Dagozilla Electrical and Software Description 2020

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Abstract. In order to participate in the 2021 RoboCup Middle Size League (MSL), Dagozilla designed and manufactured a new generation of MSL robots. This paper covers the electrical systems used in the robots and also the software architecture implemented in the robots' system. The electrical systems described in this paper are the power distribution system, locomotion system, dribbler system, kicker system, Hardware Interface, and Inertial Measurement Unit.

Keywords: Middle-size League, RoboCup.

1 Electrical System Overview

The electrical system which the new Dagozilla MSL robots utilize is an overall improved version from the last generation. The new improvements of the system are operating the user to a hardware interface, installing back the standalone rotary encoders, and placing servo for kicking mode.

The primary computing unit of Dagozilla MSL robots is a custom-built personal computer. The computing unit controlled decision-making and environment sensing. A camera is connected to the PC to gather complete information about the surroundings regarding the robot's position and attitude, line detection, ball position, and other robot's position. An ordinary Logitech C922 webcam is implemented for this purpose. The microcontroller in this robot handles the interfacing between the PC, the sensors, and the actuators.

The actuators that the robot utilized are four locomotion brushed DC motors, two dribbling mechanisms brushed DC motors, a kicker system servo, and a solenoid plunger kicker system. The sensors used in the robots are a camera, two dribbling mechanism potentiometers, three standalone rotary encoders, an infrared sensor, and an inertial measurement unit (IMU). The electrical system diagram of the Dagozilla MSL robot is shown in Fig. 1

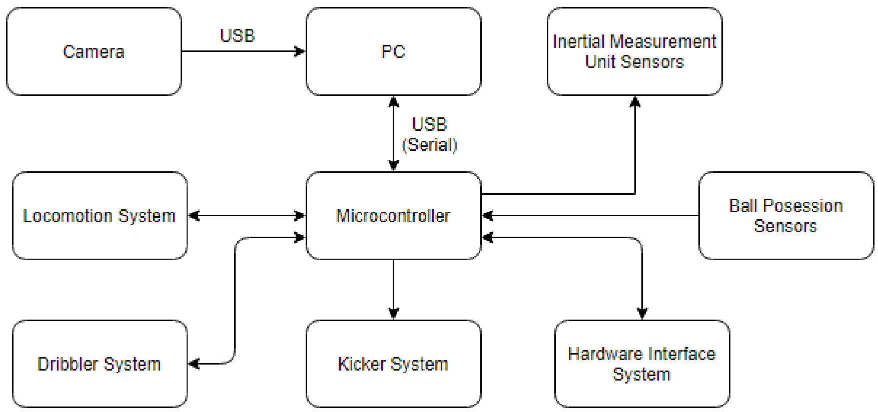

Fig. 1. Electrical Systems Diagram

2 Microcontroller Board

The microcontroller board is a home-designed PCB with an STM32 Nucleo F767ZI development board for outfield player robots and an STM32 Nucleo F446RE development board for the goalkeeper robot as the microcontroller. The microcontroller board serves as the core of the low level control and hardware interface. This board simply connects the development board pins with the peripherals, which consists of actuators and sensors. The electrical schematics of this board can found in Appendix A. Fig. 2 shows the outfield robot schematics and Fig. 3 shows one of the goalkeeper.

3 Kicking System Board

The kicking system board is designed to control the charge-discharge cycle of the kicking system while also providing high-voltage protection to the rest of the robot's system. The kicking system board connects the voltage booster, the capacitor set, the solenoid, and the control circuit. The electrical schematics of this board is shown in Appendix A, Fig. 4.

4 Locomotion System

As with all the brushed DC used in the robot, the four RS775 with 1:13.9 planetary gear used in the locomotion system are driven by a BTS7960 IBT-2 motor driver. The motors had encoders attached on each of them. However, this robot also uses a standalone rotary encoder to improve stability and accuracy of the measurement. In order to improve the modularity and so the electrical parts can fit more compactly, a standalone locomotion and encoder system board is designed. This locomotion system board connects the pins from the microcontroller to the motor driver, the motor encoders, and the standalone encoders. It also reduces the pin amount needed to drive the motor by using a NOT gate. The electrical schematics of this board can be found in Appendix A, Fig. 5.

5 Dribbling System

The dribbling system used a pair of high revolutions per minute (RPM) RS775 brushed DC motor coupled with a bevel gear. As in the locomotion system, the dribbling system board connects the motors with the motor driver. The board also connects the two potentiometers and the infrared sensor to the microcontroller as the ball possession sensor. The electrical schematics of this board can found in Appendix A, Fig. 6.

6 Power Distribution System

The power distribution system board regulates the power flow from the LiPo batteries to each electrical components. This board also had fuses to secure the high-current electrical components from over-current. Furthermore, there are 7 LEDs as power flow indicators. The electrical schematics of this board can found in Appendix A, Fig. 7.

7 Hardware Interface System

The hardware interface system is aimed to simplify the process of gathering hardware state conditions from the main microcontroller and interfacing them using a Liquid Crystal Display and Pushbuttons. This board is expected to show the hardware conditions such as rotary encoder readings, IMU sensor readings, automatic WiFi PC setup, calibrating the IMU, and starting the motors for debugging purposes. This board also uses the second microcontroller Arduino Nano (beside STM32 as the main microcontroller) to ensure this subsystem doesn't disturb the main process of STM32. Another reason for using a second microcontroller is the limitation of the main microcontroller's pin amount. However, due to the COVID-19 pandemic, this subsystem is still in development. The electrical schematics of this board can be found in Appendix A, Fig. 8.

