Self-standing Monopod

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Introduction

0.1 Problem Statement

When doing photography we usually needs tripods to stabilize our camera. However, the problem with a tripod is that it's heavy to carry, difficult to setup, and it does not have too many shooting angles for the camera. Plus it requires a perfectly flat ground to use tripod, which is somewhat inconvenient for photographers. Therefore, we want to design a self-standing mono-pod which is robust and stable for photographers with the technique of state feedback control.

0.2 Objectives

0.2.1 Goals

- The monopod can self stand with the wheels attached on it.
- Give user control that the monopod can be placed in most of the terrains.
- The monopod can withstand at least a weight of a camera at the center with lens
- The monopod is lighter weight than a tripod with same length.
- The above are basic goals we want to achieve, if we can accomplishe these goals early, we may try to adjust the length of the monopod and make it salf-stand. In addition, we can load heavier cameras.

0.2.2 Functions

- Monopod can balance at the vertical position when no camera is attached and no external forces applied to it with less than 2 degree oscillation in any direction.
- Monopod can withstand constant external forces less than 5N. That is to say, monopod will be able to go back to vertical position when constant force less than 5N applied with no camera attached.
- Monopod can withstand tapping force less than 7N and get back to equilibrium position within 5s with no camera attached. (Below is if we have time part)
- When a camera with weight less than 200g is attached onto monopod, it can balance at the vertical position with less than 5 degree oscillation in any direction.
- The length of the monopod is adjustable and can be auto-detected by monopod.

0.2.3 Benefits

- Users don't need to worry about the monopod with a camera will fall down in most of the cases.
- Ability to hold heavy weight camera.
- No need to manually set the monopod to center point.

0.2.4 Features

- It will self balancing due to the technique of state feedback control.
- It can recover to original state when it feels any impulse from outside.
- The monopod is very robust to withstand wind.

Chapter 1

Design

1.1 Block diagram

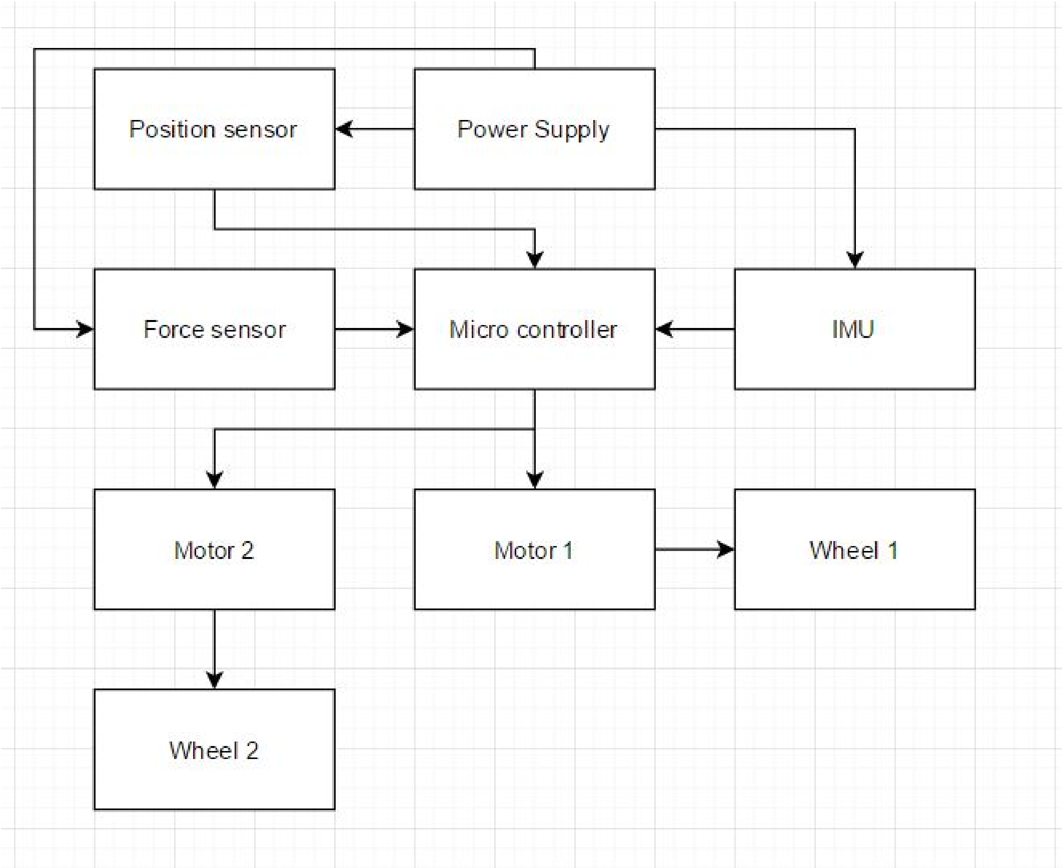

diagram.JPG

1.2 Block description

1.2.1 Power supply

: We use power generator in lab to provide power for our circuit.

