DESIGN AND DEVELOPMENT OF HOMOGENEOUS SELF RECONFIGURABLE ROBOTS

İZMİR KÂTİP ÇELEBİ UNIVERSITY 2010

Mehmet Cahit KANKAYA, Ardıl AKÇA, Doğukan TEZOĞLU

Supervisor: Assoc. Prof. Dr. Erkin GEZGİN

MEE DEPARTMENT OF MECHATRONICS ENGINEERING

Abstract

The topic of our project is modular self-reconfigurable robots, abbreviated as MSRR. These robots are formed by the assembly of similar modules in different configurations, both in terms of appearance and structure. In addition to their capability to create different formations, they can easily self-replace malfunctioning, damaged or worn-out modules with new ones without the necessity of complete system or operation halt. Although possible assembly formations may vary with respect to different tasks, this study focuses on two different main formations as a mobile robot platform, and a multi degrees of freedom serial manipulator. In light of this, our objectives are ranging from pick-and-place tasks, which involve the actions of grabbing, carrying, and placing objects, to mobile robot manipulation.

1. Introduction

Our project focuses on Modular Self-Reconfigurable Robots (MSRR) that can be formed by combining similar modules in different configurations. The two main formations we aim to achieve are a dexterous mobile platform and multi degrees of freedom serial manipulator. The mobile platform consists of main modules, power modules, and wheel modules, functioning as a vehicle. The serial manipulator formation involves main modules, power modules, and an end effector for pick-and-place tasks. To enable movement and manipulation, the main module incorporates a gear mechanism with high-torque motors and motor drivers. Connections between modules are established through magnetic coupling and electrical connections using neodymium magnets and spring-loaded pins. The power module contains batteries, while Arduino Mega processors facilitate communication between modules. The prototype requires human assistance for formation changes, but future models will autonomously switch formations and perform various tasks concurrently. In conclusion, MSRR offers innovative possibilities in robotics, as demonstrated by our Mechatron project.

2. Conceptual Design

Coarse structural representations of selected modules can be seen below in preliminary project drafts along with detailed inner design.

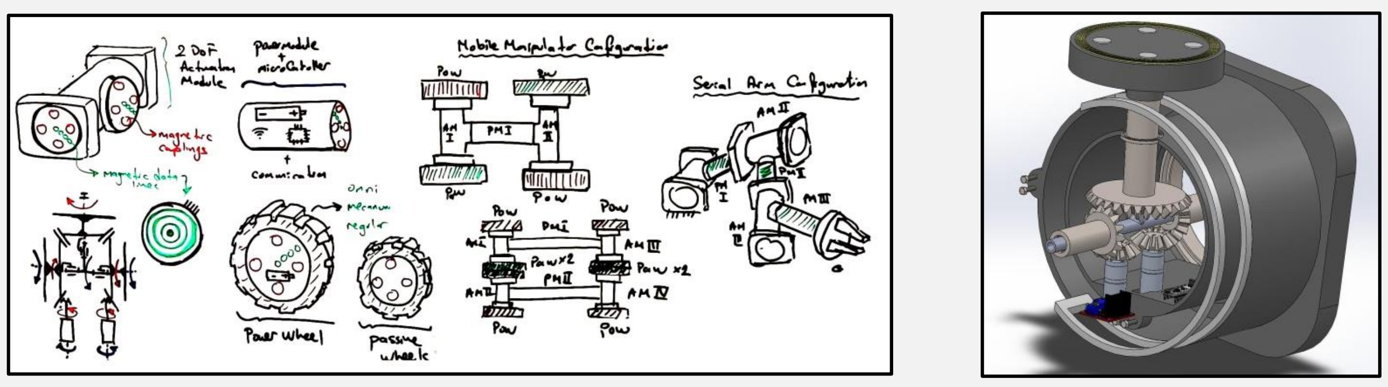

Figure 1: Conceptual Draft and Detailed Design

3. Theoretical Calculations

Diameters of Gears:
Small Gear: D = 50mm
Medium Gear: D = 57mm
Big Gear: D = 110mm

