

Department of Mechanical Engineering

Engr 466 Design Report 2

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| Authors: | Anderson Li  Andrew Bornstein |
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# Introduction

* 1. Current State of the Project
  2. Objectives of this Report

KEEP THINGS CONCISE. GO THROUGH THE DESIGN IN DETAIL BUT ONLY SAY WHAT YOU HAVE TO. SAY IT DIRECTLY AND SIMPLY.

# Final Design Description

The following section outlines the design of a Telecine machine for converting analog 28 mm film to a digital format. The device is made up of a number of design modules which interface with one another to perform the task of cycling through the individual frames on a film reel.

The subsystems of this device are as follows:

* **Film gate**: This device flattens and aligns the film as it passes in front of a digital camera. The component itself is made of two aluminum plates which sandwich the film, forcing it flat. The aluminum plates have a narrow channel for the film to follow, lined with spring-loaded guides to align the film horizontally (preventing sideways drifting of the frames).
* **Film transport mechanism**: The film transport mechanism is what propells the film, pulling it through the film gate. A set of custom-made sprockets were machined to fit the dimensions of the 28 mm film. One of the sprockets is actuated by a stepper motor while the other is free-spinning. The sprockets pull the film by the sprocket holes in the film.

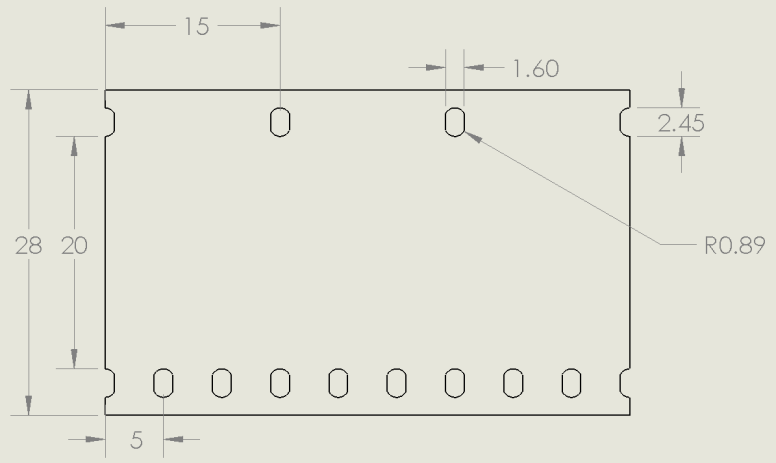


Figure - 28mm Film Segment

The sprockets are fabricated from aluminium and are sandwiched by two aluminium disks for the film to rest on. The sprockets are spaced apart with a delrin spacer of much smaller diameter than the sprockets so the frame of the film is not resting on its surface. The coupler between the sprockets and the stepper motor is also fabricated from delrin.

* **Film Reel Actuation**: The reels of film need to rotate, both feeding film to the sprockets (avoiding unnecessary tension in the film), and spooling up film that has already been imaged on a take-up reel (avoiding a pile of tangled film at the end of the system).

A set of custom-made steel shafts are designed to fit a 28 mm standard film reel. Each of the two shafts (one for out-take, one for up-take) are coupled to a DC motor via a set of aluminum pulleys. The pulley system serves two purposes. One, the ratio of the pulley diameters reduce the speed of rotation from the DC motors; a relatively fast-spinning DC motor can turn the film reels at a slower rate. The ratio of the pulley diameters is approximately 2:1. The other important role that the belted pulley system plays is to allow for slippage. If, for some reason, the film transport sprockets are not moving the film at the same rate as the film reels are rotating, the film will not be providing tension to stall the shaft of the DC motor driving the reel shaft, the belt driving the pulley will slip and provide relief.

As mentioned above, the reel shafts are stainless steel and the pulleys are aluminium. The DC motors are mounted to a piece of 1/8” angle aluminium.