8 Inertial Measurement Unit

An IMU (Inertial Measurement Unit) board used as an intermediary between the orientation sensor and the microcontroller to obtain orientation data (and localization purposes) of the robot. This orientation data, concurrently with encoder data, is being processed in high-level software. The communication between the orientation sensor and microcontroller is using I2C protocol. The IMU sensor that is used in this system is the BNO055 9-DOF Absolute Orientation Sensor. The electrical schematics of this system can be found in Appendix A, Fig. 9.

9 Software Architecture

The robot's software can be divided into 4 major processes: the vision system (codenamed Hyperion), world model (codenamed Prometheus), strategy (codenamed Athena), and control (codenamed Odysseus). There is also a process that handles the robot localization using Augmented Monte Carlo Localization method, which is codenamed Atlas. These processes are implemented as packages, each consisting of several nodes, in a Robot Operating System (ROS) workspace. Each computing unit communicates with each other to share its respective local world model in order to build a distributed global world model as the source of truth for every robot. The communication between computing units is handled using a websocket communication protocol. The diagram of our software architecture can be seen in Appendix B, Fig. 10.

10 Robot Specifications Summary

Each of our robots is equipped with a custom-build PC as the main computing unit. This computing unit handles high-level processes such as computer vision and perception, strategy computation, local world model generation, shared world model integration, as well as communication with base station, low-level control computation, and communication with the microcontroller.

A summary of the robot's computing unit, sensors, and microcontroller is shown in Table 1.

Table 1. Robot Hardware Specifications.

Component	Specification
Computing Unit	
Motherboard	Asus ROG Strix B450
CPU	AMD Ryzen 5 3400G
GPU	Integrated
RAM	8 GB 2400 MHz
Power Supply Unit	Pico Box 300W
Microcontroller Boards	
GK Microcontroller	STM32 Nucleo F446RE
Outfield Microcontrollers	STM32 Nucleo F767ZI
Sensors	
Camera	Logitech C922 Webcam
Actuators and Drivers	
Locomotion Drivers	BTS7960 IBT-2 Driver
Locomotion Motors	RS775 Brushed DC Motor
Dribbler Motors	RS775 Brushed DC Motor

Appendix A Electrical System Schematics

This appendix contains the electrical system schematics or drawings that are used in each of our robots. The schematics start on the next page.