Circumferences of Gears:
Small Gear: $C = \pi\, 2\, (D/2) = 314.16$mm
Medium Gear: $C = \pi\, 2\, (D/2) = 358.14$mm
Big Gear: $C = \pi\, 2\, (D/2) = 691.15$mm

Angles of Gears:
Small Gear: $\alpha = (26.18/D)\, 180° = 93.95°$
Medium Gear: $\alpha = (25.58/D)\, 180° = 80.78°$
Big Gear: $\alpha = (24.68/D)\, 180° = 40.49°$

Angular Velocities of Gears:
Small Gear: W = 100 rpm for motor
Mid Gear: W = 100 rpm (N1/N2) = 85.71 rpm
Big Gear: W = 100 rpm (N1/N3) = 42.86 rpm

Motor Torque:
$T = K_t.I = 0.805$N.m/A 5.5A = 4.428 Nm

4. Experimental Setup

3D models of the proposed system modules were designed in SolidWorks prior to the prototype manufacturing.

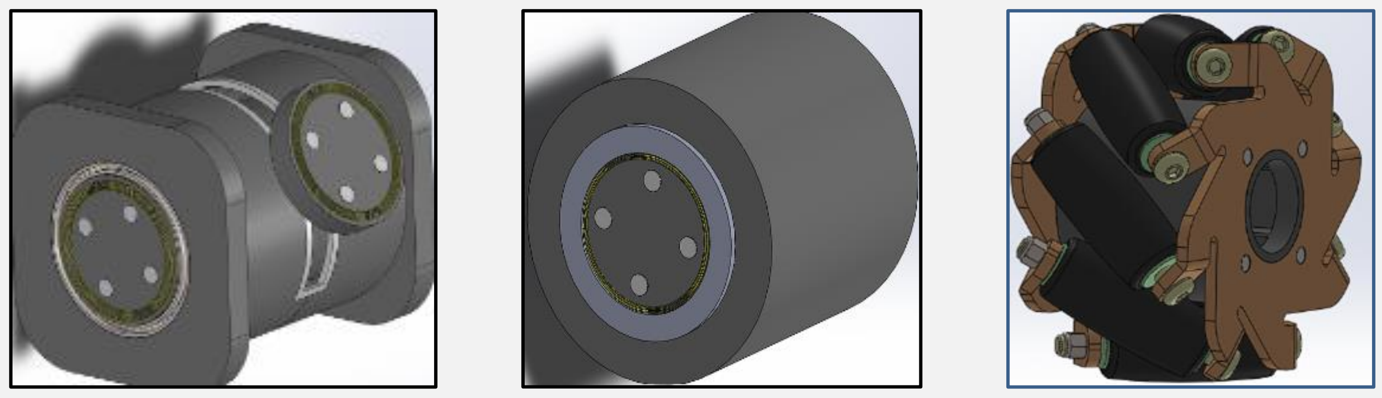

Figure 2: 3D CAD drawings of the main module, power module, and wheel module, respectively, are as follows.

The mobile manipulator configuration and serial arm configuration were created by the modules were conceptualized by using SolidWorks.

Figure 3: Serial Arm and Mobile Manipulator Configurations

This study introduces a master and slave code written to realize simultaneous control of two motors and also to communicate with other ESP32 devices. It is used to control motors and communicate with other devices using these ESP32 microcontrollers.