* **Passive Roller Array**: The film is guided from the reels to the sprockets by a set of four delrin rollers. The rollers are free spinning and machined to only contact the film on the edges, in order to prevent unnecessary friction forces on the film. The rollers spin on stainless steel shafts and are sandwiched by two delrin washers.
* **Film Tension Monitor**: Should the tension in the film become too high, a monitoring system will alert the actuators moving the film and act to remedy the problem. One of the passive rollers mentioned above is fixed to the end of an aluminum lever-arm which pivots about the knob of a potentiometer. As the tension in the film increases, the roller will deflect and rotate the knob of the potentiometer, creating an analog output which can be measured and translated into a digital quantity of the tension of the film. The lever-arm is attached to a spring so that, as the tension is reduced, the arm rotates back to the zero-displacement position.
* **LED Frame Illumination Device**:
* **Camera Mount**:

In summary, the combined action of the above-described subsystems is as follows: The DC motor driving the out-take film reel feeds film through an array of passive rollers which guide the film to a set of sprockets, which rigidly fix and actuate the film through the film gate (positioned between the two sprockets). The film then passes through another set of rollers and is rolled onto an up-take reel driven by another DC motor. As each frame passes through the film gate, it is framed and illuminated by a light source and then captured by a digital camera mounted above the film gate. The tension in the line is monitored by a spring-loaded roller which deflects as the tension increases.

