Design of a Stabilized Camera for UAVs

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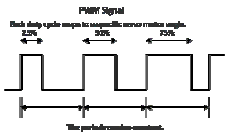
The stabilized camera is a mechatronic system which provides steady video feed from an aircraft. This stabilized camera system was designed to be mounted under the fuselage of Dr. Gabriel Elkaim's unmanned aerial vehicle. There are two parts to this stabilized camera system; the video system and the gimble. The video system captures, transmits, and receives live video. The gimble controls and maintains the orientation of the camera by responding to the aircraft's attitude.

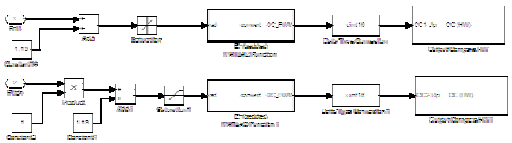
Control System

The gimble houses two standard-sized servos - one for adjusting roll and one for adjusting pitch. In order to hold the camera level and fixed on the horizon, the servos must turn to the negated roll and pitch angles as reported by the aircraft's gyroscopes.



The servos are controlled using PWM signals which are generated by the Output Compare channels on the dsPIC33F.

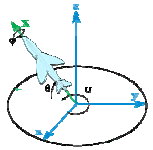
The control system model for the servos was designed using Simulink and is shown below.

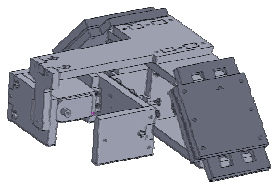


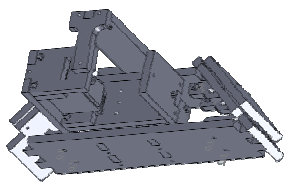
In the model above, there are two sections: the top controls the roll servo and bottom controls the pitch servo. Each section takes the roll or pitch angle in radians as input from the gyroscopes and, after some scaling and offsets, outputs a PWM signal to turn its respective servo to the negative of the input angle. The addition block in each section is due to the servo's angle range starting at a non-zero duty cycle rather than starting at a 0% duty cycle. The saturation block applies limits to prevent the servo from assuming angles outside the gimble's mechanical range. After a simple conversion from double to uint16, the Output Compare block outputs a PWM signal with the appropriate duty cycle.

Mechanical Hardware: Designing the Gimble

Gimble's Function: This gimble compensates for two angles of rotation of the aircraft. The gimble does not adjust for changes in the aircraft's yaw (Ψ), meaning that the camera always points at the horizon in front of the aircraft. However, the gimble does compensate for the pitch (θ) and roll (Φ) of the aircraft by rotating about two axes. As a result, the camera mounted on the gimble is always pointed at, and is level to the horizon.



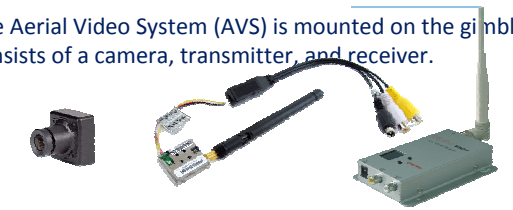




Gimble Design: The gimble was designed in SolidWorks and the parts were cut out using a laser cutter. The sides of the gimble, angled at 46.5°, are designed to attach to the landing gear of the UAV. The parts are firmly fastened together using T-slots. Because of the weight restrictions, the final design is made from balsa wood. However, throughout the six design iterations, the gimble was also tested in cheaper materials like foam core and medium density fiberboard.

Electrical Hardware : AVS and power distribution board

The Aerial Video System (AVS) is mounted on the gimble and consists of a camera, transmitter, and receiver.



The camera captures video and sends it to the 300mW transmitter to be transmitted at 1.3GHz. The receiver at the ground station allows the live video to be viewed remotely.

In order to power the AVS and the gimble's servos, the power distribution board was designed to take 11.1V power from an onboard Li-Polymer battery pass that voltage directly to the camera and transmitter and regulate it to 5V to power the servos. The layout for the board was done in Altium for a single-layer PCB. The power board's schematic, shown below, was designed in Eagle Lite.