6 Work Accomplished

6.1 Designing the mount

While designing the mount, there were several things to take into consideration. First, the camera must sit on an arm, allowing it to rotate freely from the robot. The arm would have to be more than four inches long because there is an antenna that reaches four inches higher than the top of the Thumper chassis. Second, it was known that the ZED Stereo Camera is light, and it would be virtually impossible to design a mount that would break under any loads applied by the camera. Third, the total weight of the mount and camera would not be able to exceed 11 pounds. Based on these criterion, it was concluded that the mount should be kept as short as possible to minimize weight and vibration. It was also concluded that a step motor would be easier to control and program, so a step motor will drive the platform that rotate the camera. PVC pipe will be used to build the mount due to its low cost and weight.

6.2 Mount Design Analysis

The mount must be able to support the ZED Stereo Camera during acceleration and deceleration of the Thumper. To determine the stresses within the mount arm, the maximum acceleration of the Thumper must be calculated. The Thumper has six motors which can muster a max torque (T) of 49 N-cm, a wheel diameter (D) of 120 mm, and a mass of 2.7 kg.

$$\boldsymbol{T = F * d} \qquad \textbf{Equation 1}$$

$$\boldsymbol{F = M * A} \qquad \textbf{Equation 2}$$

Applying Equation 1 with *d* defined as the distance from the force to the axis about which the torque is applied, it can be shown that the max force (*F*) the Thumper can apply to the ground is 8.2 N per motor. The maximum acceleration the Thumper can achieve is 18.3 m/s^2, by applying Equation 2. Knowing the mass of the camera is 159 g, Equation 2 can be reapplied to determine the max horizontal force applied at the top of the mount arm is 2.91 N.

$$\boldsymbol{\sigma = -\frac{My}{I}} \qquad \textbf{Equation 3}$$

Knowing the maximum force applied and the length of the lever arm, we can use Equation 3 to calculate the maximum stresses in the mount arm. At full acceleration, the maximum moment (M) on the arm is 369.57 N-mm. The distance from the centroid of the cross section of the arm (y) is ±44.45 mm. This yields the maximum stresses in the arm at ± 11.64 kPa. The maximum tensile stress of PVC plastic is on the order of 60 MPa, therefore, the maximum stress predicted is well beneath the failure capacity of the material being used.

6.3 Battery Supply Analysis

Two Turnigy hard case pack LiPO batteries will be used to power the entire system, including the Thumper, Jetson TX1, ZED Stereo Camera, and Pixhawk. Each battery is a 5000mAh 2 cell 7.4 volt battery. The recommended motor voltage for the Thumper is 2-7.5 volts. The Jetson TX1 uses a 5V/3V converter. The ZED USB is rated for 5V and 380mA. The Pixhawk USB is rated for 4.8-5.4 volts. The total maximum input voltage for these components is approximately 23 volts; however, that much voltage is not required for operation. Prior testing has confirmed that the two provided batteries are capable of running the entire system together.

6.4 ZED Mapping and Localization Capability

Our main feasibility criteria for this project was the system had to be able to map an area and localize itself within that area. The ZED Stereo Camera meets and exceeds this requirement because it has been designed to add depth perception, positional tracking, and 3D mapping to any application. It can generate a 3D map of an area by using its binocular vison, also known as stereo vision. Similar to how humans can view the world around us in 3D by combining images from each of our eyes to create a 3D image, the ZED Stereo Camera combines images from its two side-by-side cameras to create a 3D stereo picture. The ZED is able to do this process in real-time at a frame-rate up to 100Hz in WVGA mode and can sense how far away objects are from 70cm to 20m. The ZED Stereo Camera is also able to localize itself within the area it is mapping because it has built in 6-axis positional tracking that is accurate within +/- 1mm and 0.1°. Figure 5 shows an example of a 3D map generated by the ZED Stereo Camera. On the right side of Figure 5 the red line shows the camera's ability to track its location within the map it generates. On the left side of Figure 5 the top picture shows a real-time view whereas the bottom picture shows what the ZED Stereo Camera is seeing.