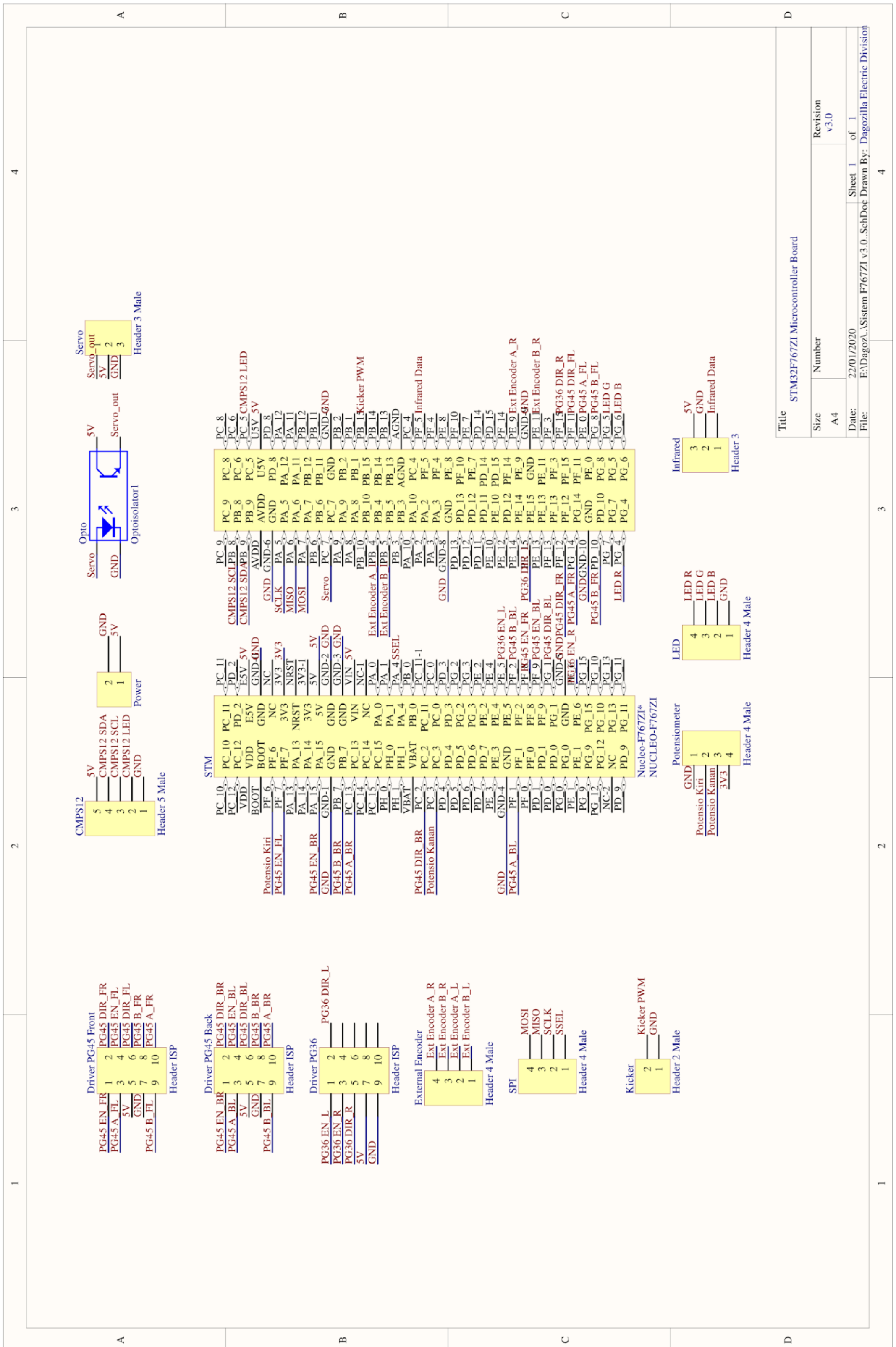

Fig. 2. Outfield Player Microcontroller Board Schematic

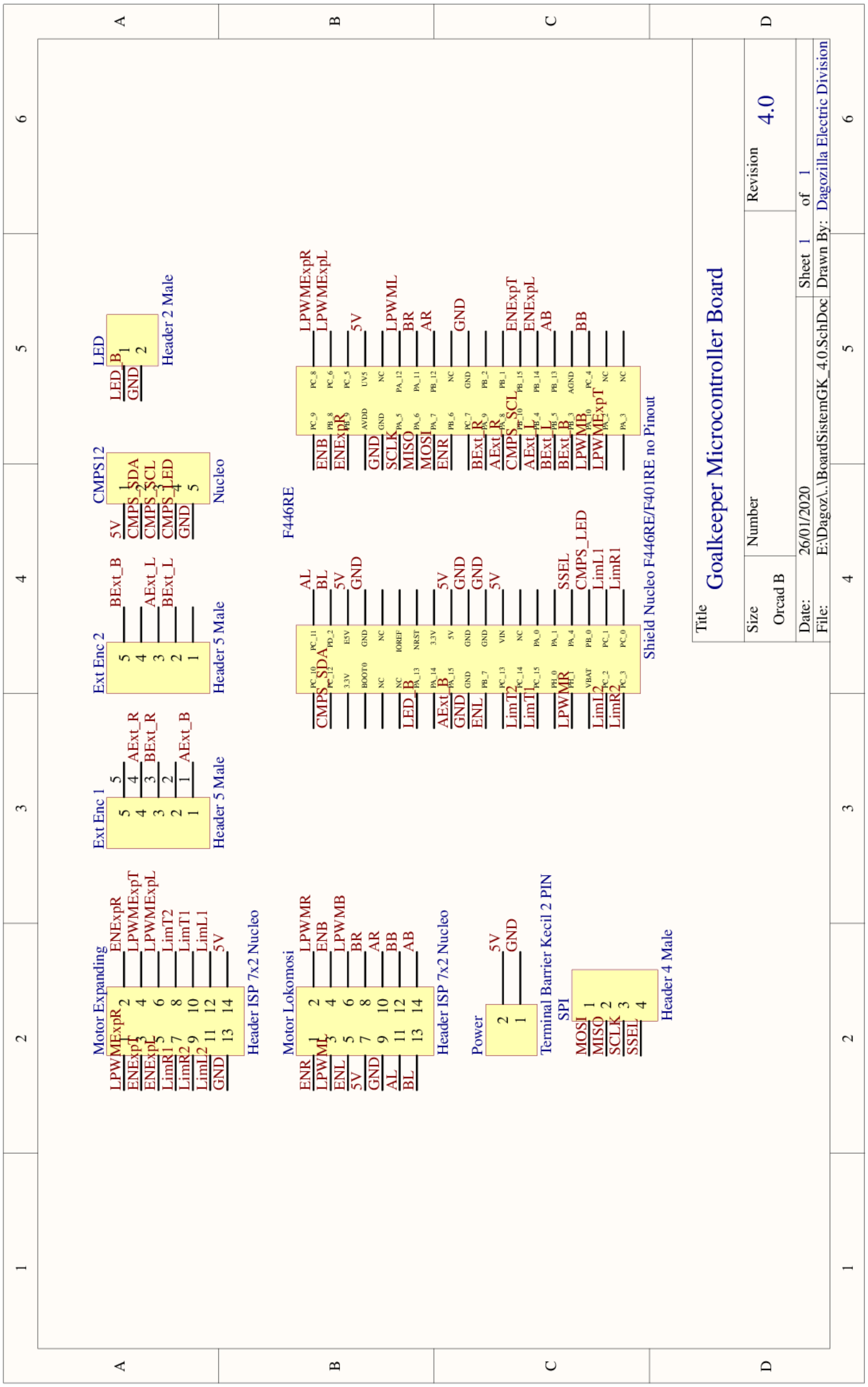

