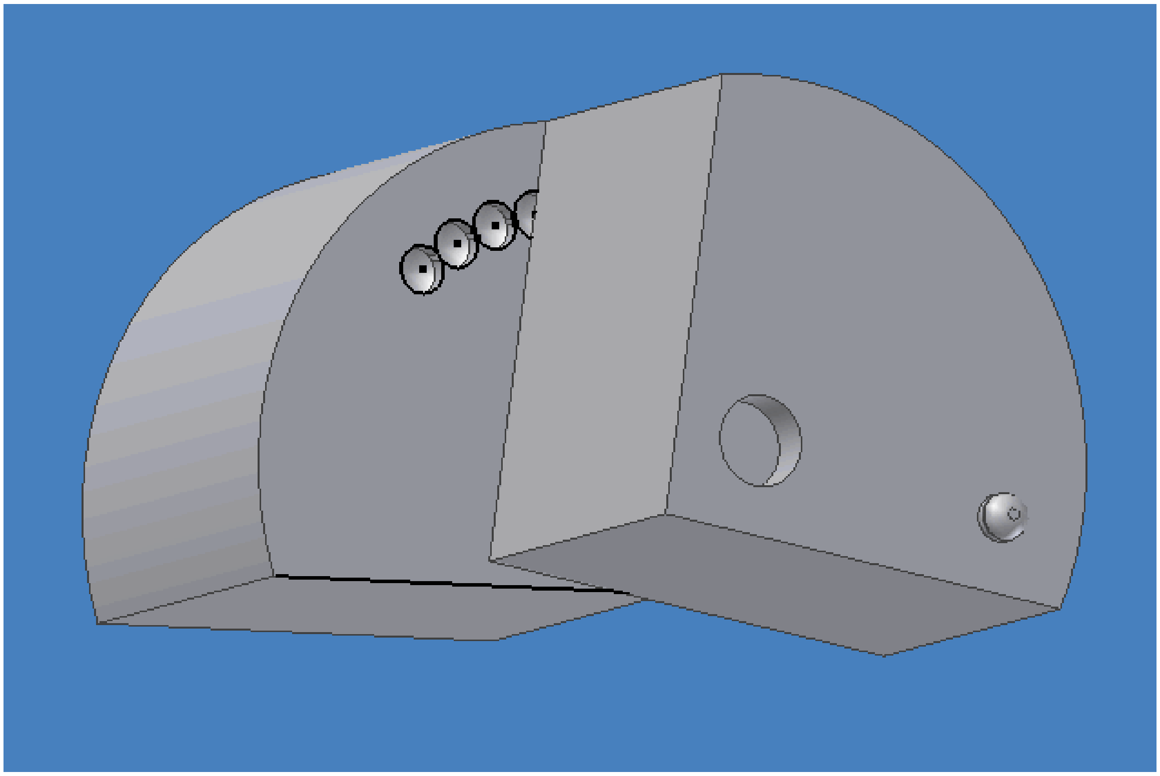
Appendix B3: Drum Set Locking Mechanism



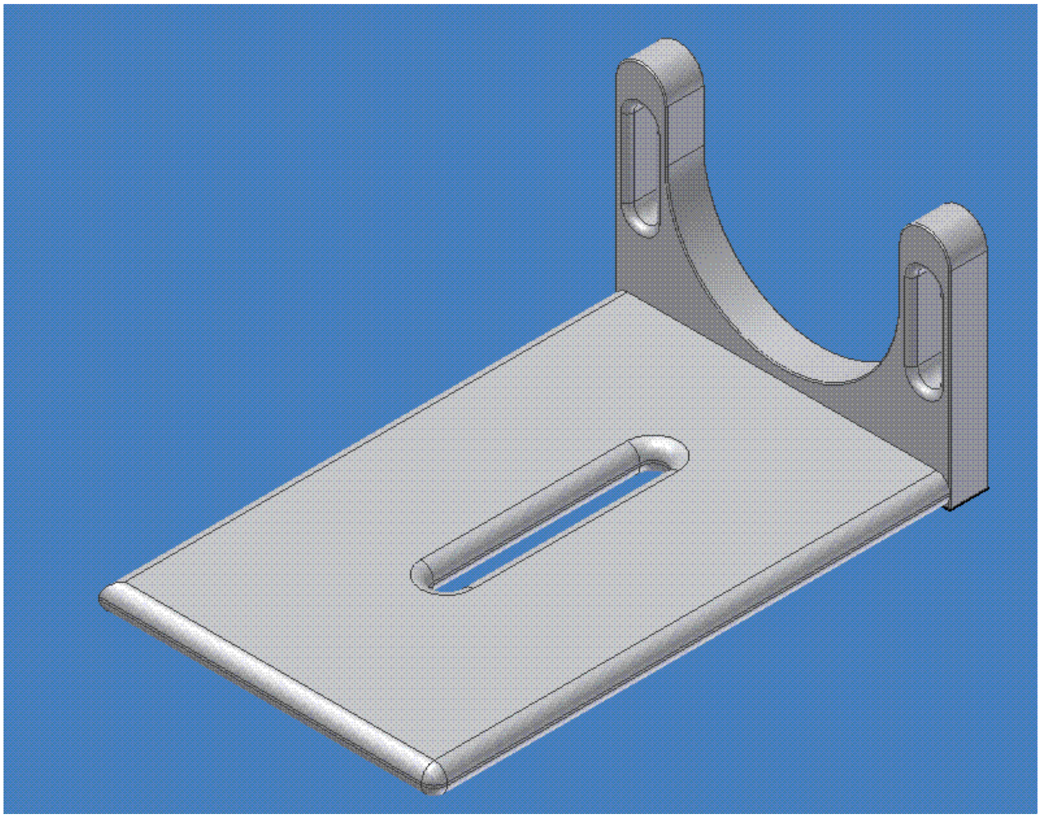
Appendix B4: Spring Loaded Pin Locking Mechanism