# Detailed Mechanical Overview

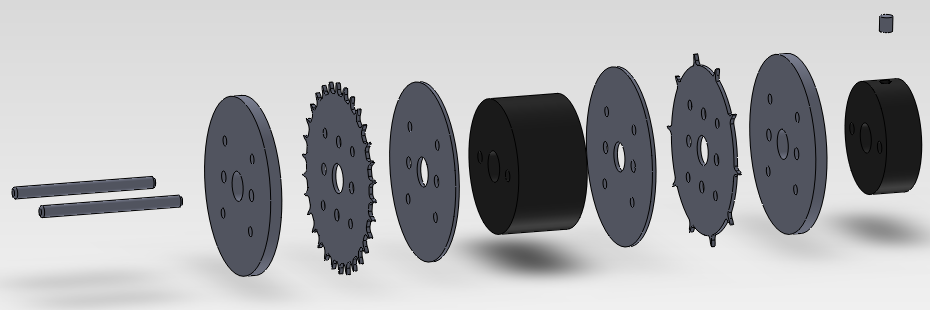
* 1. Film Transport Mechanism

|  |  |
| --- | --- |
|  |  |

* + 1. Specifications

-description and function

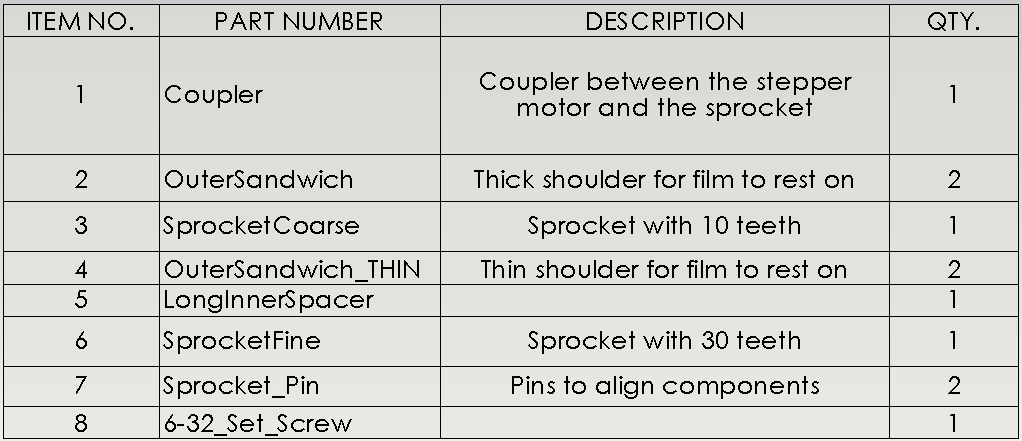
-exploded drawing



-components, material, interfacing actuators

-fasteners

-drawings



* + 1. Failure Modes

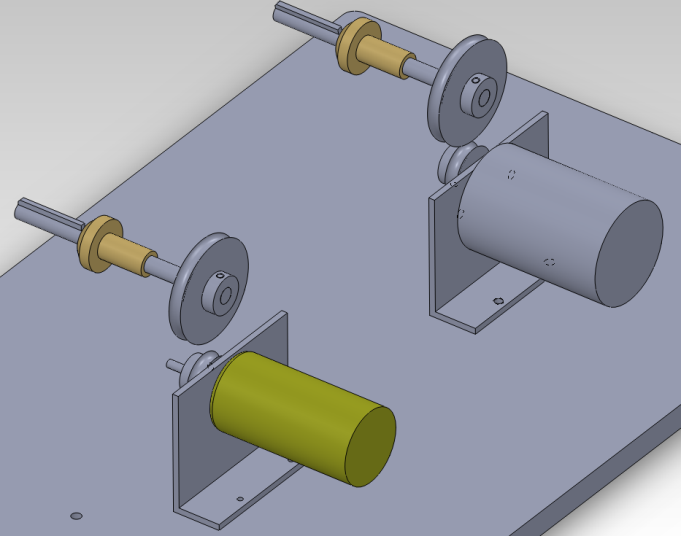
-periodic shaft loading

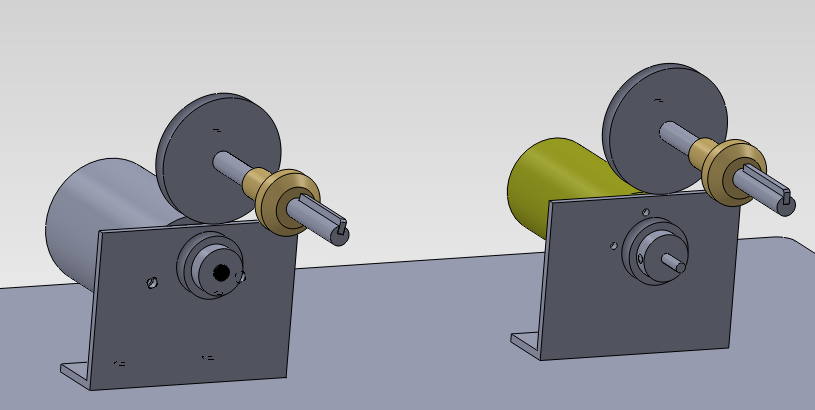
-static shaft loading from its own weight

* + 1. Comments

How could it be better? Why it might be overdone?

* 1. Film Reel Up-take and Out-take





* + 1. Specifications

-description and function

-components, material, interfacing actuators

-fasteners

|  |  |
| --- | --- |
|  |  |

-drawings



* + 1. Failure Modes

-periodic shaft loading

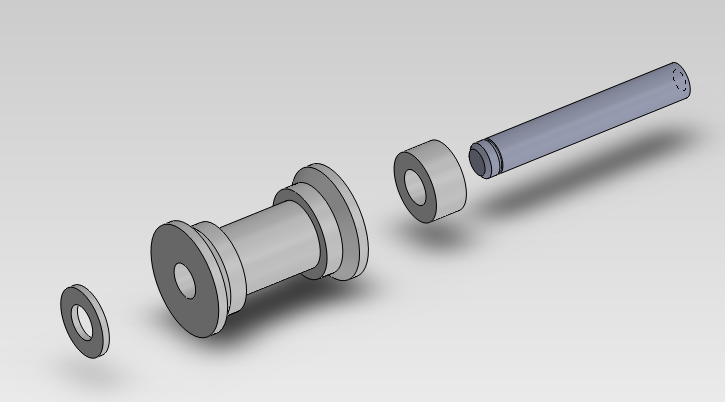
-static shaft loading from its own weight