Fig. 3. Goalkeeper Microcontroller Board Schematic

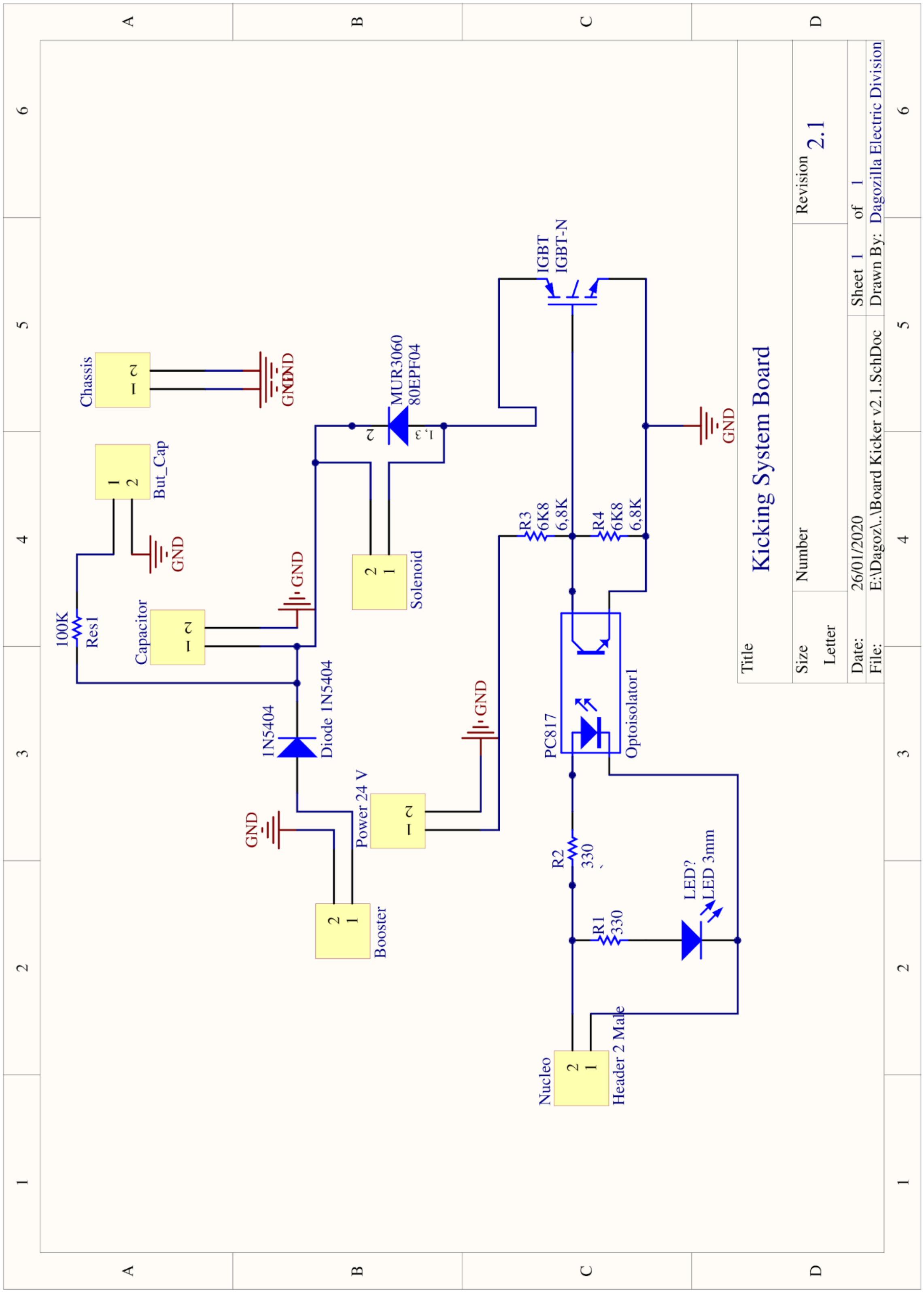

Fig. 4. Kicking System Board Schematic

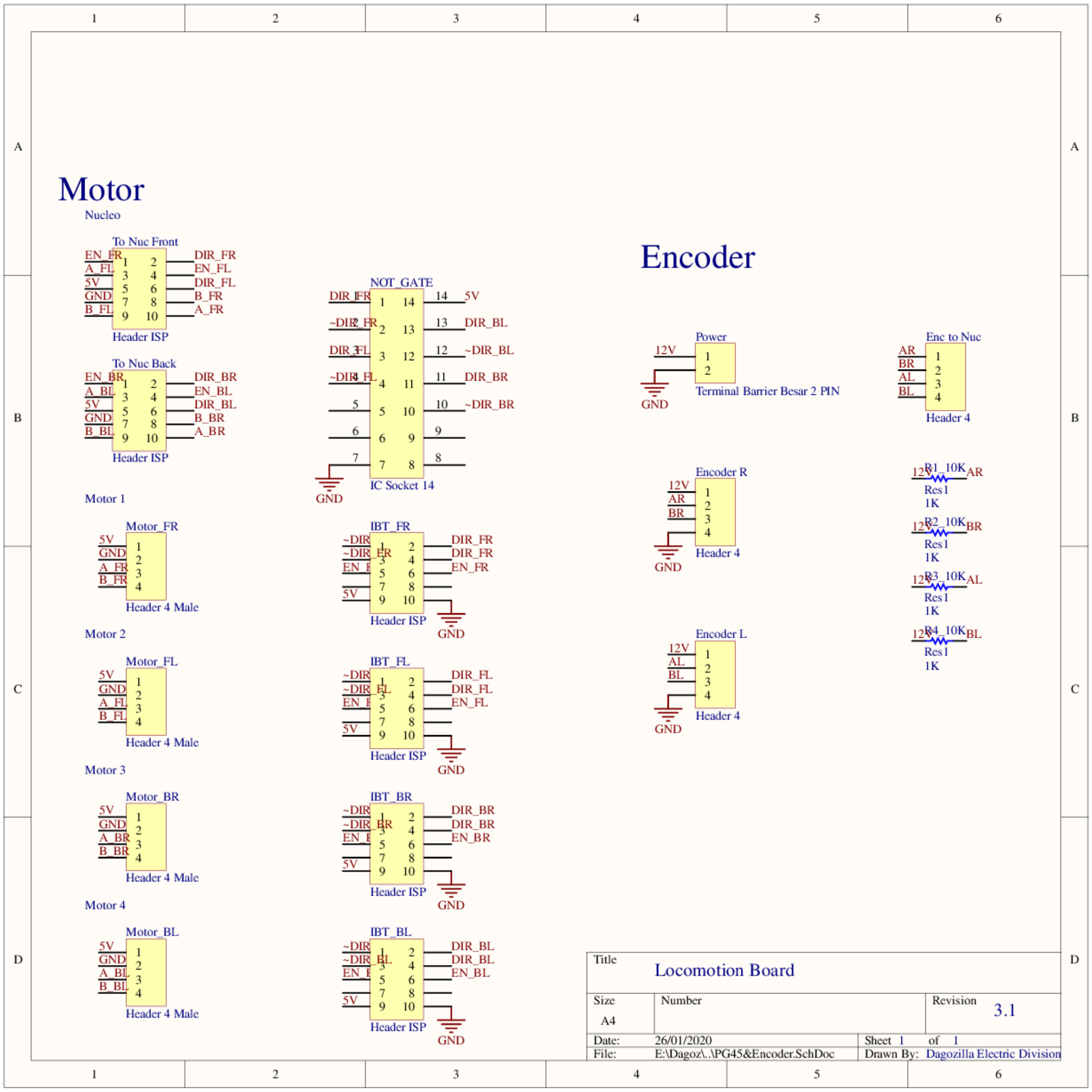

