University of Central Florida

Orlando FL

Divide and Conquer

Senior design

8/27/2021

Automated Outdoor Laser Beam Profiler

Group 3 Members

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Objective

Design and build a remotely controlled, solar powered and waterproof system that can image and track a laser beam from collected light off of a diffused surface.

Goals of building the device are to design and build a zoom system with lenses that will be remotely controlled to locate the laser beam on an outdoor diffused surface. Design a filter to control the amount of ambient light introduced to the device. The laser signal captured by the camera system will be sent to a corresponding receiver device and the vital information about beam location and characteristics will be displayed on the receiver. Design a battery source which can deliver the appropriate power to each individual system within the device and also integrate solar panels for solar charging of the battery. This device will be controlled remotely from the laser's location (roughly a kilometer away).

Background

Our team is working with a graduate research group, the Laser Plasma Laboratory at CREOL UCF, to solve a problem that occurs during outdoor high power energy experiments. Currently there are few devices on the market which are built specifically for outdoor high energy laser propagation testing. Without access to such devices, setting up outdoor laser experiments can be both extremely time consuming and inefficient. Current equipment must be aligned by hand and monitored from both the laser output as well as the target. This distance varies but for the purposes of this design the distance is a kilometer. With an automated system that can locate the laser beam and record its characteristics, the amount of personnel on the ground can be reduced. Due to experimenting outdoors, sunlight can make it quite difficult for camera systems to read the laser beam on the surface of the target board. However, a specially designed filter system can control the amount of ambient light entering the system. The equipment being used traditionally is not designed to deal with the outdoor elements. When weather changes sporadically all equipment must be quickly salvaged and covered as to not get damaged. Most optical equipment on the market right now uses a direct power source to power the instruments, which is inefficient for outdoor use. Large batteries or a backup generator are needed to power the equipment. The solution to this is to incorporate a power source which is both chargeable and solar powered. With such a large distance a remotely controlled device will not only cut out the need for additional personnel, saving time and potential costs, but will be able to withstand any weather without the need to be physically covered or removed from its optimal testing location.

Methods

Several approaches will be used to optimize the projects outcome. Optical simulation tools such as Zemax will be used to design the zoom system for the camera. CAD software will be used to simulate and design the movement system which will control the tilt and spin of the device. Thorough testing will allow a progressive scale of laser power and wavelengths. Theoretical exploration will help make informed decisions about sensing filters used to filter out ambient lighting. The most efficient way to transfer data is also being discussed and thought out. Ideally our system would transmit data over a medium which does not have to be hardwired.

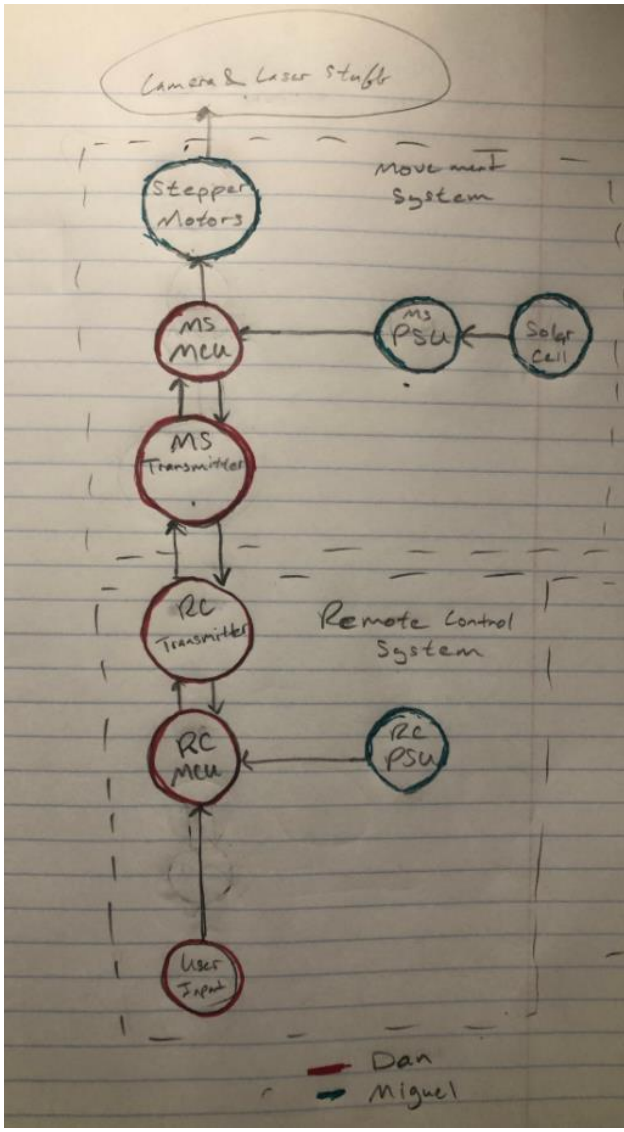
The system will be powered by solar energy. It will have (estimate size) solar panels which will be connected to a rechargeable battery, providing power to the system. The system will use direct power coming from the solar panels. In the case of low sunlight, i.e. rain or cloudy, the battery will provide its charge to the system. In the case of full sunlight, the system will use the excess power to charge the battery. Between the panels and the battery, a charge controller will regulate the power given to the battery, and supervise the battery charge, avoiding excess charge or discharge, in order to avoid damage. A microcontroller will hold the connections to the components which will allow the camera to move accurately and detect the beam. The components connected to the microcontroller also include an estimate of two motors adding a precise movement to the system gears. There are two displacement options which are in an angular rotation from left to right, and up and down. The other displacement option is a linear motion vertically and horizontally. Signals to the motors will be controlled through a motor driver that will receive a signal in real time directing the camera platform to follow the beam on the target. Also connected to the controller is the camera, requiring a lower amount of power than the motors. In order to handle the different types of components with varying types of currents and voltages, DC to DC converters will be designed as well as implemented, in order to scale up or down the voltage coming from the solar panels. Since the proposed project will be a weatherproof system, a case will be built in order to keep the components safe. This will increase the heat coming from the components, meaning that a couple of fans will also be powered through solar energy. Heating sensors will be connected inside the housing, which will throw a signal to the controller activating the cooling fans, that way no power is consumed till it’s absolutely needed.