* + 1. Comments
  1. Roller Array

|  |  |
| --- | --- |
|  |  |

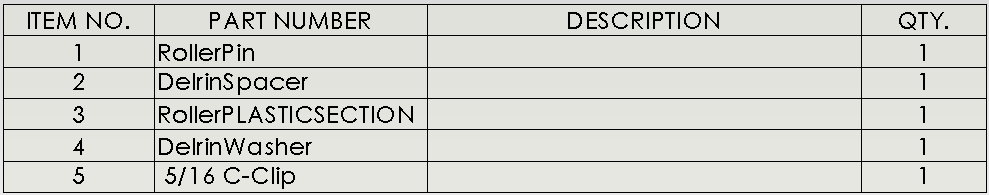
* + 1. Specifications

-description and function



-components, material, interfacing actuators

-fasteners



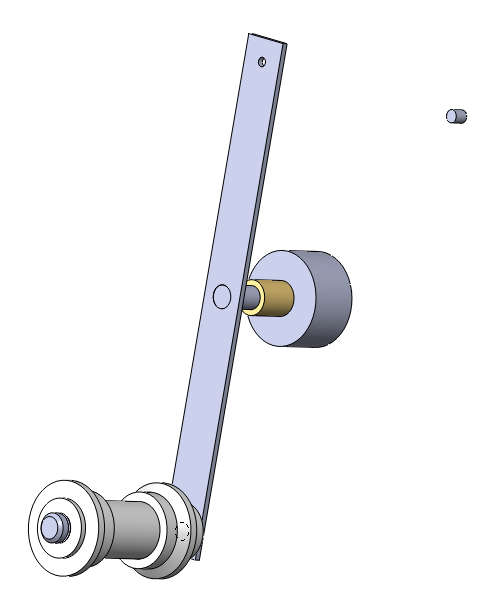
-drawings

* + 1. Failure Modes

-periodic shaft loading

-static shaft loading from its own weight

* + 1. Comments
  1. Film Tension Monitor



* + 1. Specifications

-description and function

-components, material, interfacing actuators

-fasteners

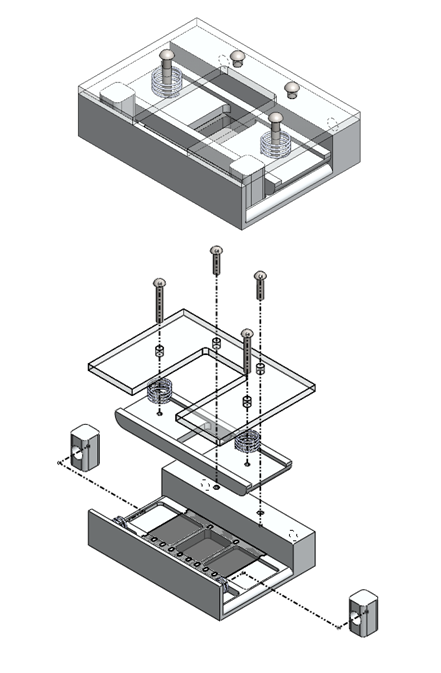
-drawings

* + 1. Failure Modes

-periodic shaft loading

-static shaft loading from its own weight

* 1. Film Gate



* + 1. Specifications
       1. Description and Function

The purpose of the film gate is to align and straighten the film as each frame passes by for capture by the camera. The main criteria of concern are to pass the film through this device with a margin of error less than 1/64 inches without causing damage the film.