Fig. 5. Locomotion System Board Schematic

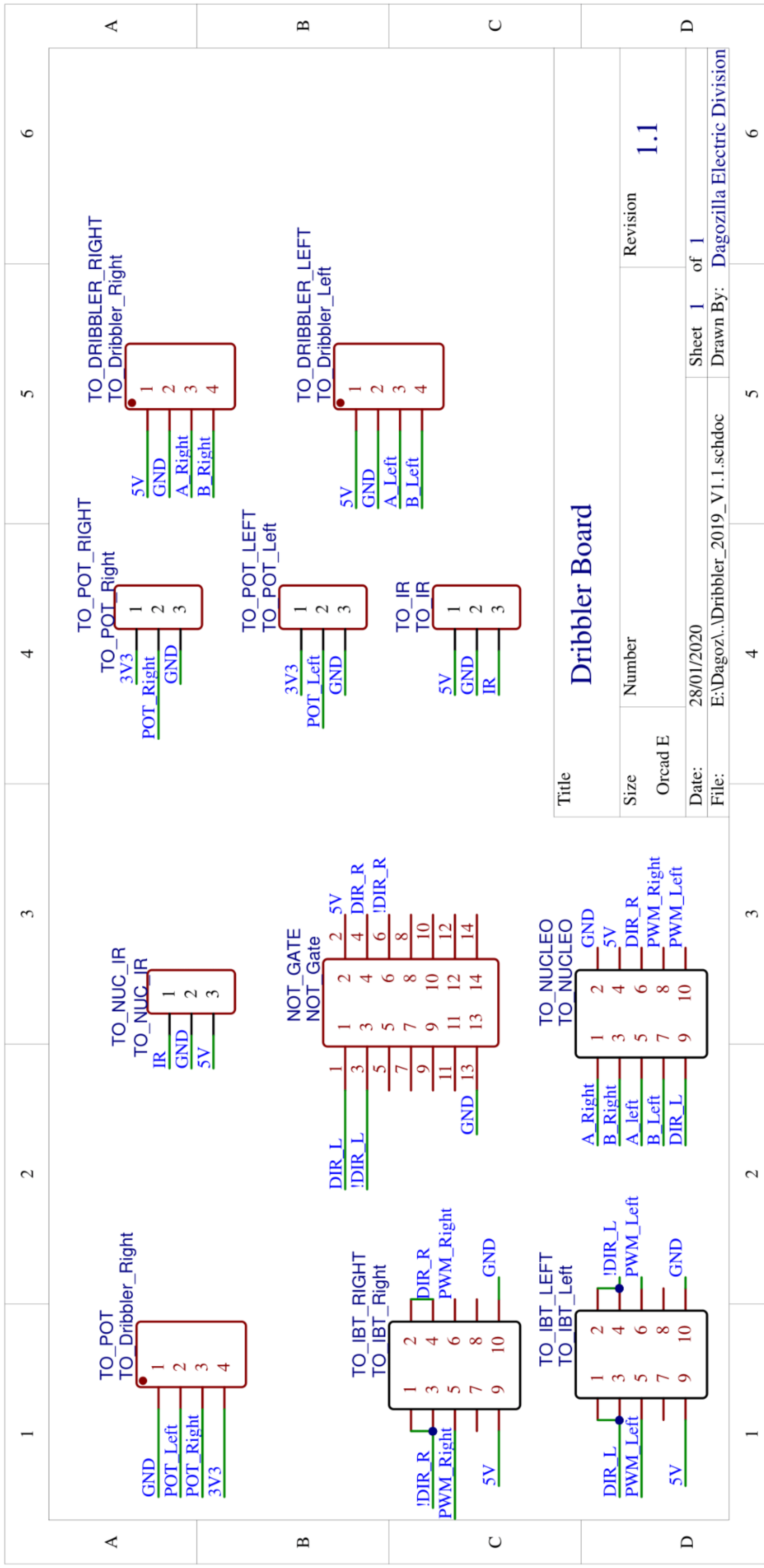

Fig. 6. Dribbler System Board Schematic

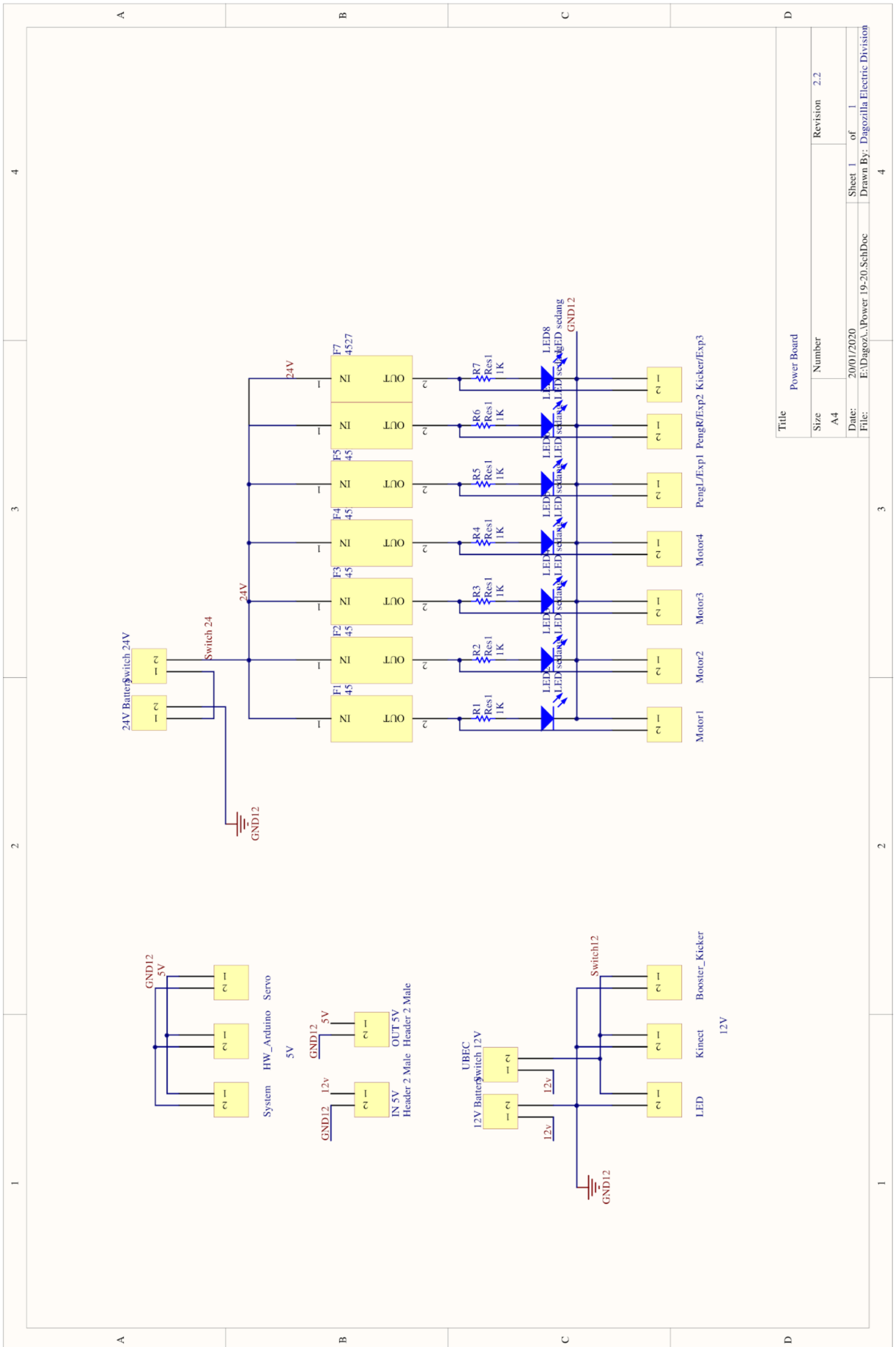