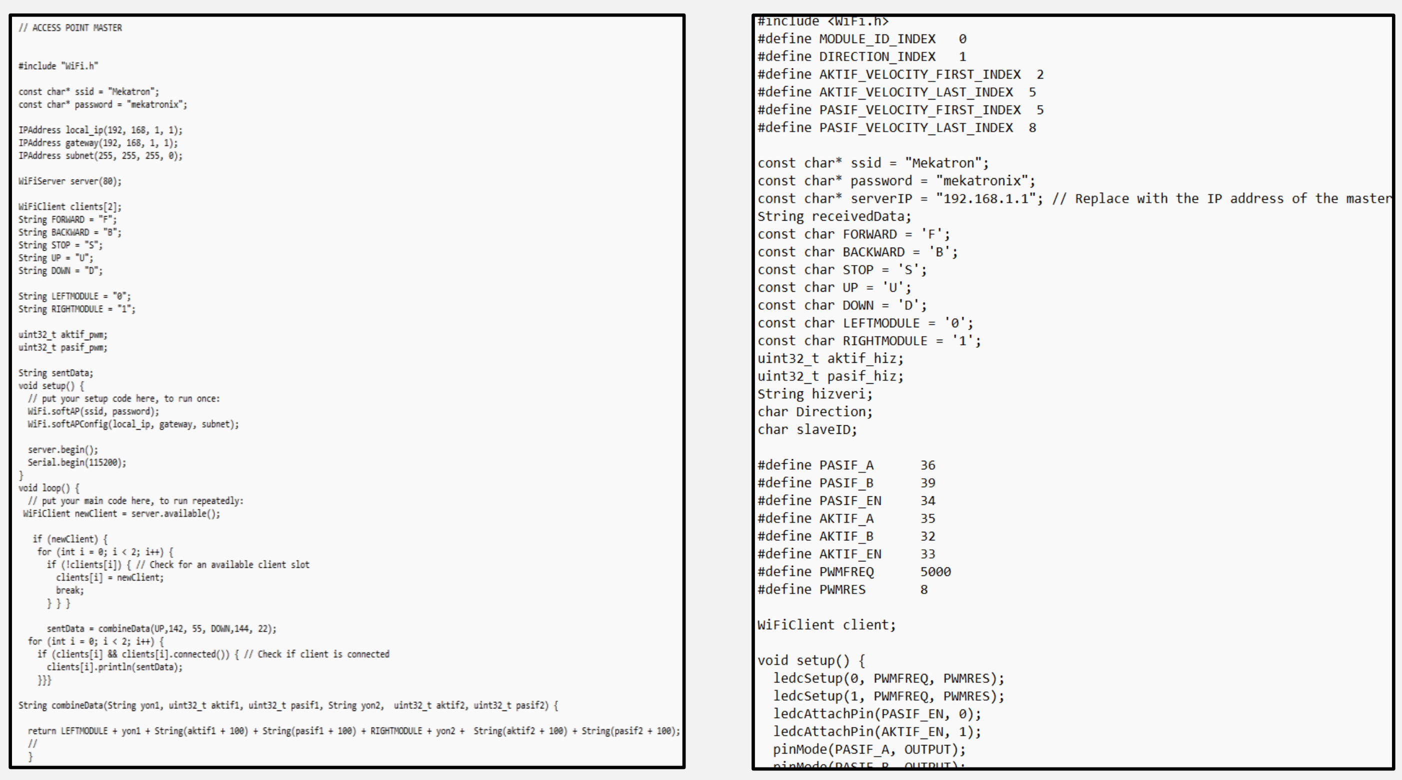

Figure 4: Code for System Integration

5. Conclusions

This project has utilized a differential gear box system, enabling a successful theoretical transition from a mobile platform structure to an industrial robotic arm structure through its self-reconfiguration capabilities. Our designs have been created using the Solidworks application and successfully assembled in simulation environment. The next steps for this project will involve optimization of its physical dimensions and achieving autonomy. Once these stages are completed, the project will be able to be used in various fields of activity and can be remotely controlled. Looking at other modular robots, a similar differential system has been used in the Smores-ep, which assists in lifting other modules. Another aspects of future work includes to perform simulations of the entire system in a simulation environment where physics can be applied and rapid prototyping of whole system for hardware verifications.

References

[1] The SPHERES Guest Scientist Program (PDF), Mark O. Hilstad, John P. Enright, and Arthur G. Richards Swati Mohan, 2010-01-05.