* + - 1. Components and Materials

This device will be mainly constructed out of aluminum. To prevent wear on the film it will be anodized by the client. Aluminum was chosen because the client requested this as his material of choice and that it would be more durable than using plastics. The springs used in this assembly are commercially available through capital iron and are chosen because they are cheap and abundant. Two types of screws were used, both of them are standard ANSI Inch sized which makes it easier for the machine shop to make threading and holes. The mounting frame for the pressure plate is made out of transparent plexi-glass so that the pressure plate can be exposed. This makes it easier to assemble the film gate and it acts as a visual verification of how well the film is passing through the device. The bill of materials is listed in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
| 1 | A002-B003\_base | Base plate | 1 |
| 2 | virtualFilmModel^A002-003\_assem | Film Representation | 1 |
| 3 | A002-B003\_topTensioner | Pressure Plate | 1 |
| 4 | A002-B003\_TensionMount | Pressure plate Mount | 1 |
| 5 | A002-B003\_screw | #4-40 Screw Short | 2 |
| 6 | A002-B003\_screw | #4-40 Screw Long | 2 |
| 7 | A002-B003\_spring | Pressure Plate Springs | 2 |
| 8 | A002-B003\_tensioner | Tension Blocks | 2 |
| 9 | A002-B003\_spring-2 | Tension Block Springs | 2 |
| 10 | A002-B003\_Post | TBD | 2 |

* + - 1. Drawings and Machined components

Besides minor modifications and adjustments, all the components of this film gate device have been machined and made. The drawings that were used to create these parts in the machine shop can be found in APPENDIX. The assembled film gate can be seen in the figure below.

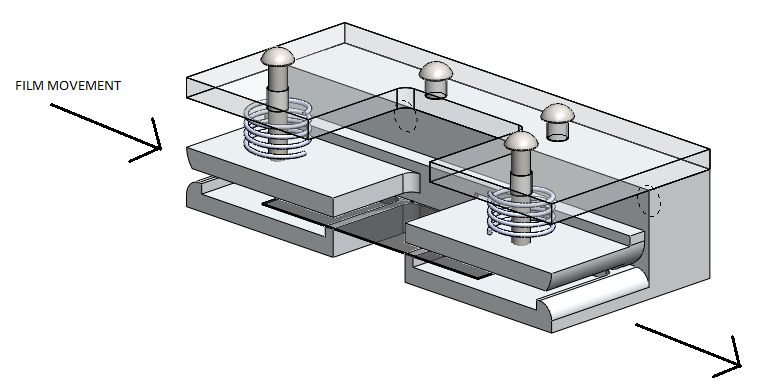


* + 1. Failure Modes

Since this component is not under any type of major strain or stress it is unlikely for the part to break especially since it is made out of aluminum. This device can align the film with an error of les than 1/64 of an inch thanks to the spring loaded mechanisms. However there is still major concern on the integrity of the film, especially on the pressure plate where pressure is added to straighten the incoming film. Several features were incorporated in the film gate to minimize this potential wearing on the film.

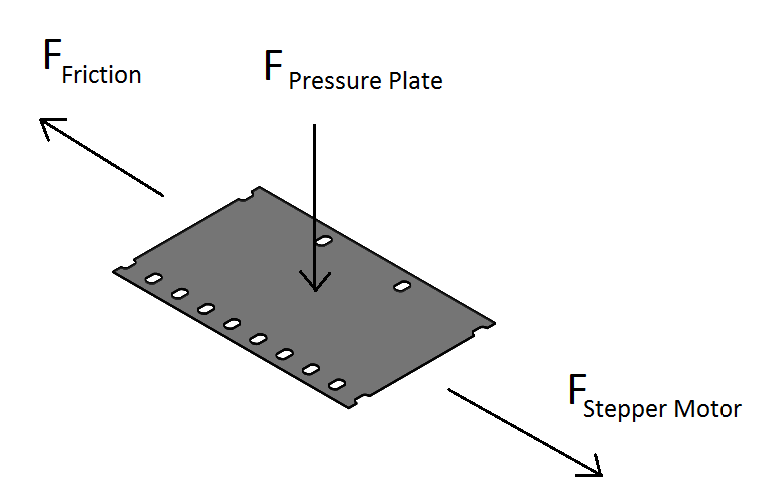
* + - 1. Filleted Film Entry and Exit

The entry and exit for the film gate are designed to be rounded so that the film can slip into and out of the film gate with ease. The cross section figure shown below illustrates this design.