Fig. 7. Power Distribution System Board

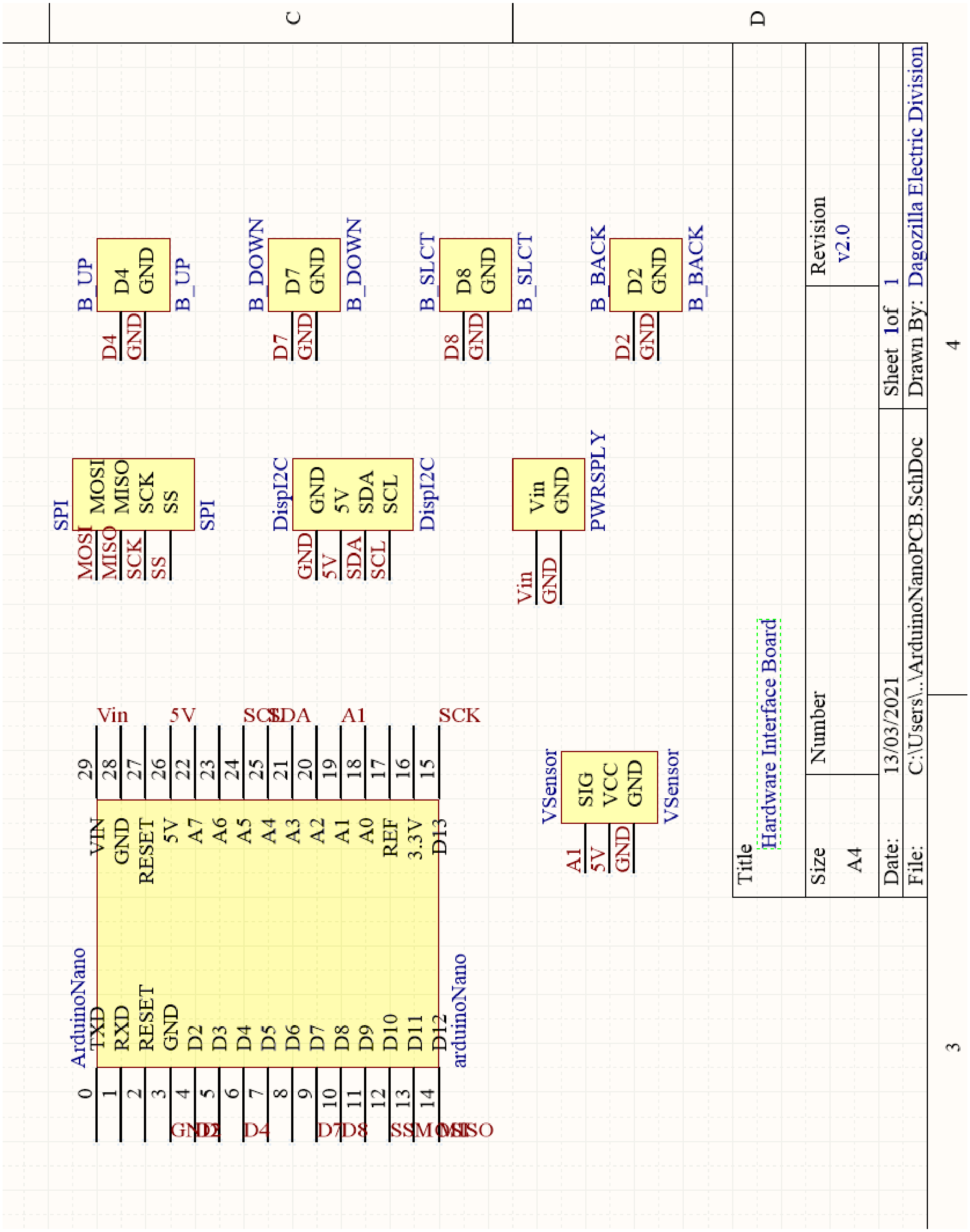

Fig. 8. Hardware Interface System Board

