REMOTELY CONTROLLED
SELF-BALANCING
MINI BIKE

Team 22

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Introduction

1.1 Problem:

Bike Share and scooter share have become more popular all over the world these years. This mode of travel is gradually gaining recognition and support. Champaign also has a company that provides this service called Veo. Short distance traveling with shared bikes between school buildings and bus stops is convenient. However, since they will be randomly parked around the entire city when we need to use them, we often need to look for where the bike is parked and walk to the bike's location. Some of the potential solutions are not ideal, for example: collecting and redistributing all of the bikes once in a while is going to be costly and inefficient; using enough bikes to saturate the region is also very cost inefficient.

1.2 Solution:

We think the best way to solve the above problem is to create a self-balancing and moving bike, which users can call bikes to self-drive to their location. To make this solution possible we first need to design a bike that can self-balance. After that, we will add a remote-control feature to control the bike movement. Considering the possibilities for demonstration are complicated for a real bike, we will design a scaled-down mini bicycle to apply our self-balancing and remote-control functions.

1.3 Visual Aid:

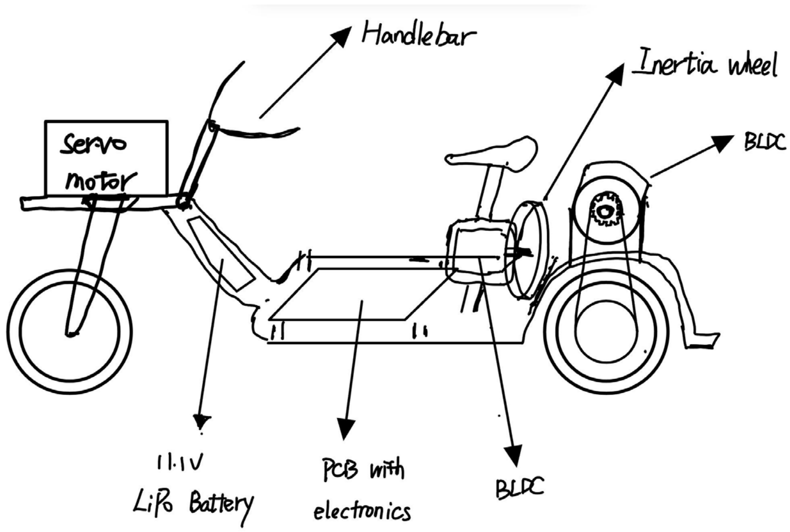

Figure 1: Visual Aid Hand Draft

1.4 Three High-level requirements list:

a. The bicycle should be able to remain self-balanced when the power is on.

b. The bicycle should be able to self-regulate lateral force disturbances within +- 10 degrees and continue to maintain balance.

c. The bicycle should be remotely controlled by the controller within a radius of 5 m from a bicycle and can maintain self-balancing during controlled movement.

Design

2.1 Block Diagram:

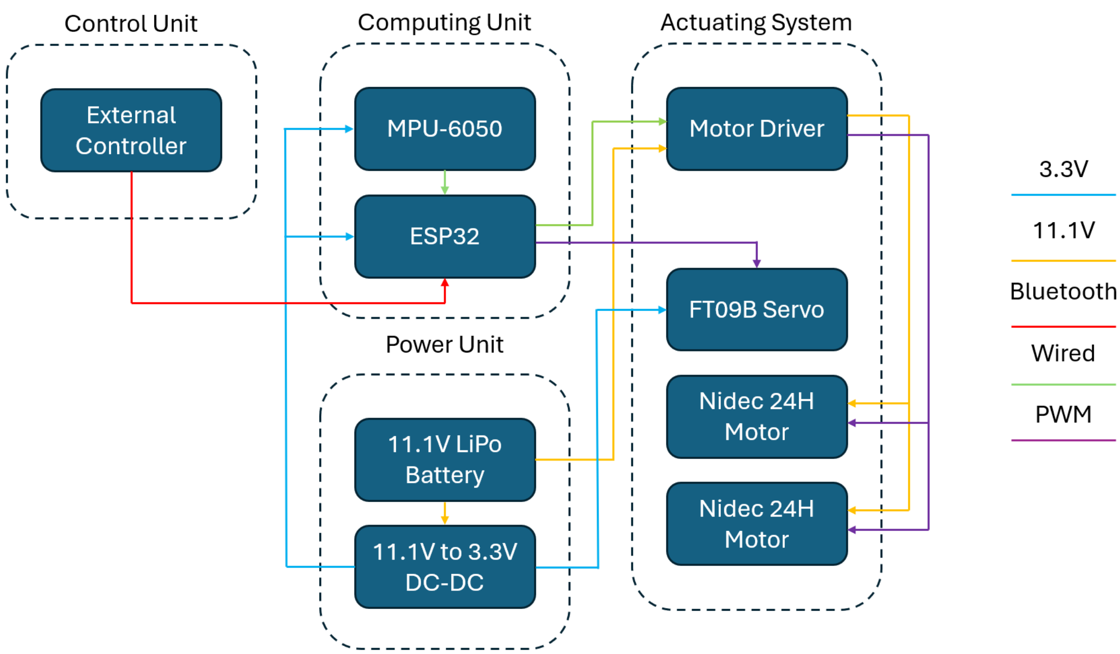

Figure 2: Block Diagram

2.2 Subsystem Description

2.2.1 Power Unit

Overview:

We plan to use one 11.1V LiPo Battery to power all 3 motors and one 11.1V to 3.3V DC-DC converter to power all other electronics, such as microcontroller ESP32-S3-WROOM[2], and MPU-6050.

