Conference Camera PPM Gimbal

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Abstract

The K-State Salina Unmanned Aerial Systems Department has a camera which needs to be mounted to a variety of UAVs for onboard video capturing. The Toshiba IK-WB21A is a conference camera which includes a gimbal with stepper motors that are not designed for the speeds required to perform in-flight video. The Unmanned Aerial Systems Department wants a camera mounting system with smooth pan and tilt actions that provides the operator with improved situational awareness. To do so, new servos are needed to create a smooth continuous motion for 360 degree pan and 180 degree tilt. The new gimbal designed by the team is a simple and cost-effective solution for the desired result. The camera retains all Toshiba electronics while utilizing a new and improved system for pan and tilt. The system also allows for auto-stabilization software which reduces camera shake.

Introduction

For this project, we were tasked with modifying a Toshiba conference camera gimbal owned by the UAS Department at K-State Salina and adapting it for use on an Unmanned Aircraft. The Toshiba camera gimbal had several setbacks. The stepper motors which controlled the gimbal were jerky and were not compatible with the stabilization software the UAS department wants to use in conjunction with it. To fix these issues we decided that the stepper motors had to be replaced. After researching it was decided that servos are the best alternative for controlling the gimbal. After replacing the stepper motors with servos, the speed and smoothness of the gimbal will be greatly improved. The servos are also compatible with the stabilization software. Three overall solutions were debated during the project. The first is to design and build a completely new gimbal to which the Toshiba camera can be mounted. Secondly, the existing gimbal platform and belt drive could be adapted for use with servos. Finally, the existing platform could be modified for the use of a gear drive system.

Technical Approach

The first problem to address is the stepper motors. There was really only one solution which made sense and that was to replace the original stepper motors with standard servos. Servos would supply fast, smooth movement and could be utilized by the stabilization software. Next, we had to come up with a solution to mate the servos to the hardware that would allow them to control the movement of the camera. The original hardware used a belt pulley system for both the pan and tilt. We considered three solutions for this problem. The first was to redesign the belt/pulley system to accommodate the new servos. However, finding pulleys to mount to the servos was very difficult. Another problem with this solution was finding a way to rotate the pan 360 degrees while maintaining only 180 degrees of servo rotation. Our second solution was to use a chain and sprocket configuration. Even though chain and sprockets were easier to find,

keeping the servo rotation to only 180 degrees resulted in an ugly chain reduction or a sprocket that extended past the outside of the current envelope. The solution we settled on was to use gears. Gears were easier to find than sprockets and provided a much smaller configuration. Gears also provide positive displacement which is preferred over a system that slips if the camera was to be bumped such as a belt system. Next, the servos and gear drive system needed to be mounted to the camera. We considered a couple ways to do this. We could either modify the existing hardware to accommodate the new servos and gear drive system or completely redesign and build a new frame. It was decided that designing and building a new frame was out of the scope of this sophomore design project.

At this point, servos and gears needed to be selected and ordered. For the pan, we used the smallest possible gear that would fit comfortably on the shaft of the original frame and still offer enough space to mount it to the tilt assembly. Then a simple 2 to 1 gear reduction system was used to maintain only 180 degrees of servo rotation. Bushings were designed to mount the free gears to the existing frame at the right heights. For the tilt, a 1 to 1 ratio was used since the tilt would not rotate farther than 180 degrees. Small gears were selected and ordered.

Results

The objectives of the project where met which consisted of modifying or designing and building a camera mounting system for the UAS department to use on their unmanned aircraft. The gimbal was able to pan 350 degrees and tilt 150 degrees with a smooth, fluid motion. The entire system, including the servos and circuitry of the gimbal did consume less than 30 watts of power.

Technical Accomplishments and Design Lessons Learned

During the project many skills were used including the use of CAD programs like Solidworks, CNC machining and manual machining skills, and technical approaches to the design of the gimbal. During the design many ideas circulated throughout the group but finding the best way to build and meet the requirements of the project with the allowed time was a major factor that the group had to accept and start designing after this was accomplished.