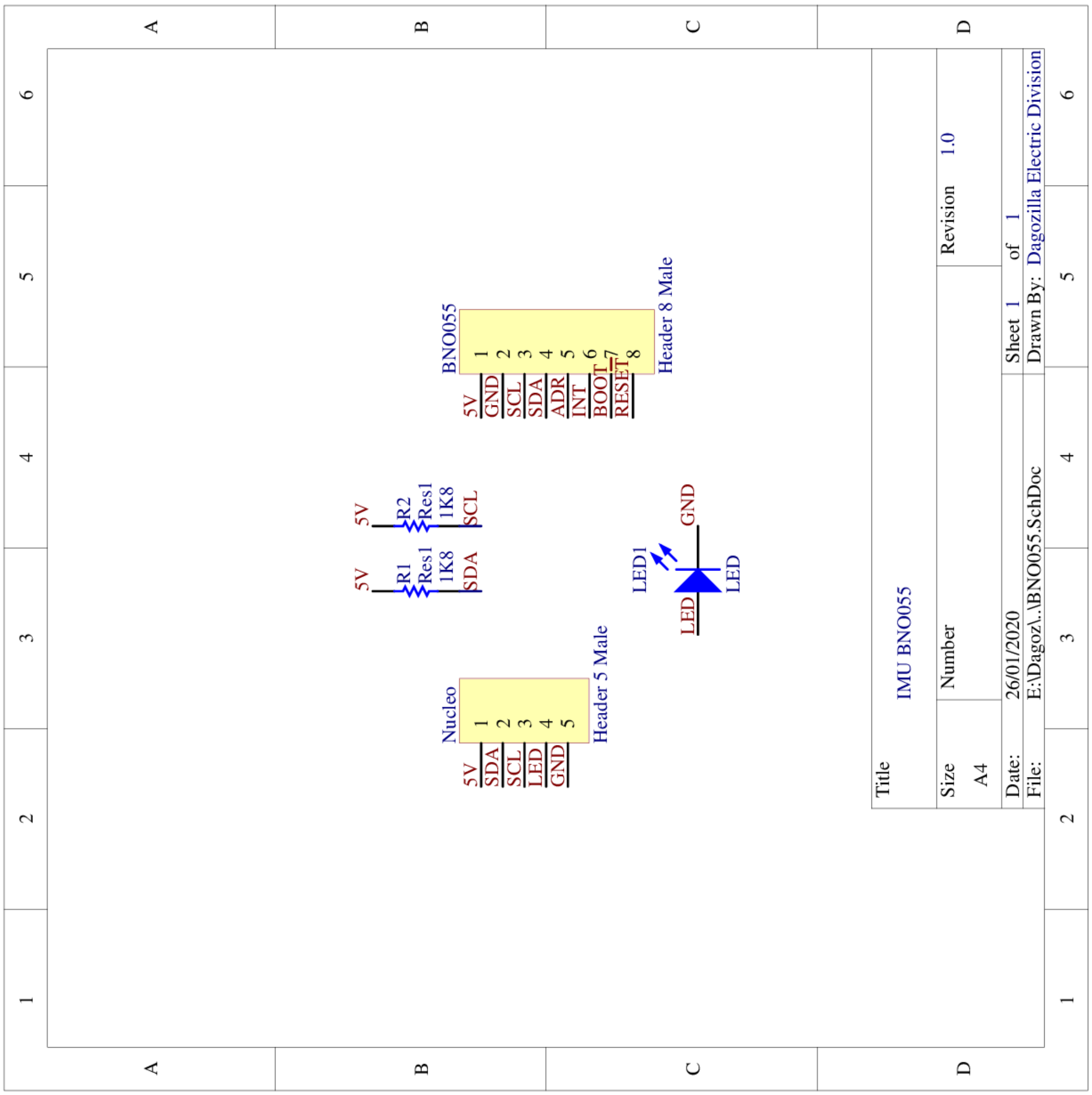

Fig. 9. IMU System Board

Appendix B Software Architecture Diagram

This appendix contains the diagram of the robot's software