Motor 1 & 2: These two motors are connected to wheels respectively and will control how the wheel move to generate torque.

Wheel 1 & 2: These two wheels are mechanical device to generate torque to offset the acceleration caused by monopod.

Inertial measurement unit(IMU): We use IMU's accelerometer to calculate the angle. The IMU sends (x,y,z) acceleration information to Arduino to calculate the angle when it senses the movement.

Micro-controller: We use a ATmega328 RedBoard AVR® ATmega MCU 8-Bit AVR Embedded Evaluation Board as our MCU. This works as a control unit that will take input as output from IMU, force sensor and height sensor and process to get the duty cycles the PWM signal need for motor to balance the monopod.

1.3 Requirement and verification

Requirements	Verifications	
Micro-controller • Input: signals from IMU outputs that tells MC the acceleration. • Output: signals to two motors that can control spin speed. • Requirements1: it must be able to communicate with IMU and motors simultaneously at speed greater than 4mHz. • Requirements2: it must be able to work under 5V voltage and calculate how fast the motor will spin to generate torque to offset the acceleration caused by monopod itself.	• Connect output to computer monitor to check if the micro-controller has correct output when monopod has some acceleration. • Provide input voltage for the microcontroller and test if it can run under the specific voltage. • Check code for calculating the torque for each motor to ensure the functionality for wheels.	30
IMU • Input: power supply with 5V voltage • Output: angular velocity, acceleration. • Requirement1: it should detect correct angular velocity and acceleration with the 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer inside the circuit. I • Requirement2: it should report all the data collected from experiments.	• Check the circuit inside the manual and eyebow the correctness of the circuit. • Connect the output to computer monitor and check if the output of angular velocity, acceleration make sense to us. • Provide 5V voltage and test the functionality of the chip.	30
Motor 1 & 2 • Input: power supply and signal from microcontroller. • Output: motor spinning. • Requirement: it will spin in the direction we assign.	• Provide 5V power supply and test if the motor can spin in speed of 10400RPM • Reverse the power source and test if it can spin another direction.	10

Wheel 1 & 2 • Since they're mechanical devices, we need to make sure it can work fluently.	• Test the friction inside wheels and find the maximum torque it can generate.	10
Power supply • This power supply is from lab function generator.	• Test if the function generator can work.	10
Force detector • We buy this sensor online and test it ourself.	• Test if the force detector can work.	5
Ultrasonic range finders • We buy this sensor online and test it ourself.	• Test if the Ultrasonic range finders can work to detect position sensitively.	5

1.4 Risk assessment and tolerance evaluation

After evaluating the whole project, we may encounter the following difficulties:

1:Math model for the system is fundamental for our project, everything is based on it, and since it is a multi-input and multi-output system, we may use advanced math and physics to solve.

2:Microcontroller communication would be difficult if we designed a circuit with large noise and turbulence.

3. IMU doesn't have that sensitivity to detect tiny changes in angular velocity and acceleration.

4. Ideally the x and y axis for IMU should be perfectly aligned with the two wheels. In reality though, such accuracy is difficult to achieve. We might end up having offsets between the IMU, axis and wheel directions.

5. When camera is attached to the monopod, the center of mass for camera is hard to detect.

6.Therefore we may not be able to get the accurate torque generated by the camera.We control the angular velocity by changing the power supplied to motor. However, finding the exact relationship between motor speed and input power may be a challenge.

Chapter 2

Cost and schedule

2.1 Cost

2.1.1 Labor

Employee	Hourly rate	Total hours	Total cost
Xin Chen	$50	150	7500
Diyu Yang	$50	150	7500
Jianan Gao	$50	150	7500

2.1.2 Equipments

Device	quantity	Model	Total cost
IMU	1	SparkFun 9 DoF Razor IMU M0	$50
Microcontroller	1	Netmega	$25
Motor	2	uxcell motor	$2
Wheel	2	Carbon Fiber Propeller for Mini Electric Planes, 32mm	$8
Force detector	1	Tekscan force sensor	$5
Distance sensor	1	HC-SR04 Ultrasonic Distance Sensor Module	$3

total: 22585

2.2 Schedule

Week	Task	Responsibility
Week4	We contact with machine shop and build math model for the system and buy the equipments we want	Xin Chen,Jianan Gao, Diyu Yang
Week 5-Week 8	Program the IMU and microcontroller to make them work as we expected, document design review	Diyu Yang, Xin Chen
Week 9	Testing the device with the monopod and document some mistakes to fix	Diyu Yang, Xin Chen
Week 10	Fixing the bugs we observed in previous weeks	Diyu Yang, Xin Chen, Jianan Gao
Week 11	Implementing new functions: adjusting height	Diyu Yang, Jianan Gao
Week 12	Implementing new functions: holding heavy camera	Diyu Yang, Xin Chen
Week 13	demo	Diyu Yang, Xin Chen, Jianan Gao

Chapter 3

Ethics

Since our project is involved in any human testing or animal testing, we are not concern about ethics in our project.