* + - 1. Spring Force and Spring Length

The amount of force the pressure plate adds to the film is important in terms of keeping the film in shape and aligned. However if too much force is added, the friction that results can tear the film apart during film advancement from the stepper motor. To simplify this problem, the forces acting on the film are analyzed as shown in the figure below.



The force that caused friction will be equal to the amount of force the stepper motor will have to pull in order to advance the film. The force from the springs on the pressure plate will provide the normal force for the friction. The formulas for the calculations are shown below.

Equation

Using the equation above, the maximum amount of spring compression can be calculated. The spring constant was found by compressing the spring using a known amount of weight. The apparatus is shown below.



The spring constant was found by measuring the deflection of the spring that was caused by the 108g of weight. The equation used to calculate the spring constant is shown below. The deflection was measured to be 5mm. Therefore the spring constant for one spring is approximately 211.68 N/m. Keep in mind there are two springs so the total spring constant is double this value.

Equation

Unfortunately, the coefficient of friction µ is not known. These values have to be found experimentally which is difficult to do. The closest estimate would be to take the coefficient of friction to be aluminum against mild steel which is 0.47 REFERENCE. The maximum amount wanted friction would be 1 N (approximately 100 grams). Therefore the maximum amount of allowed spring deflection is approximately 5 mm. In the actual film gate device, the springs were cut so that the maximum deflection is VALUE which is below the safety limit. However it not known if this is enough pressure to keep the film from bending too much. It will be up to experimentation and troubleshooting the film gate to find out.

* + 1. Comments

The assembly of the film gate device was done very well and as expected. There are a few minor improvements that could be made to make the device more accessible to the user. For example, the two screws that secure the top mounting plate require screw drivers to remove. Every time a new roll of film is replaced, these screws will need to be undone. It would be better if they were thumb screws instead so the user can quickly setup the telecine system.

* 1. System Frame

The system frame supports and aligns the mechanical components of this telecine device.

* + 1. Specifications

-description and function

-components, material, interfacing actuators

-fasteners

-drawings

* + 1. Failure Modes

-periodic shaft loading

-static shaft loading from its own weight

* + 1. Comments

# Design Component Interfacing

…the mechanical interfacing.. spacing between film gate and sprockets.. how things are layed out on the frame ex, so the tensioner will fit and operate. (basically a detailed discussion of the frame)

Identify all the interface circuits

Identify the software relationships between

# System Assembly Overview

# Electrical Design

The control system for the telecine machine will be controlled by an Adruino microcontroller as shown in the figure below. The client requests an interface system that will allow the user to reverse the film as well as adjusting the speed of film advancement.

PICTURE

The electrical componets and its functionality is shown in TABLE. The full electronic schematic diagram can be found in APPENDIX.

|  |  |
| --- | --- |
| **Component** | **Description** |
| Adruino Microcontroller | Microcontroller used to control the motors, camera capture, sensor information, and user interface for the telecine setup. |
| LCD Screen | Displays information to the user. For example, frame counts, motor speed and motor direction. |
| Tension Sensor | The tension senor is a potentiometer attached to a lever so that a change in tension can be measured as a change in voltage. |
| DC motors (2 qty) | The DC motors uptake or releases the film for the stepper motor to advance. The speed of these motors is based on the values obtained from the Tension sensor. |
| IRFZ40 (2 qty) | MOSFET that allows the Adruino MC to control the DC motor speed and to turn on or stop the motor. |
| 955 Power supply | 5VDC power supply that is powered by a power outlet. This power source will supply 5VDC to the microcontroller, LCD and the DC motors. |
| VEXTA 5 phase Stepper Motor | Stepper motor to drive the film sprockets. |
| VEXTA Motor Controller | The motor controller for the 5 phase stepper motor. It is powered by an electric outlet. |

# Preliminary Software Design

The implementation of the software control system is aimed for simplicity and robustness. Since the main project objective is only focused on capturing film, most of the microcontroller’s resources will execute the operations one at a time. The preliminary software design for this project is displayed in FIGURE and TABLE.