architecture and data flow. The figure is on the next page.

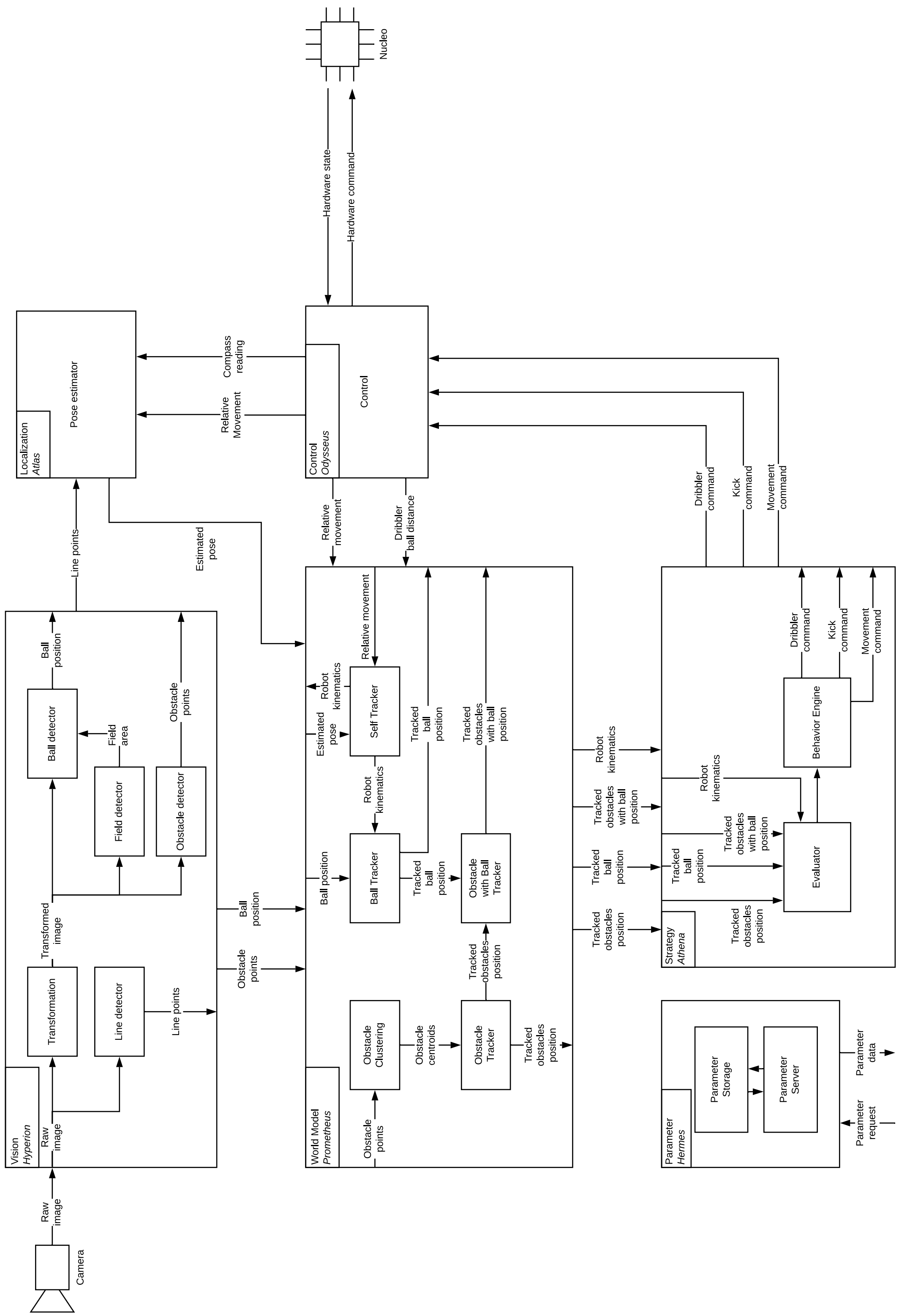

Fig. 10. Dagozilla Software Architecture Diagram