Final Project Proposal

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1 Project Description

1.1 Motivation

Unmanned autonomous vehicles (UAVs) are a notable tool that promote environmental interaction without human intervention. UAVs are used in many different applications such as search and rescue, environment mapping, security, etc. Improving the functionality and robustness of these vehicles is paramount as they continue to be integrated into daily applications. To improve robustness of flight, researchers can look to birds as inspiration for fixed-wing UAV designs. Birds morph their wings in flight to adapt and successfully maneuver through unforeseen disturbances. Research in design, modeling, and control of morphing wing UAVs has begun to build momentum in recent years. However, there are not many projects that link biologically inspired data to fixed wing UAV modeling and control. This project will use data from a study of gull wing configuration changes based on observed windspeed [1]. Using this data, the PIC will actuate servo angles based on accelerometer measurements to imitate active gull-wing morphing.

1.2 Functionality

The PIC will simulate fixed wing UAV morphing by controlling two servos that represent two joints of a gull wing displayed in Fig. 1. Additionally, an accelerometer will be used to intake velocity data that will be used in conjunction with a lookup table (LUT) containing predetermined velocity and orientation values that map to joint angle configurations. Therefore, based on the data from the accelerometer the PIC will be able to actuate the 2 DOF system to the optimal configuration.

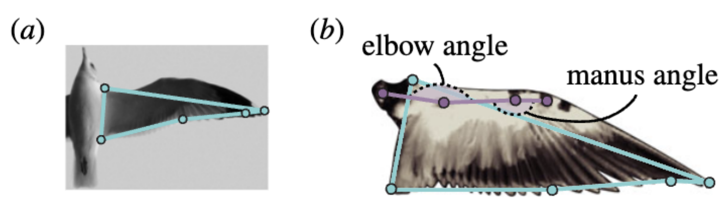

Figure 1: Diagram of Gull-wing [1]

The LUT will be loosely based on the data from Harvey et al. [1]. However, to increase the data points and project complexity, unsupported data points will be added to the LUT to increase the number of output scenarios that the PIC should achieve. The LUT for the system will be preloaded into the EEPROM. The elbow angle will vary between 82-149°at windspeeds of 2-26m/s.

The manus (wrist) angle will be varied from 120-165°. Since this relationship is seemingly linear (Fig. 2), the unsupported data will contain other shifted linear relationships between these angles. First, using the pitch angle of the UAV, a linear set will be selected. Then, the exact angle pair will be selected based on the wind-speed relationship in Fig. 3.

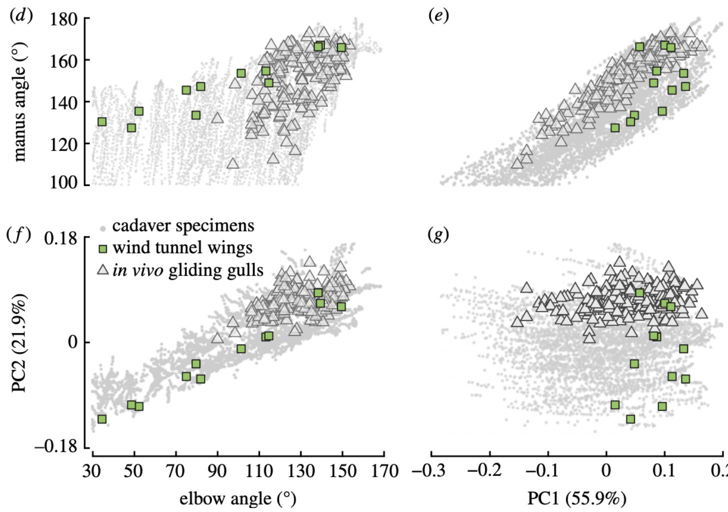

Figure 2: Linear relationship between manus and elbow angle [1]

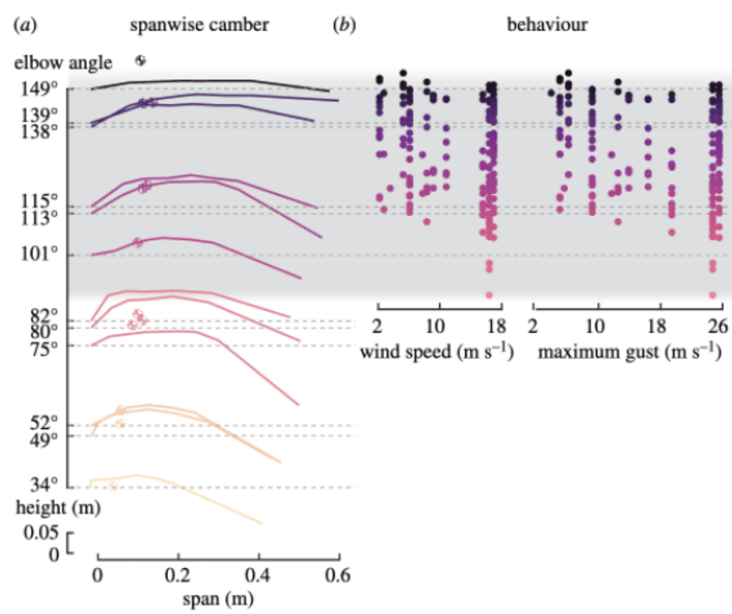

Figure 3: Relationship between elbow angle and velocity [1]

A SparkFun accelerometer will be used to intake forward velocity data (x-axis) in conjunction with the pitch angle of the UAV data. Gulls flap their wings just under 3 times a second at their fastest. However, to ensure that the configuration is updated at a fast enough rate, the measurements will be read at 10Hz. Therefore, 10 times a second, the orientation and forward velocity should be updated for accurate morphing.

