Versatile swarm robotics platform for distributed algorithms developer and interaction

ABSTRACT

This paper introduces a versatile swarm robotics platform for distributed algorithm test and visualization, also an extendable open-source open-hardware platform for developing tabletop tangible swarm interfaces.

CCS CONCEPTS

• **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

KEYWORDS

datasets, neural networks, gaze detection, text tagging

ACM Reference Format:

. 2020. Versatile swarm robotics platform for distributed algorithms developer and interaction. In *Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY*. ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/1122445.1122456

1 INTRODUCTION

2 HARDWARE DESIGN

To make our hardware more universal, we design two different version of Misaka: the commercial version and the explorer version.

2.1 Commercial version

The commercial version aims at HRI applications, as well as algorithms development and visualization senarios. It is small custom-made robot as shown in Figfig:CommercialVersion.

The commercial version consists of a 3D printed frame, custom designed PCB, battery, omni-directional wheels and micro stepper motors.

The frame is printed using PLA(Polylactic Acid). It is carefully designed to fit the motors, wheels, and the PCB. The 3D Model of it is shown in Fig 2, and the CAD detail is shown in Fig 3.

Its dimensions are 100 mm in diameter and 50 mm in height. Each robot is powered by a 450mAh 2S 7.4V LiPo battery. Most of the power in the robots are consumed by the motors. The current draw of each robot is approximately 100 mA when the motors are stalled and 800 mA during typical use. Thus, with a 450 mAh battery, robots are capable of moving for half an hour, and can work even longer with BLE(Bluetooth Low Energy).

Woodstock '18, June 03–05, 2018, Woodstock, NY

ACM ISBN 978-1-4503-XXXX-X/18/06…$15.00
https://doi.org/10.1145/1122445.1122456

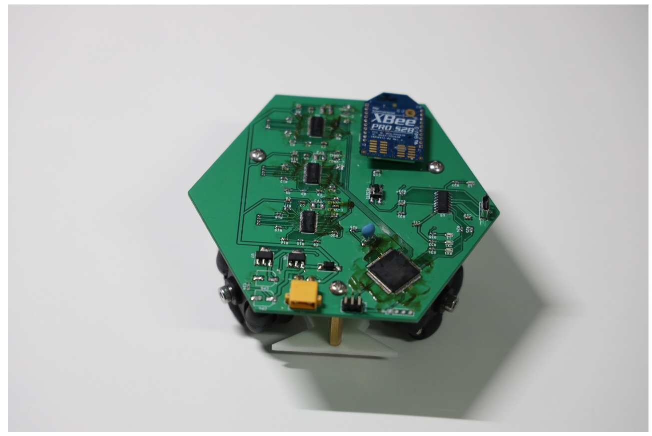

Figure 1: The commercial version

Figure 2: 3D Model of the Frame

Three 38-mm-diameter omni-directional wheels are driven by micro stepper motors to precisely control the rotation angle of each wheel. To drive the robot, a motor driver chip (DRV8825) and three 2-phase 4-wire Stepper Gear Motor are used. With this combination, the robot has a maximum speed of approximately 20 cm/s. The holonomic system allows the robots to move precisely and can easily respond to user interaction. The shape of holonomic chassis is shown in Fig 4, and the real picture of it is shown in Fig 5.

The commercial version main circuit board is shown in Fig 6. The main processors onboard is a AVR microcontrollers(Microchip ATmega2560-16AU) that combines 86 general purpose I/O lines, 32 general purpose working registers, PWM, 4 USARTs, 16-channel

