

Design Team 3

Design Issues



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In the course of this project our team has identified several potential design issues. They are related to safety, life-cycle management, and universal design. We have chosen to focus on these issues because they are very relevant to our project's goal. Issues such as those from the environment or adhering to standards, are not very important to this project. This is due to the project being a proof of concept demonstration for a research laboratory and not for use in a production environment.

Safety

This project utilizes two stepper motors which require currents of about 2A while moving, and up to 4A while holding position. Thus, proper precautions must be made to ensure no damage is made to the components or to the user. The power supply used on the mount produces 20V, and is connected to a wall outlet (110V AC), and so this project requires a fuse or other over-current protection in case of a short circuit or ground fault. Additionally, all components must be completely within an enclosure, for the larger components, or insulation, for the wires between them, to prevent short circuits. As this mount is meant to be used outside, these precautions should protect the user and circuitry from electrical shocks caused by water as well other sources. Improvements could be made by producing more electrically stable PCBs for the circuits used.

Even under normal operation, the project still has the capability to be damaged due to high currents. Multiple motor controller boards overheated, or even melted, during development. In order to prevent this from occurring, a custom motor controller board was built with proper heat sinks on all voltage regulators and power MOSFETs. Additionally, active cooling in the form of laptop fans have been added to cool the project. More thermal protection could be done by using a current limiter in series with the motors, to stop over-currents without shutting down the mount.

This camera mount has the ability to rotate up to a rate of 270° per second, and weighs over 30 pounds with the \$40,000 infrared camera attached. This poses a hazard both to the user and the mount during operation. The mount stops and starts suddenly, with

varying durations between movements while it verifies its orientation, so it should never be interacted with while under power. There are currently no safety precautions being taken to address this issue. One possibility for a mass-produced version of the product is to put it within an infrared-transparent dome, which would rotate with the mount, and would not allow the mount to collide with the user. The mount could then shut down when the dome is opened.

Lastly, this rotating platform requires wires be attached to many moving parts. Multiple wires are fed down the central pipe for a variety of purposes, which can become tangled and pull at their connections as the mount rotates. To prevent this, the phone's control software has been made to only allow 190° of movement in either direction from a starting untangled orientation, which must be set manually at startup. The mount can then return to this position as necessary. Additionally, the phone and camera require multiple connections, and both spin vertically up to 180°. These wires must be carefully routed to allow full rotation without interfering with the gears or images taken from the cameras.

Lifecycle

This project was developed while keeping a very strict \$500 dollar limit; this include all electrical & mechanical components, cellphone, power-supply, motors necessary materials. The final project's cost is approximately \$325 dollars with approximately 8 hours of labor needed for production. Production complexity is low. To facilitate the fabrication of the wooden supports and base, CAD drawings were made in 1:1 scale making this part as easy as following the contour line of the CAD drawing stapled onto ½ inch wood boards with a jig-saw. The construction of the camera housing is the most complex part of production, requiring sheet metal breaking and two MIG welds to join the aluminum housing with the aluminum shaft that hold the thermal-camera and phone.

The design is easily maintainable. The entire camera mount was built so that it may be quickly assembled and dis-assembled with each component being individually accessible. regular maintenance requires the bearings be properly lubricated. This

would need to be done every 3.5 months if the mount is under constant use over that time. The components used are of international standard sizing (motors follow a standard casing for stepper motors, all bolts are #10) or common to electronic shops (TI 4000 series ICs and PICs). The motors are easily accessible and secured by a few bolts; similarly to the power supply. The phone, gears and bearings are held in place with set pins and set screws. All custom made electronics, including the phone to motor integration and the motor controller, are in bread-boards located in the vertical support closer to the android phone. Careful consideration was given to the wiring, keeping them flat and flush to the breadboards with the phone connection following the contour of the supports. This works aesthetically, with the white breadboards on our hunter green mount contributing to the spartan MSU theme of the finished product, increases the ease of maintenance should an electronic component fail and allows for easy future expansion/upgrades to the circuitry/motors.

The entire mount is controlled through the use of an Android 2.3.3 smartphone, the predominant Android OS as of May, 2012; consisting of nearly 43% of all smartphone OS market-share according to the think-tank Garner ® Inc. This significantly cuts cost (our phone costing \$50) and also adds to the longevity and maintenance to the product. Any Android 2.3.3 smartphone with a hard outer plastic casing can be used as long as it has the standard GPS, accelerometer, magnetometer and camera equipment of most smartphones. The phone was purposely placed to the right of the camera in its own section with maintenance and upgrading in mind. All that is needed is to place a small hole in the center of phone's outer casing in order for it to be secured to the mount. As far as software is concerned, familiarity with the sideloading of apps into Android and the installation of custom drivers into Windows will be needed.

