Team B1 Asterism Statement of Work

System Design Re-scoping

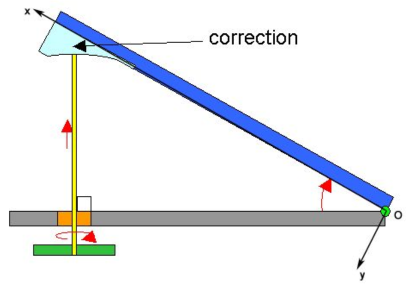

Fig. 1: Barn Door Compensator Structure[1]

Since we no longer have access to Techspark's fabrication facilities, we plan to significantly reduce the mechanical complexity of our project. Rather than constructing a full equatorial camera mount, we will be building a barn door tracker (illustrated in Fig. 1). Instead of having a complex arrangement of gears and multiple rotating shafts, our new design will consist of a hinged lever arm upon which the camera is mounted with a ball-joint. Mechanical actuation will be performed through a long threaded rod pushing against a ramp attached to the lever arm. The base of the camera mount will retain the originally planned mechanical degrees of freedom for the purpose of automating the mount's polar alignment setup procedure. The camera mount base's turntable and the hinge joints are largely unchanged but will need to be redesigned to work with standard gears available from McMaster.

As a contingency for the unavailability of proper fabrication facilities, the mechanical design of the barn door tracker can be simplified drastically. Omitting the curved correction ramp, which may require access to a 3D printer to construct, causes the design to reduce to that of a simple tangent mount with marginally lower accuracy. Switching to a curved rod also permits the omission of the correction ramp with a minimal accuracy penalty at the cost of requiring access to a vise for producing the curvature (which is the case for one team member).

This change to the mechanical portion of our project will not overly affect its ability to achieve the capabilities that we had originally planned to demonstrate, with the exception of the camera mount's ability to track objects. Due to the difficulty of sensing the position of the ball-joint the camera would be mounted on, the user would be required to manually measure said position to facilitate the mount's object tracking routine.

Tasks and Division of Labor

Joy Gu:
Motor control (software component)
Camera-to-Pi interface (libgphoto2)
User interface
Object tracking algorithm
Software testing

---

[1] https://en.wikipedia.org/wiki/Barn_door_tracker#/media/File:Corrected-scotch-mount.png

Kenny Ramos:
Gearing design and fabrication, some of mount construction
Mount construction and CAD of gearing and mount
Polar alignment algorithm
Test input generation and whole system field testing
Test environment construction
Final debugging

Yuyi Shen:
Motor controller design and layout
User interface board
Testing setup circuit design and layout

Testing and Verification Considerations

To debug and verify the motor controller and testing setup boards, a relatively slow oscilloscope is required to record the PWM waveforms. In the case where an oscilloscope cannot be obtained, these waveforms are low enough in frequency that the usage of more accessible meters is possible, such as a simple voltmeter probe or an arduino-based oscilloscope.
Similarly, verifying the testing setup boards' ability to drive the test setup's laser diodes requires the usage of a multimeter. Fortunately, we've confirmed that both the multimeter and Arduino are available to at least one team member.

Demonstration Changes

Polar Alignment Procedure Demo 1
Feed mock data into the Pi representing data flow usually seen in alignment procedure. Record the output PWM waveforms from the Pi with the Arduino oscilloscope and work backwards from that to verify that target position is "being reached". No actual need for physical implementation in this case.

Polar Alignment Procedure Demo 2
Construct the turn-table and lever arm for polar alignment. Feed mock data into the Pi and check through the mount's polar scope if alignment has physically occurred successfully.

Polar Alignment Procedure Demo 3
Use user input through normal user controlled procedure in order to feed real alignment data into the pi through the system. Measure final alignment accuracy and subsystem error sources through the process by comparing with Demos 1 and 2.

Sky-tracking Demo 1
Manually align the barn-door compensator without the polar alignment setup to the axis of the laser test setup, and do a long exposure. Measure image noise and motion blur by image similarity comparisons

with generated images. These generated images are still captures of the same scene with gradual application of different degrees of blur.

Sky-tracking Demo 2
Field test of the same method as Demo 1.

Object-tracking Demo 1
Set up the mount to track a laser dot from the test setup. Keep the bottom motors disconnected, and simply read out the PWM waveforms using an Arduino o-scope.

Object-tracking Demo 2
Set up the same field of laser dots as in sky-tracking demo 1 along with a single laser dot as in Object-tracking Demo 1 that moves with an offset to the rest of the array. Set up a laser dot mounted onto the camera sensor that points antipodally to the lens's axis. Track the movement of the antipodal dot and compare to the movement of the target dot to demonstrate correct alignment.

The reasoning for the tracking dot to be antipodal is to not disturb object tracking (due to the "test" dot never being in "frame") while accurately measuring alignment.

Schedule Changes

A	B	L	M	N	O	P	Q
		Week					
		10	11	12	13	14	15
TASK TITLE	TASK OWNER	3/23	3/30	4/6	4/13	4/20	4/27
Fabrication and Mechanical							
~~CAD Mount (not including gearing)~~	JG						
~~CAD Mount with gearing~~	JG						
Design compensator ~~gearing~~ barn door mount	KR						
Order parts and supplies	JG + KR + YS						
~~Constructing Equatorial Mount~~	JG + KR + YS						
Assemble mount	KR						
Obtain Camera Adapter	JG + KR + YS						
Circuitry							
Motor Driver Redesign + Fab	YS						
User interface board layout + Fab	YS						
CV System and Interface							
Polar alignment algorithm	KR						
Interface PA with mount circuitry	YS + KR						
Object tracking prototype (with video)	JG						
Interfacing Camera with object tracking	JG						
Integrate with Mount Movement	JG + KR						
Calibrate for mount	JG + KR						
GUI							
Software implementation	KR						
Obtain and install peripherals	JG + KR + YS						
Testing of software implementation	KR						
Verification							
Skychart laser array circuit design	YS + KR						
Skychart laser array board layout+fab	YS						
Assembly of Skychart laser array	KR						
Sky tracking and object tracking tests	JG + KR + YS						
Integration and Additional Testing	JG + KR + YS						
Mock input generation	KR						
Oscilloscope/testing instrument implementation	KR						
Course Logistics							
1st Status Report	JG + KR + YS						
Design Presentation	JG + KR + YS						
Design Document	JG + KR + YS						
Final Presentation	JG + KR + YS						
Final Report	JG + KR + YS						