Appendix B5: Detent locking Mechanism

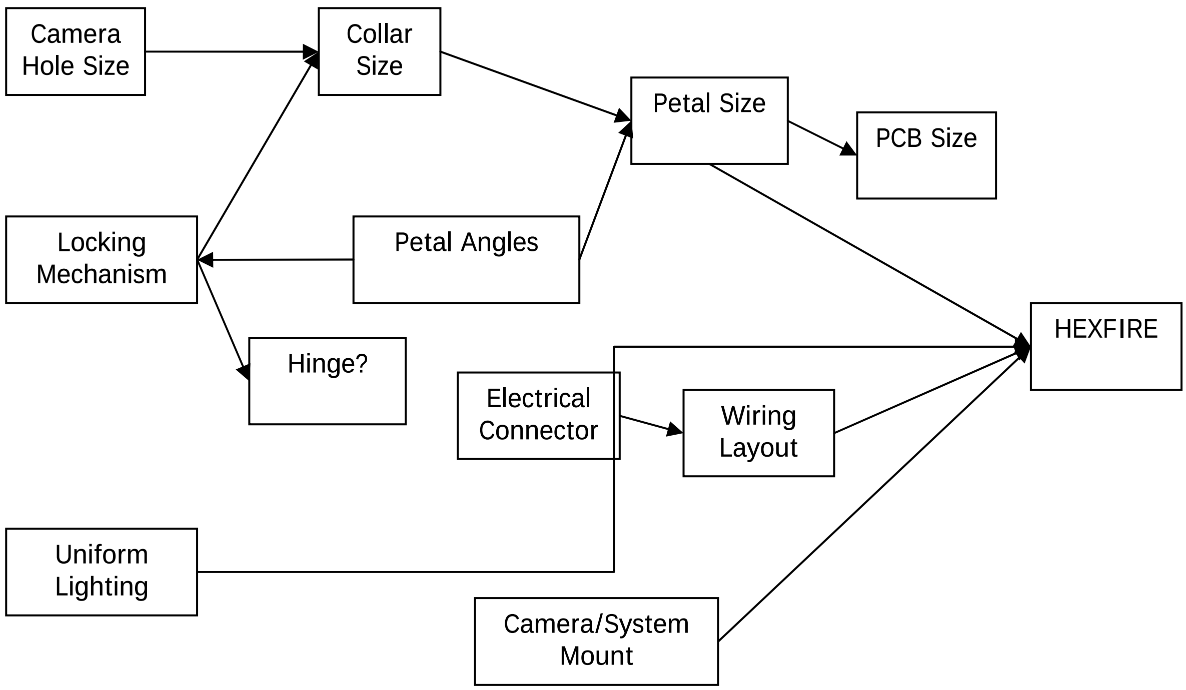


Appendix B6: Camera and System Mount



Appendix C: Flow Chart for Method of Approach

Method of Approach Flow Chart



Appendix D: Task Assignments

COORDINATION ASSIGNMENTS

START DATE	11/16/04
EXPECTED COMPLETION	5/20/04
COMPLETION	
WORK TIME	

TASK	Documentation Coordinator
ASSIGNED TO	Dawn

TASK	Design Coordinator
ASSIGNED TO	Andy

TASK	Purchasing Coordinator
ASSIGNED TO	Kurt

TASK	Website/Schedule Coordinator
ASSIGNED TO	Josh

TASK DESCRIPTION
Coordinate task area and delegate relevant responsibilities.

Appendix E: Budget

Budget - Preliminary

	Unit price	Quantity	Price
Raw Material			
Aluminum stock	$4 / lb	5 lbs	$20.00
Electronics			
Petals (from Opsci)	$20 / petal	6	$120.00
connectors			
per petal	2	6	$12.00
main connector	8		$8.00
wiring			$10.00
hardware			
hinges	10	6	$60.00
pcb spacer			
fasteners			
petal/hinge	$0.05 per	18	$1.00
hinge/collar	$0.05 per	18	$1.00
camera/ unit	$1 per	3	$3.00
led board/petal	$3 per	6	$18.00
diffusion pannel/ petal		6	$15.00
end cap to petal	$0.10	12	$1.20
wiring harness / colar		4	$5.00
Machining			
aluminum	$75 / hr	1	$75.00
finishing			
annondizing			$20.00
Total			**$369.20**

Opsci Inc Budget Limit $500.00

Expenditures To Date

Item	Unit Price	Quantity	Price	Date
Detent Plunger 5/16"	$3.05	1	$3.05	12/10/2004
Detent Plunger 3/8"	$3.05	1	$3.05	12/10/2004
		TOTAL	**$6.10**	