The HiTec HS-485B servos will be updated at 50Hz. The elbow varies within a range of 60deg, and the manus varies within a range of 45deg. Therefore, these servos will be able to achieve this range of motion. When loaded the current draw and operating voltage of the servos are 200mA and 6V. The two servos will be connected in parallel, and the power supply will be set according to these specs. This project will not actually load the servos, but an external power supply will be used to ensure the servos don't have any issues rotating.

1.3 Levels of Success

The baseline goal of this project is to achieve successful actuation within the 2DOF system for one orientation at the full range of windspeed values. Ideally, the system will be able to successfully achieve the correct joint configurations for a set of at least ten different orientations. Drafting and uploading the LUT to the EEPROM and ensuring that the PWM for the servos is correctly updated will be a time-consuming process. However, it seems achievable within the timeline left to finish the project. Alternatively, if there are major issues with this implementation, the goal will be to achieve the same steps as above, for at least the servo representing the elbow angle.

2 Graphics

2.1 Software

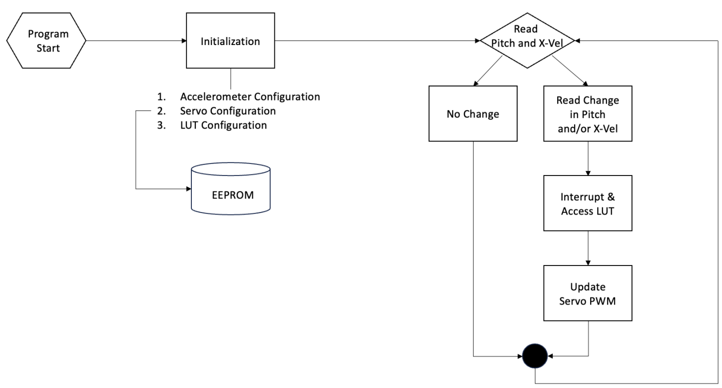

Figure 4: Software Flowchart

2.2 Functional Block Diagram

The following diagrams summarize the functional components of the system. SPI interface is used with the accelerometer using pin RC3. The servo PWM interface will be set up on RC1 and RC2.

PIC Resources	External Resources
TMR1 & TMR3	Accelerometer
ECCP1 & CCP5	2 Servos
Low/High Pri Interrupts	Power Supply
MSSP1 (SPI)	
EEPROM	

Figure 5: Board Resources

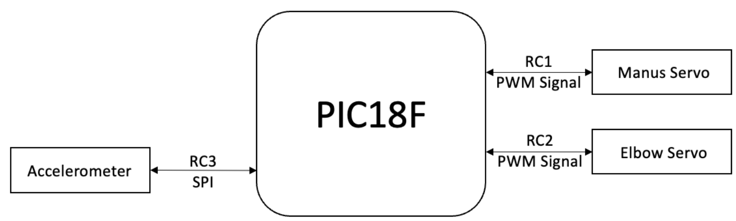

Figure 6: Functional Block Diagram

2.3 Electrical Wiring

The following diagram summarizes the wiring schematic for the system. The powersupply will be tuned according to the constraints of the servos during loading (6V, 200mA).

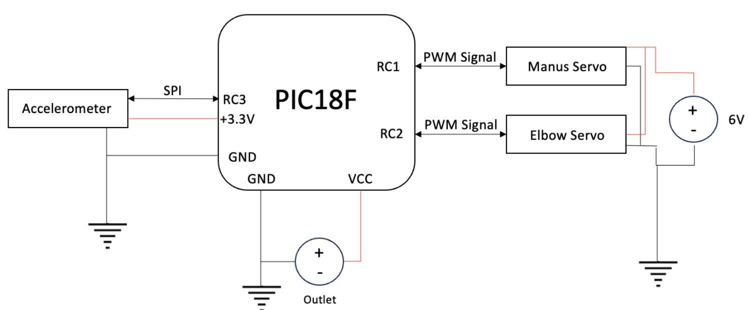

Figure 7: Electrical Diagram

3 Bill of Materials

All of the parts for this project have been ordered, received, and are ready for assembly. Additionally, I will need to check out a power supply from the Aero department.

Part Number	Vendor	Source Manufacturer	Description	Lead Time	Unit Cost	Qty	Line Cost	Purchased
KX132-1211	Sparkfun	Kionix	Low power, 16-bit resolution, 3-axis, Qwiic breakout digital accelerometer	0 days	$17.95	1	$17.95	X
HRC33485S	HiTek	Spektrum	DELUXE HD BALL BEARING, Analog Karbonite Gear Servo	0 days	$0.00	2	$0.00	X
	CU Aero		6V ACDC Power Supply	0 days	$0.00	1	$0.00	X

Figure 8: Bill of Materials

4 Status

Due to the focus on class labs, not much progress has been made towards the project yet. Currently, all the project components have been ordered. Over the next couple of weeks while lab 6 is still being completed, and we are learning about the remaining course concepts, I will focus on the LUT. The values that need to be loaded into the LUT still need to be constructed. Additionally, learning how to use and program EEPROM is a current task that will be manageable to work on before the completion of Lab 6.

References

[1] C. Harvey, V. Baliga, P. Lavoie, and D. Atschuler, “Wing morphing allows gulls to modulate static pitch stability during gliding,” *J.R. Soc. Interface*, vol. 16, 2019.