Requirement:

d. The 11.1V LiPo Battery is supposed to power all 3 motors.
e. The 11.1V to 3.3V DC-DC converter is supposed to provide stable 3.3V+-0.3V to microchips and IMU.

2.2.2. Control Unit

Overview:

We plan to use the Xbox Bluetooth controller and the ESP32-S3-WROOM [2] microcontroller to implement the function of remote control. The Xbox Bluetooth controller serves as the primary input device, providing control inputs such as acceleration, braking, and steering. It communicates these inputs wirelessly to the ESP32-S3-WROOM [2] microcontroller. The ESP32-S3-WROOM [2] Microcontroller decodes and processes these data packets to extract control commands, including steering angle, brake intensity, and any additional functions mapped to the controller buttons.

Requirements:

1. The bicycle can be remotely controlled by the Xbox controller within a radius of 5 m from a bicycle.
2. The remote controller must maintain stable communication with the bicycle with a delay $\leq$ 20ms.

2.2.3. Computing Unit

Overview:

We plan to use an MPU6050 6-axis Gyro and accelerometer sensor to obtain the necessary information about the bike to calculate its tilted angle. The MPU6050 will take 3.3V from the 11.1V-3V converter as input, and it will also be connected to the microcontroller ESP32-S3-WROOM [2]. The microcontroller ESP32-S3-WROOM [2] will decode control information received from the controller, compute the bike's tilted angle with information from the MPU6050, and output the corresponding control signals to each motor.

Requirement:

1. The microcontroller must compute the correct tilted angle of the bike with information from the MPU unit with a tolerance of 1 degree despite external disturbance.
2. The MPU6050 must detect the correct orientation and acceleration of the bike.

2.2.4. Actuating Unit

Overview:

Currently, we plan to use L298N as the motor driver. The controlling signal from the microprocessor ESP32-S3-WROOM[2] will be sent to motor drivers and then passed to each motor. All 3 motors will take 11.1Volts as input voltage. We will use FT90B Servo[3] from FeeTech to control the steering of the bike. One Nidec 24H BLDC Servo motor[4] will be connected to the customized reaction wheel to achieve self-balancing, and the other Nidec 24H BLDC servo motor will be connected to the rear wheel of the bike to achieve the movement of the bike.

Requirements:

1. FT90B Servo [3] must provide correct steering based on the controller inputs.
2. The reaction wheel and connected BLDC servo motor should provide self-balancing to the bike.
3. The second BLDC servo motor should provide movement to the bike based on the controller inputs.

2.3Tolerance Analysis:

Our project has two 11V motors connected parallel to one 11V power source. A voltage regulator(LM2596)[5] converts to 3.3 V which powers all control units and steering servo motors. For our 3.3V circuit the expected maximum current draw is around 1.5 A, but to be safe we set 2.5 A as our average current draw. The maximum output of LM2596 [5] 11V to 3.3V dc to dc regulator is 3 A which means we are in the safe zone. The average 11V LiPro Battery can discharge above 10A, which each of our motors will take 1 A to operate. Thus, all operations are underload.

Ethics and Safety:

Throughout this project, we adhere to the IEEE Code of Ethics. We will "uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities"[1]. We will "treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others"[1]. We will "strive to ensure this code is upheld by colleagues and co-workers"[1].

We recognize that there are some potential safety concerns during this project. The battery must be kept safely, and if the battery shows any signs of leakage or malfunction, we must immediately stop using it and depose it accordingly. The workstation must be kept clean and organized, and tools such as soldering irons must be shut down immediately after use. When handling motors, we must ensure that they will not cause damage or danger to anyone around. We should also be aware of potential electric shock from electronics and batteries. Safety is always the priority throughout this project.

Reference:

[1] "IEEE Code of Ethics." *IEEE*, https://www.ieee.org/about/corporate/governance/p7-8.html

[2] "ESP32-S3-WROOM-1" datasheet, Version1.3 EspressifSystems https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf

[3] "FT90B" FreeTech https://www.parallax.com/product/3v-digital-micro-servo-standard-ft90b/

[4] "Nidec CMC_24" datasheet https://www.nidec.com/en/product/search/category/B101/M102/S100/NCJ-24H-24-01/

[5] LM2596, Texas Instrument https://www.ti.com/lit/ds/symlink/lm2596.pdf