Conclusion

The needs for this project included smooth movement, allowance for camera stabilization software, and moderate size and weight. The implemented solution accomplishes these goals in a way that is practical and economic. The 180 degree servos used allowed the use of the camera stabilization software and gave the gimbal a smooth motion when controlled. The 2 to 1 gear ratio on the pan part of the gimbal allows for 360 degree rotation which meets the objective stated. The tilt was required to have at least 150 degree motion and with using the servo and one to one ratio full movement was achieved. Overall the UAS department was very satisfied with the outcome of the gimbal and all problems seemed to have been solved with the redesign of the pan and tilt mechanisms.

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Conference Camera Gimbal

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BACKGROUND

The K-State Salina Unmanned Aerial Systems Department has a camera which needs to be mounted to a variety of UAVs for onboard video capturing. The Toshiba IK-WB21A is a conference camera which includes a gimbal with stepper motors that are not designed for the speeds required to perform in-flight video. The Unmanned Aerial Systems Department wants a camera mounting system with smooth pan and tilt actions that provides the operator with improved situational awareness. To do so new servos are needed to create a smooth continuous motion for 360 degree pan and 180 degree tilt.

OBJECTIVES

Either the existing gimbal must be modified or a new camera mounting system designed in order to satisfy the following requirements:

- Must pan 350 degrees
- Must tilt 150 degrees
- Complete system must not consume greater than 30 watts of power
- Must withstand 15 G's of acceleration longitudinal to the aircraft
- Must weigh less than 1 kg
- Must withstand vibrations from the UAV's engine

DELIVERABLES

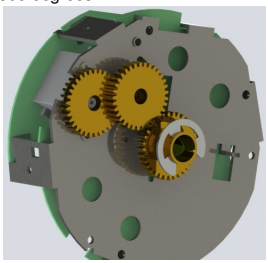
- Working gimbal prototype
- Written Project Report
- Project Presentation

SOLUTION

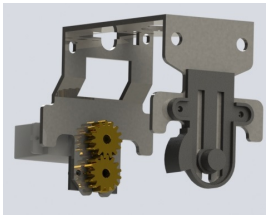
There were several options considered in the design of the gimbal:

- A completely new gimbal design
- Purchasing and modifying a gimbal which includes proper servos
- Modifying the included gimbal in order to incorporate the control of pan and tilt by servos

We decided to modify the existing gimbal to allow for the use of 180 degree TGY-R5180MG servos for pan and tilt. We decided to use the 180 degree servos because 360 degree servos are difficult to find and tend to be too large for this application. The pan consists of a 2:1 gear ratio which allows the camera to pan a full 360 degrees.

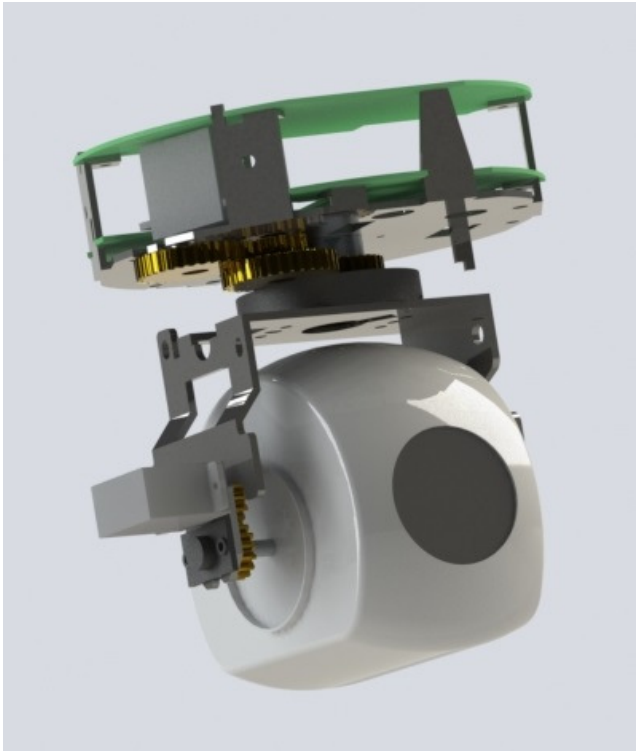


The tilt is controlled by a 180 degree servo and 1:1 gear ratio for a tilt capability of 180 degrees



CONCLUSION

The new gimbal design is a simple and cost-effective solution for the desired result. The camera retains all Toshiba electronics while utilizing a new and improved system for pan and tilt. The system also allows for auto-stabilization software which reduces camera shake.



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