Even though this project uses low-cost materials with accessible, easy to maintain cheap components, it is quite sturdy. It is able to be mounted in any angle, including upside down. The main electrical line and USB cord that connects the cell-phone to its PC counterpart run along the contour of the mount and pass through the center mounting shaft of the mount. This allows for greater freedom of motion, eliminating many issues

with cable entanglements and rotational range. The largest issue to our design is the lack of an clear plastic dome to protect the camera, phone and mount. Plastic extrusions were outside our shop's capabilities, however the project was designed so that a dome could be easily placed. All the components, including the camera, fit within the radius of the mount's base.

Due to its sturdiness, this project can be transported without the need of many precautions. The main support shaft would need to be removed so that the mount could be accommodated inside a box with some styrofoam-peanuts or boards placed on the sides to absorb shock should it be mis-handled during shipping. The thermal-camera it holds however, would require great caution as it is worth at least 15x the value of our project with far more sensitive and non-replaceable components.

As was mentioned earlier, upgrades can be quickly made to this design. Upgrades not mentioned would include: more power-efficient power supplies, stronger or weaker but more power efficient motors and electronic components with more features such as micro-stepping of the stepper motors.

This project is a proof of concept, however if it were to be marketed, with a protective plastic dome for outdoor use, the mount has an expected life-cycle of 2 years. Potential failures would come from the motors as they do operate with a large amount of power and are constantly on, even when holding a camera stationary. Given that the motors acquired for the initial build are chinese made, we were not able to get much information on their longevity and it is for this reason that our estimate was lowered. Smartphones are regularly replaced every 2 years, however this did not come into consideration since in this scenario, the smartphone would not undergo its normal wear and tear. All other components, including the paint used, have a foreseeable product life cycle of at least 5 years. After 5 years, the integrity of the power circuitry would become a slight concern and the flexing of the wood due to changes in humidity may start to un-level the mount. If this product were to be marketed, the mount would be made entirely of plastic or aluminum, so as not to interfere with the compass, and the stepper motors would be

replaced by higher-performance models.

Universal Design

This design poses a few problems from the standpoint of universal design. To start with, blind people or people with poor eyesight would have trouble operating the device. Schedule files need to be written to an SD card and then inserted into the phone. Without eyesight the process of creating one of these schedule files would be difficult since a computer is required. Also inserting the SD card in the phone is tough without being able to see since the slots on the phone are very small and the SD card itself is rather tiny. Finally, since most of the user interaction with the device is through the phone all of the problems that phones pose to blind people are present in this design. Some of these problems could be somewhat mitigated by including audible notifications of what is going on in our software, there isn't much that can be done about having to physically insert an SD card into the phone however. Many of these same problems are present for people without hands. It is very difficult to interact with the touch screen phone or the physical switches on the circuitry if a person is an amputee. Again, software may be a solution, programs like voice-to-text could assist in writing the scheduling files, and other other forms of spoken commands could be used to reload the schedule on the phone or activate and deactivate switches.

Another problem with the design is the technological learning curve required to use it. Although this device was designed to be simple much of the configuration and interaction with the device is done through the phone and anyone unfamiliar with operating an android phone or SD card technology would have problems launching and running the software. The design also communicates with a laptop through the android debug bridge, this software needs to be set up and running on the laptop in order for the phone to communicate with the camera. Setting up this software can be tricky and all of drivers need to be installed on the laptop to ensure proper communication between the phone and the camera. Unfortunately these challenges are inherent to the android phone and the concept of the project in general and not much can be done to alleviate them outside of proper training. Keeping that in mind, because the operation of the

device itself is quite simple, teaching somebody to operate it would not take very long regardless of a person's technical competence.

The last aspect of the design that may pose problems to some operators is its size and weight. With the camera mounted in the assembly and a laptop attached to it the whole thing will weigh about 40 lbs. The entire device needs to be mounted on a tripod and the physical strength required to handle and mount it will be quite high. Small operators or people with physical disabilities will most likely have trouble setting it up alone. This is easily avoided by having more than one person set it up.