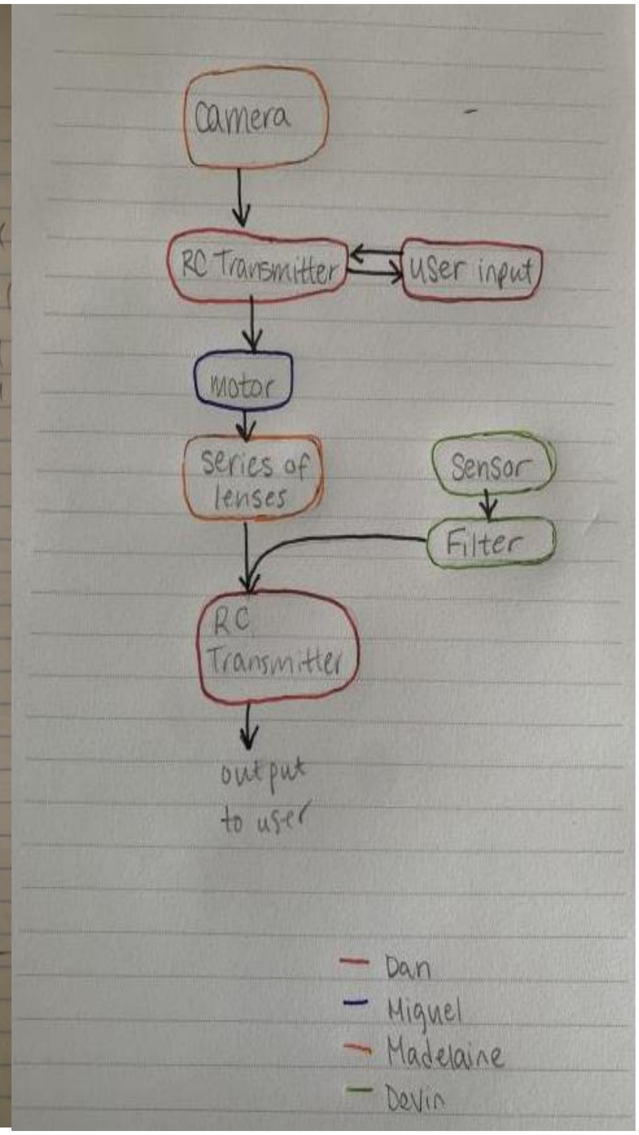
Expected results

By the end of this project, it is expected to have a fully functioning device that is capable of remotely locating a laser beam off a diffused surface and be able to track and record characteristics about the beam profile. Data transmission will be efficient and remote.

Design Blocks

Each block is currently in research.





Project Milestones

SENIOR DESIGN 1	Assigned to:	Start Date:	End Date:	Status:
Determine project objective	Group 3	8/26/2021	9/3/2021	Completed
Assign roles	Group 3	9/3/2021	9/3/2021	Completed
Project familiarization	Group 3	9/3/2021	9/9/2021	Completed
Technology and Design Research, Documentation				
Zoom/Camera System	Madelaine	9/9/2021	11/5/2021	Researching
Filtering System	Devin	9/9/2021	11/5/2021	Researching
Movement System	Daniel	9/9/2021	11/5/2021	Researching
Remote control system	Daniel and Miguel	9/9/2021	11/5/2021	Researching
Solar power	Miguel	9/9/2021	11/5/2021	Researching
Project Report				
Initial DC document	Group 3	9/13/2021	9/17/2021	Completed
Updated DC document	Group 3	9/18/2021	10/1/2021	Completed
First Draft	Group 3	10/1/2021	11/5/2021	In Progress
Final Draft	Group 3	11/8/2021	11/19/2021	In Progress
Final Document	Group 3	11/22/2021	12/7/2021	In Progress
Order & Test Parts	Group 3	11/19/2021	12/14/2021	Researching

SENIOR DESIGN 2	Assigned to:	Start Date:	End Date:	Status:
Build initial prototypes of individual systems	Group 3	12/14/2021	1/21/2022	
Initial testing (indoor)	Group 3	TBD	TBD	
Join system prototypes	Group 3	TBD	TBD	
First round of outdoor testing	Group 3	TBD	TBD	
Second round of prototype building	Group 3	TBD	TBD	
Second round of outdoor testing	Group 3	TBD	TBD	
Finalize prototype	Group 3	TBD	TBD	
Peer presentation	Group 3	TBD	TBD	
Final report	Group 3	TBD	TBD	
Final presentation	Group 3	TBD	TBD	

Estimated Expenses total: $2,500

- CCD camera ($300, Imaging Source)
- Adjustable zoom lens (to be designed)
  - Lenses for imaging system ($400)
  - Automated rail to control zoom ($200)
- Camera filters
  - ND filters ($350)
  - Sensor ($100)
- Camera pointing control
  - Automated tip/tilt control ($500)
- Weatherproof housing ($100)
- Control/viewing software (to be designed and programmed)
  - Data transmission/reviving components ($200)
  - Display of beam ($150)
- Solar panels ($200)