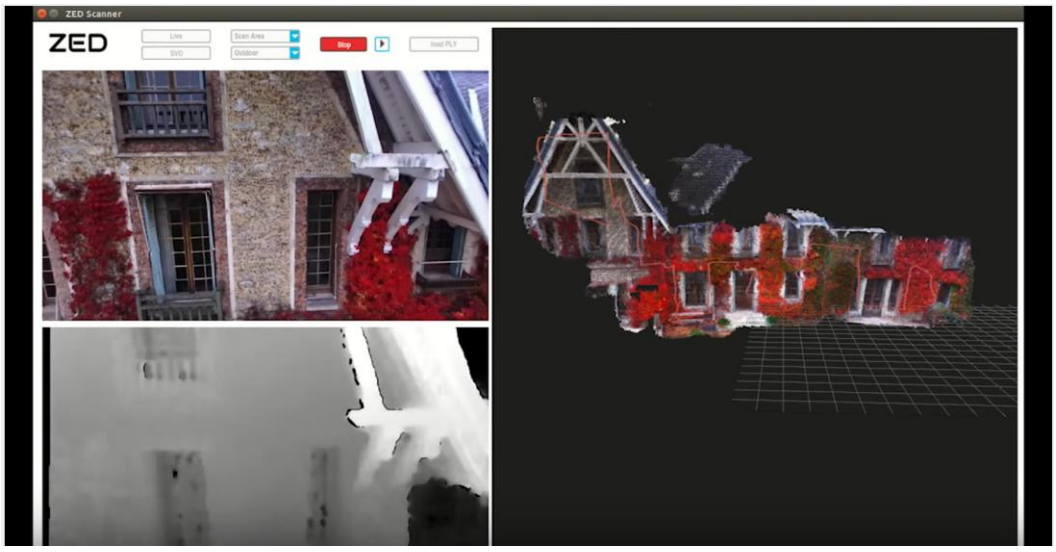

Figure 10: Example 3D Map Generated by ZED Stereo Camera

6.5 Jetson Ability to Process Data

The Jetson TX1 contains a quad-core ARM Cortex-A57, which extends the reach of ARM architecture into premium 64-bit mobile and infrastructure applications. The Cortex-A57 features cache coherent interoperability with ARM Mali™ family graphics processing units (GPUs) for GPU compute applications. The Jetson TX1 also contains an NVIDIA Maxwell GPU with 256 CUDA-cores delivering over 1 TeraFLOPs of performance and has 4GB of LPDDR4 memory. The included camera interface is capable of 1400 MPix/s. These technical specifications make the Jetson TX1 a highly desired and competitive piece of technology for processing SLAM algorithms and will contribute greatly towards the success of this project.

6.6 Size of Area Able to Map

Since the ZED Stereo Camera is a new device, we were unable to find information about the size of the files created when the ZED Stereo Camera maps an area. This information will be gathered through future testing and our information will be updated accordingly. Since the Jetson TX1 will be where the files are saved and it has 4GB of RAM with the ability to increase this capacity through the SD card slot, we predict the system should be able to map any area our client desires.

7 Final Design Specifications

The final design specifications are divided into two categories, system requirements and mount design.

7.1 System Requirements

For the ZED and Jetson TX1 system to function properly, all the following hardware and software requirements must be met.

Requirements for ZED Stereo Camera and ZED SDK:

- Dual-core 2.3GHz processor or faster
- 4 GB of RAM
- NVIDIA GPU with Compute Capabilities > 2.0
- CUDA 8.0
- USB 3.0 port with latest drivers
- Windows 7, Windows 8, Windows 8.1 (64bits), Ubuntu 14.04

7.2 Mount

The chosen mount design, Design 2 which can be seen in Figure 11, will be constructed from PVC with an arm length of 5” and a platform width of 7”. The ZED Stereo Camera will be secured to the platform by using a nylon strap. Constructing the mount out of PVC will keep the cost low, $115, while still meeting all feasibility criteria.