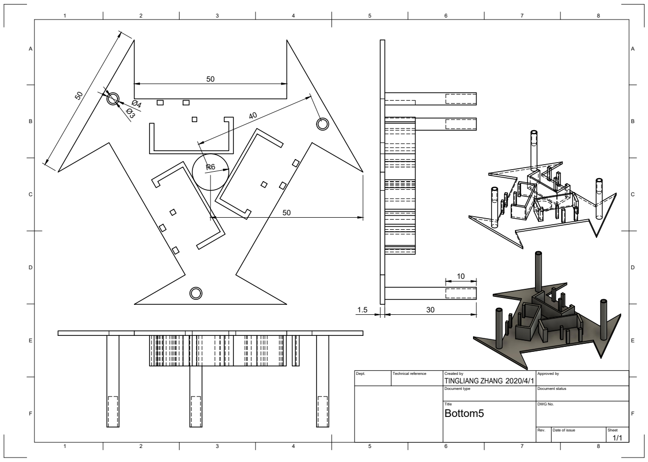

Figure 3: the CAD of the Frame

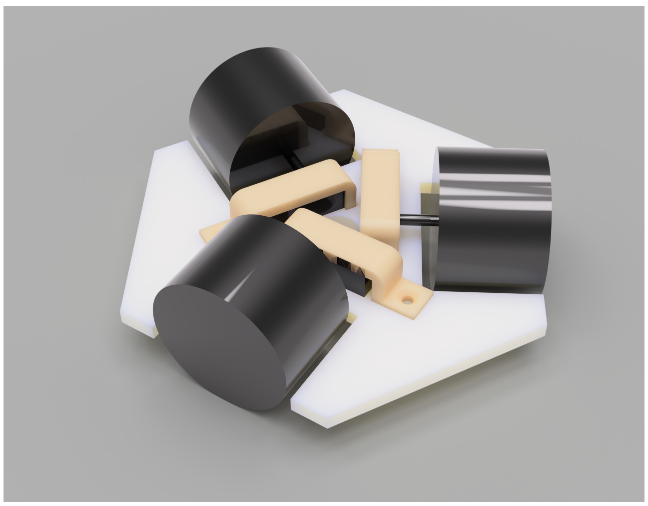

Figure 4: Chassis render

10-bit A/D converter, and a JTAG interface for on-chip debugging. ATmega2560 manages most logic computation.

The PCB schematic is shown in Fig 7, layout is shown in Fig 8

Eight independently WS2812B LED on PCB illuminated in full RGB using are wrapped inside the 3D printed enclosure to provide the robot's state display as well as full color indicating, shown in Fig 9.

Now robots communicates with each other using Digi XBee module. XBee supports mesh networking which can be decentralized. We can use this feature to develop and test distributed algorithms which are also decentralized.

Users can modify the robot for their applications by designing custom modules that attach to its core module or adding powerful chips and development boards to achieve more functions, such as computer vision, wifi, machine learning algorithms, etc. Currently its compatible extensions are shown in Fig 10. For example, in order to give Misaka Linux development environment and capabilities of

Figure 5: The holonomic chassis

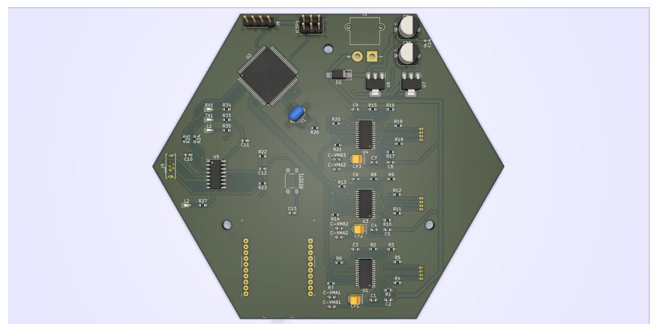

Figure 6: The commercial version PCB

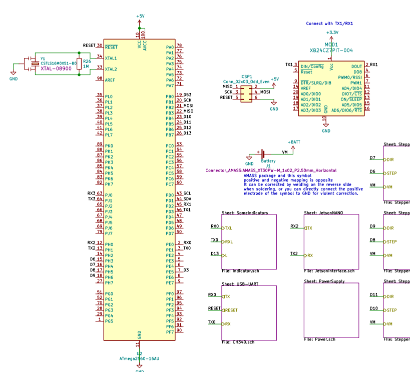

Figure 7: The commercial version PCB schematic

testing machine learning algorithms, we add Nvidia Jetson Nano to Misaka core through UART for high-level control and image processing. And to connect them with bluetooth and wifi, we add

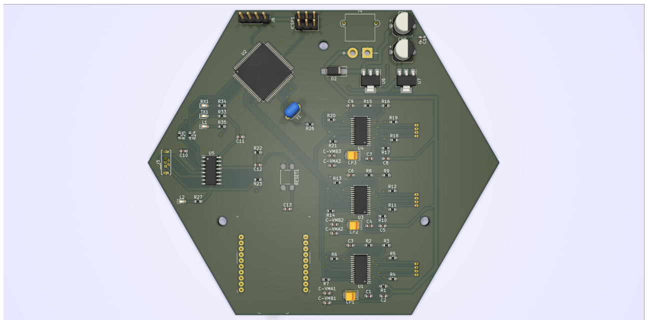

Figure 8: The commercial version PCB layout

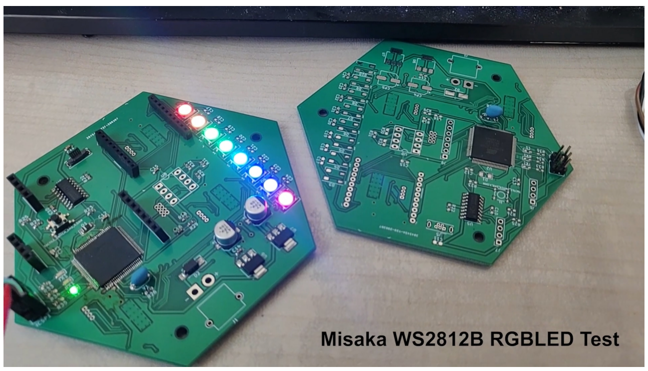

Figure 9: The RGB LED

ESP32 modules which also interact with Misaka through serial communication.[2]

