Documentation

Freestyle Showcase

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Project title:

SPLE – Solar Powered Laser Engraver

Part 1

• Mechanical aspect

SPLE - Solar Powered Laser Engraver is a robot which uses computer numerical control (CNC) and linear motion to manufacture small to medium sized engravings using a laser. The ensemble is powered normally and by LiPo accumulators which are charged using solar energy.

The following materials were used to construct the robot:

i. 20x40 aluminum extrusion
ii. 2 Nema 17 stepper motors
iii. linear guide
iv. 6mm GT2 timing pulley
v. 6mm GT2 timing belt
vi. aluminum angle
vii. Delrin T-slot wheels
viii. metric screws (M5, M4)
ix. M5 spacers
x. M4 T-nut for aluminum extrusion
xi. M5 nuts, washers
xii. 3D printed accessories (gantry plates)

xiii. laser

From a mechanical standpoint, the robot construction was done in 3 different stages:

- 3D Design

Before buying any of the above-mentioned materials I used *Rhinoceros 4* (CAD software) to get a better perspective of the final product and to ensure the design didn't have any major flaws. For parts such as the aluminum extrusion or the stepper motors I imported the *.step* files from open-source websites such as *GrabCAD* or *Misumi*. During the 3D design process, I aimed for the following milestones:

i. *Balance*. This is achieved by strategically placing the 2 stepper motors or by using additional parts such as a linear guide
ii. *Efficient linear motion system*. It is important to design a system that optimizes the use of space.
iii. Optimize working area. Get as much working space as possible.

I opted for a design which uses a linear rail guide to balance the structure. This resulted in an overall much stronger base that didn't limit the working area. For the motion system I chose Delrin T-slot wheels paired with a pulley-belt system. The final working area ended measuring approximately 40 cm wide and 70 cm long.

- 3D Printing

Instead of buying pre-made aluminum Gantry Plates for the linear motion system I opted to 3D print them using PLA (Polylactic acid). The hole measurements were taken from the Universal Gantry Plate which is compatible with any king of extrusion. I settled for a 2mm thickness, 30% infill and Honeycomb design to ensure stability while also conserving material and time. The temperature and speed of the nozzle as well as the output thickness respected the recommendations on the manufacturer's website. The 3D prints were made with an *Artillery* 3D printer using the *Prusa* software.

- Assembly

When assembling the robot, I started by taking the appropriate measurements and then cutting the 1 meter aluminum extrusion in half to construct the X and Y axis. I assembled gantry plates alongside the t-slot wheels and spacers, followed by the timing-belt system. Lastly I fixed the laser onto the Y axis gantry plate and fixed the whole construction onto a wooden base, balancing it using a linear rail guide.

Part 2

• Electronic Aspect

The following electronic components were used in the manufacturing process:

i. Arduino UNO
ii. Arduino CNC Shield v3
iii. A9488 Stepper Motor Drivers
iv. 3S LiPo accumulator
v. 20A BMS module (battery management system)
vi. step-down voltage regulator
vii. 12V Solar Panel
viii. Switches
ix. Accessories

From an electrical standpoint, the project has two main points of interest:

- The microcontroller

To be able to control the robot I used an Arduino UNO development board paired with a CNC shield to control the 2 stepper motors more efficiently using the A9488 drivers. The PWM pin from the laser connects to the z-/z+ pin on the CNC shield.

- The power station

Since I opted for an alternative power source, I had to construct a separate power management system. I connected the 3 LiPo cells in series resulting in a battery with a capacity of 12.8V and 1.8A. In ordered to safely charge them I opted for a 20A 3S BMS module which offers protection against over-charge, over-discharge and short-circuit. In order to charge it using solar energy I connected the solar panel to a step-down voltage reductor and further connected it to the BMS module.

The above-mentioned battery is used solely to charge the stepper motors. The laser is charged normally using a socket.

Part 3

• Programming Aspect

Since the robot does not require any pre-written scripts to run, it relies solely on user input. To be able to generate the appropriate *vector* files I used the following open source programs:

- *grbl* library

To be able to control the laser I installed the open source *grbl* library onto my Arduino. As mentioned above, this allows me to transmit commands using the PWM pin on the laser module and the z+/z- pin on the CNC shield.

- LaserGRBL

This program allows me to control the laser using an intuitive user interface. Additionally, it can process any *png/jpg* type files in order to engrave the resulted vector and it allows me to easily modify the intensity of the laser.