Senior Design
ENG EC 464

Memo

To: Professor Pisano, Professor Alshaykh, Professor Hirsch

From: Christopher Liao, Anton Paquin, Jeffrey Lin, Eduardo Portet, Aviva Englander

Team: 15

Date: 3/27/18

Subject: Functional Testing

1.0 Fine Tracking (Using MEMS)

1.1 Description of Test

In this test we will demonstrate a more sophisticated laser tracking mechanism. This test will use a laser (always on) being pointed with a MEMS mirror and a cluster of 24 photodiodes . As the target of 24 photodiodes moves (in any direction), the laser should follow the target.

The test will be conducted as follows: A person will hold the target (powered by 4 AA batteries) with 24 photodiodes and move around to demonstrate that the laser tracks the target, with the following restrictions:

- The target is always facing the laser. The angle of incidence measured with respect to the vector normal to the plane of the photodiodes should not exceed 30 degrees.
- The magnitude of the acceleration vector never exceeds ½*g.
- The magnitude of the velocity vector is unrestricted.
- The target is over the horizontal plane.
- Line of sight is maintained between the laser and the target.
- Ambient light is not excessive. (Testing in SLURP is possible during anytime of day with lights on and shades closed, but testing in Senior Design lab is impossible during daylight hours).
- Distance between the target and the laser exceeds 2.5 meters. We have not found an upper limit on this distance. The target can be tracked anywhere inside SLURP when it is at least 2.5 meters away.

1.2 Significance of Test

As mentioned before, tracking is the main problem in this project. This tracking method is much more sophisticated than what was previously demonstrated and shows significant progress toward meeting requirements.

1.3 Equipment and Setup

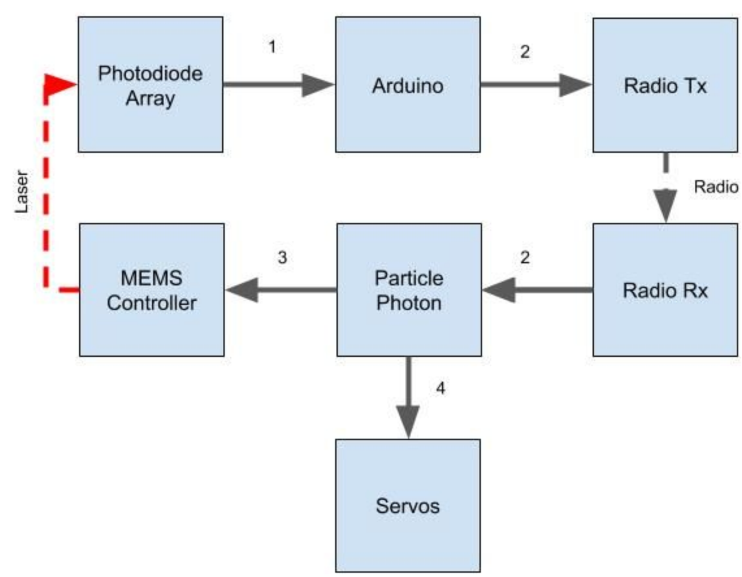
The mechanical setup is as follows:

MEMS mirror with an field of view +/- 6 degrees in either direction is mounted on servo mechanism with two degrees of freedom. The servos are able to aim the laser in any direction above the horizontal plane.

The goal of the servo is to increase the field of view of the laser. The servo will try to keep the MEMS mirror position centered to prevent the target from moving outside of the field of view of the MEMS.

The goal of the MEMS is to keep the laser centered on the target. The MEMS is necessary, since it is capable of more rapid and precise movement than the servos.

The following diagram is a high level system diagram of our setup. (numbered arrows are explained on next page)



1. Photodiode communicates the digital state of each of the 24 photodiodes to the Arduino on the target. This is done by connecting the output of each photodiode to a multiplexer input. The Arduino shifts through all the diode ids (from 1 to 24) and reads the output.
2. The Arduino averages the coordinates of the diodes that are on to obtain the approximate coordinate of the center of the laser beam with respect to the center of the photodiode array. This coordinate (8 bits for x and 8 bits for y) is transmitted to the particle photon.
3. Using the error coordinates from the photodiode array, we generate the new pair of voltages to send to the MEMS controller.
4. Using the position of the MEMS as the error function for PID control, we generate a new pair of coordinates for the Servos to move to.

1.4 Data Collection

We are interested in the following data:

- Maximum acceleration at which we can move the photodiode array before the laser loses track of the target.
- Minimum distance between the MEMS and the photodiode array to achieve reliable tracking.

1.5 Measurable Criteria

The test is successful if the laser track the photodiode array given that the restrictions mentioned in section 1.1 are adhered to.

2.0 Coarse Tracking (Using Camera)

2.1 Description of Test

In this test we demonstrate our ability to track the coarse position of an object using the Raspberry Pi and a the Pi Camera. The test analyzes the input from the camera to isolate the desired object by looking at specific ranges of the hue, saturation and color value found in the image. The output of this operation would allow us to know the x,y position of the object tracked in terms of the image's resolution (i.e. pixel height, pixel width).

The Raspberry Pi will be able to control the servo movement to track the position of the object as it moves to prevent it from escaping the camera's field of view. As we track the object and get it’s relative position we can communicate with the Photon via USB Serial to transmit this information.

Once an object to track has been defined and its hue, saturation and value ranges have been defined.

The test will be conducted as follows:
The object tracked will be placed in the field of view of the camera. The image displayed will show a circle surrounding the object tracked and a red dot at the center of mass of the object. If the object moves outside of the central area of the camera’s view it will trigger the servos to maintain the object at the center.

The biggest limitations of this tracking mechanism is that it is very dependant on the lighting that the object is receiving. The HSV range need to be very flexible in order to track in most environments, but this will also cause the algorithm to get confused with other objects that might also fall within the same HSV range.

2.2 Significance of Test

In the overall outcome of the project the necessity for a coarse tracking mechanism exists in order to make the system as autonomous as possible. In this manner, the whole system would be able to function without needing human interference to initiate the contact between the laser and the photodiode array. The system would just rely on the coarse tracking algorithm to eventually find the tracked object, and relay its position to the MEMS mirror for fine tracking.

2.3 Equipment and Setup

The setup consists of a PiCamera V2 mounted on servo mechanism with two degrees of freedom. A Raspberry Pi connected to PiCamera V2 and to two servos. Pan servo mechanism connected to GPIO pin 12, and Tilt servo mechanism connected to GPIO pin 18. The Photon connected to a Raspberry Pi USB port used for communication between coarse and fine tracking.

2.4 Data Collection

The test will demonstrate data output for the object that is being successfully tracked and the servo movements that are applied. This includes a live feed of the video captured, display an enclosing circle of the object tracked, and display of the center of mass of the object.

Optionally, we can also display the hue, saturation and value masks and ranges that are being used to create blobs and locate the object.

2.5 Measurable Criteria

The test is successful if we are able to track a predefined object and successfully follow it as it tries to escape the camera’s field of view. The Raspberry also needs to communicate information with the Photon via Serial USB and blink the onboard LED.