Figure 10: Currently compatible extensions

2.2 Explorer version

For those researchers who want to develop distributed algorithms or tabletop swarm robots of their own, we provide an open-source PCB. It supports four kinds of different communication protocols, and integrates easy-to-use programmer and debug connector. To drive the stepper motor and DC motor, we have Powerstep01 on board with necessary components. To extend its function, we provide a universal interface which can communicate with other development board such as Nvidia Jetson NANO.

All functionalities on board is shown below:

- Mega2560-16AU main MCU
- ATMega16U2 USB-UART
- USB Type C port
- PowerStep stepper motor and DC motor drive
- 9 x WS2812B RGB-LED full-color light display
- Downward looking infrared camera with dot paper for positioning
- XBee3, the main Mesh network communication
- Espressif ESP32, provides WiFi 5, Bluetooth, BLE communication
- CP2102. We can burn programs through USB Type C port
- External battery power supply
- USB port power supply
- Buck DC-DC and impulse back pressure overvoltage and overcurrent protection
- Programmable pins for testing
- Support UART, I2C, SPI communication protocol expansion interface

The PCB schematic is shown in Fig 11, layout is shown in Fig 12, and its 3D model in Fig 13. After SMT, the PCB is shown in Fig 14.

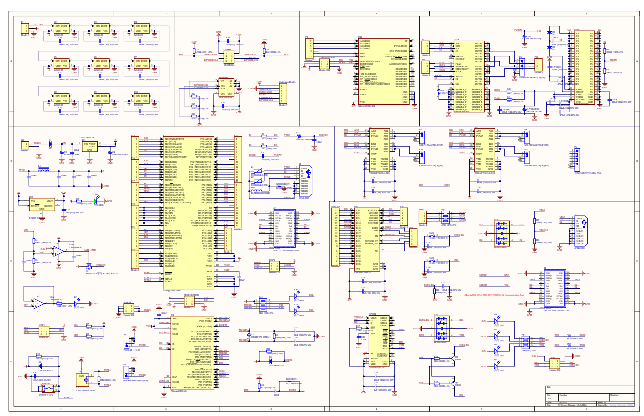

Figure 11: Explorer version PCB schematic

3 FUTURE RTLS WITH BLUETOOTH 5.1

Real-time location systems (RTLS) are used to track and identify the location of objects in real time using "Nodes" or "tags" attached to, or embedded in, the objects tracked, and "Readers" that receive and process the wireless signals from these tags to determine their locations.[1]

The Bluetooth SIG presented Bluetooth 5.1 in January 2019. With Angle of Arrival (AoA) and Angle of Departure (AoD) which are used for location and tracking of devices, we can simply use BLE 5.1 as both communication and localization methods.