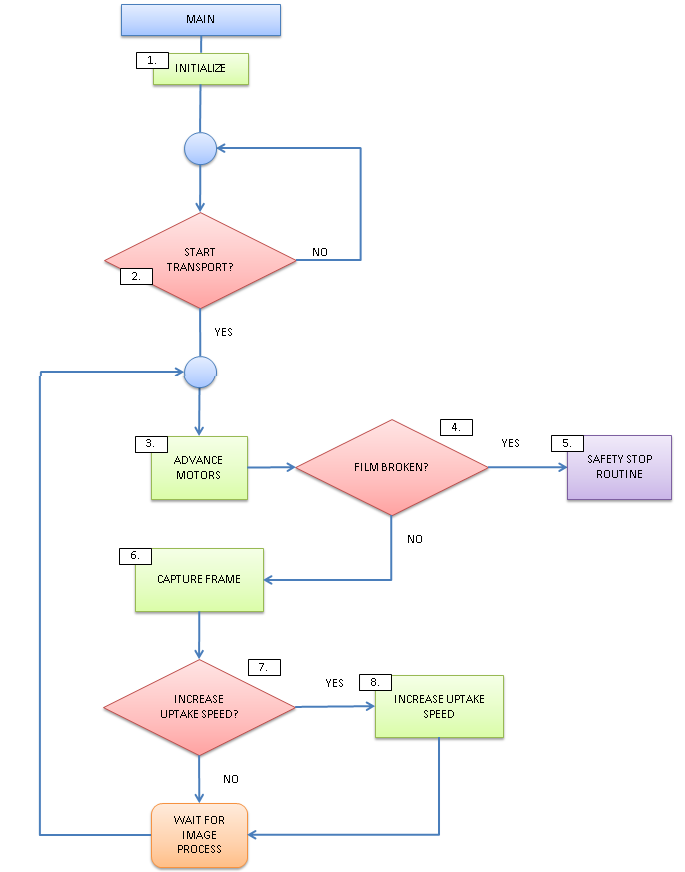


Figure – Software design flowchart

|  |  |
| --- | --- |
| **Ref** | **Description** |
| 1 | Initialization for the control system. This is where the rotational speeds for the motors are first set, along with the manual adjustments so that the frame matches with the film gate hole. |
| 2 | This is a confirmation for the user to start the film transport operation. The trigger for this event will be a push button input of some sort. Otherwise, the program will wait until the user is ready. |
| 3 | The motors advance the film forward by one frame. This means the stepper motor and the driving film motors will all move. |
| 4 | This is where the optical sensors will try to detect a discontinuation in the film. |
| 5 | This routine is accessed if there is a discontinuation in the film. It could mean that the film has been broken or the film wheel has reached the end of the movie. Either way, the whole system must stop. The micro-controller will power down everything to conserve power. |
| 6 | If everything goes well in the film advancement, a signal will be sent to the camera to capture the frame on the film. |
| 7 | Optical sensors will check the thickness left in the film wheel and decide if the motors require a change in speed. |
| 8 | Changes in motor speed are requested so it will be adjusted accordingly. Afterwards it will wait for the camera to finish processing the image before repeating the entire film capturing process. |

# Conclusions

-current challenges we are facing and how we are attacking it.

-our next steps

# References

1. Coeffient of Friction. [Online] [Cited: June 30, 2012.]

http://www.engineershandbook.com/Tables/frictioncoefficients.htm

# Appendices

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