**Advanced Control for a Robotic Quadrotor-Top Inverted Pendulum (Q-TIP)**

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**Background:**

A 6 DOF (degrees of freedom) robotic inverted pendulum, which can stabilize while moving, was designed and analyzed. Its mechanical structure was assembled by a previous student. The hardware and software subsystems were documented in the previous report. The pendulum system utilizes quadrotor propellers on top to balance while the bottom cart moves around. Quadrotors are consist of two pairs of propellers that will produce torque to stabilize the system. The cart component and quadrotor are controlled by separate compute units. The cart is driven by differential drive motors, which can communicate the information from a Bluetooth module to an Android device. An angle readings Arduino is set at the top of the quadrotor component; the MPU6050’s onboard fusion and a complementary filter are compared. Some components would be replaced and improved after various experiments. Modeling and simulations will be produced after optimizing the system.

The inverted pendulums system is on a ball that is fixed on the cart. The ball allows the system to move freely with respect to the cart. The cart can both translate and rotate on a flat surface by three omnidirectional wheels. However, there is an issue about how to stabilize the pendulum. In some cases, it is easy to stabilize the pendulum without moving the cart. In this report, since the base can also move freely, four propellers are used to maintain the stability of the system. Two orthogonal pairs of propellers are set on the top of the pendulum, one pair for each degree of freedom. Such quadrotor with a cart can be used to the real life application, such as farm monitoring. This device could monitor weeds and the health of crops in a field. Also, it might disguise as a scarecrow to prevent birds attack or expand into other application areas.

**Project Objectives:**

* Try to clean and better organize the mechanical assemblies
* Understand and operate the sensors and other components
* Read and understand the sensor data from MPU
* Optimize the complementary filter to combine gyroscope and accelerometer readings
* Read angle data from DMP and find more real variable parameters to improve the system
* Understand and learn Arduino code to drive all the motors
* Improve the controller, applying LQR

**Methodology:**

Some advanced control theories, such as optimal or predictive control, and sensing are used to get the best performance. Some physical parameters of the system, such as masses, moments of inertias will be identified inside the previous physics model of the system. The first objective is to develop and implement feedback laws that allow the pendulum can be balanced while the ground robot moving. This can be realized by improving the current design of both the sensing and control systems, as well as some hardware components such as motor/propeller selection, motor positions. The existed non-linear model should be further developed in order to improve controllers. Some tools, such as MATLAB/Simulink and C/C++, can be used to improve the controllability and lower power usage for the current design.

For the non-linear mode, it is essential that the parameters of the model can be easily changed when there is a change in the components of the system. So, some subsystems should be developed as they can be easily changed and substituted. The future job is to develop more parameters that are new for this system model in order to better predict the behavior of the real prototype.

**Detailed Work Plan:**

**March**

1. Read the papers and pervious materials in details
2. Understand the hardware structures (i.e. Arduino, basic circuits, sensors)
3. Understand the equations according to its physical parameters (i.e. angles, distance)
4. Start to read the C code while learning the basic C by myself

**April**

1. Try to operate the system and the hardware by using C
2. Keep updating with teammates, and try to figure out some small issues during operation
3. Observe what other variables should be taken in account in order to improve the system and the controller

**References**

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