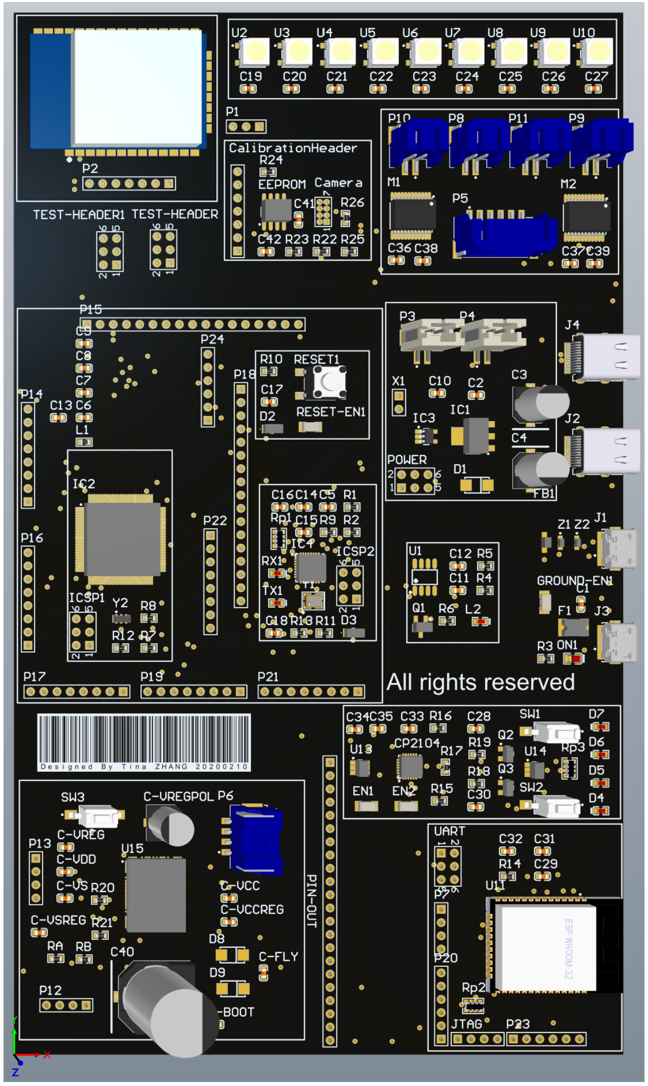

Figure 13: 3D model

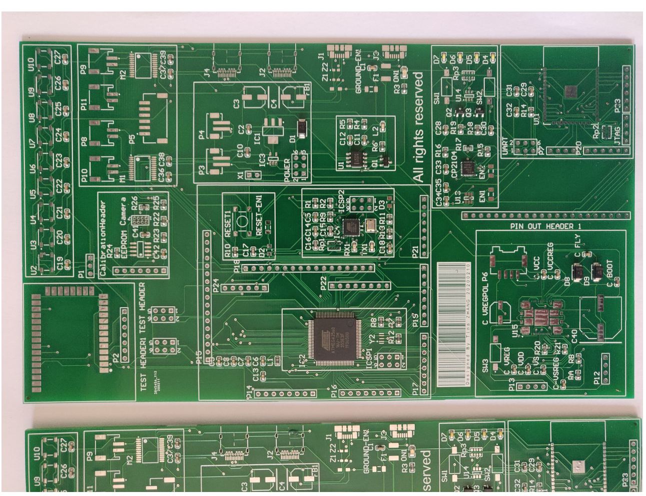

Figure 14: PCB after SMT

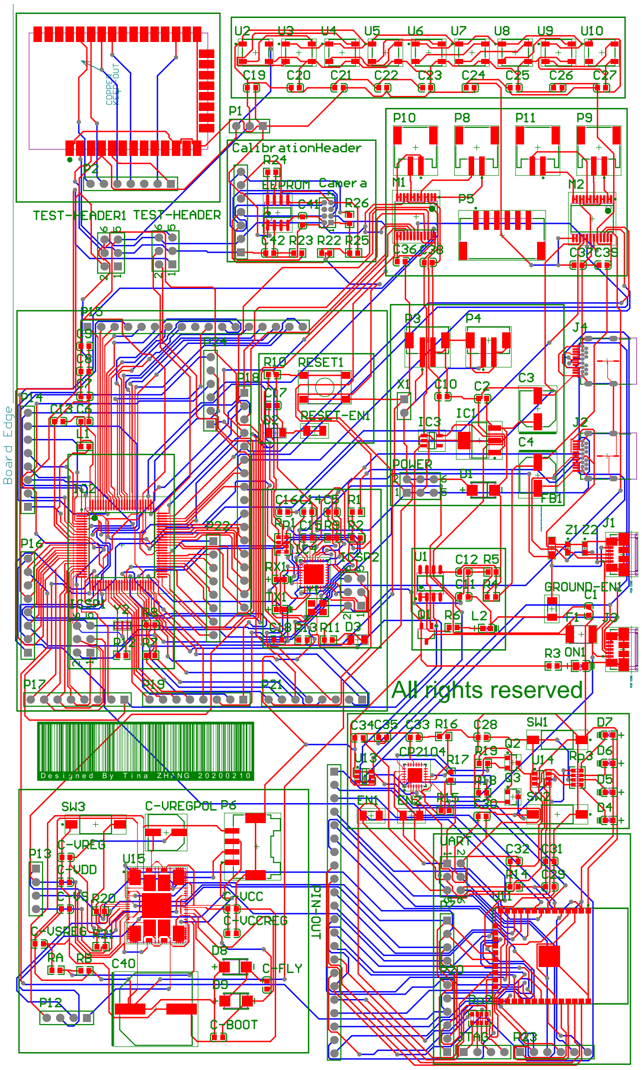

Figure 12: Explorer version PCB layout

ACKNOWLEDGMENTS

To my girlfriend Yihan Jia, for help me during the research.

REFERENCES

[1] HW costs Tags-low and Medium Medium High High. 2009. Real Time Location Systems. (2009).

[2] T. Zhang, H. Zhong, Z. Tan, and X. Yan. 2020. Misaka: Interactive Swarm Testbed for Smart Grid Distributed Algorithm Test and Evaluation. In *2020 IEEE/IAS Industrial and Commercial Power System Asia (I CPS Asia)*. 1610–1615.