SPHERICAL MOBILE ROBOT

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***Abstract*— Spherical robots utilize an original locomotion sys- tem by displacing its center of gravity in order to generate torque and rotate itself. Spherical robots, however, can generate only small amount of torque for rotation. This makes its locomotion ability for uphill climbing and obstacle over running greatly limited. Therefore, this study focuses on spherical robots operating on rough and uneven floors. It describes the basic dynamics and control methods, which can applied for enhancing the features and overcoming the disadvantages.**

First the dynamics of a spherical robot is investigated for two motions: driving and steering. Second, this paper describes the newly developed prototype robot including its wireless communication. The wireless system is one of the critical components of the prototype, since rotation does not allow physical wiring. Third, in order to avoid clumsy and unstable motion coming from the spherical shape, weight manipulation was done to achieve maximum symmetry and lower center of gravity.

I. INTRODUCTION

Spherical robots are generally comprised of an outer spherical shell and an internal propulsion mechanism.

The shell may be made of multiple parts but they all move and rotate together as a single body as the robot rolls. While the mechanical design of the internal propulsion mechanism can vary greatly, the primary means of locomotion is by shifting the center of mass of the sphere. The acceleration due to gravity acting on the center of mass generates a torque on the sphere causing it to roll. By actively shifting the center of mass inside, a spherical robot can be directed to travel in a controlled manner.

A wireless interface through Playstation 2 console is estab- lished and used as a controlling device for wireless commu- nication with the spherical robot.

II. SYSTEM DESCRIPTION

A. Remote Control

Figure 1 shows the Remote Control which comprises of a PlayStation2 Console embedded with a 2.4 GHz RF Transceiver that communicates with the Central Control Board inside the Spherical Mobile Robot. Due to the spherical nature of the robot, a wired interface would have hindered the very motion of the robot the remote is trying to maneuver. This console uses the SPI mode of communication and with a data rate option from 64 Kbps to 512 Kbps and acts as the Slave in the communication process. The console sends data according to the commands sent to it by the Central Control Board micro controlling unit which acts as the Master in this process.

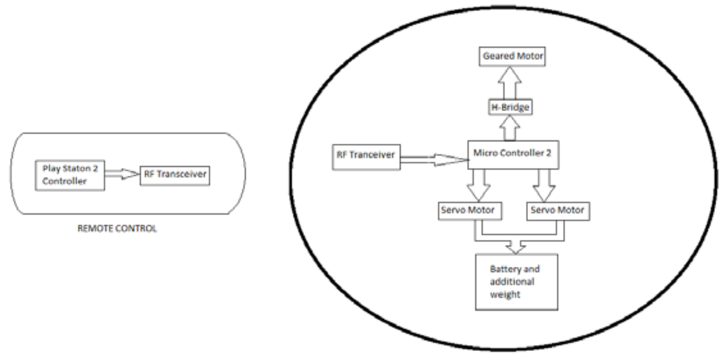

Fig. 1. System Block Diagram

B. Spherical Mobile Robot

Figure 1 shows the entire functional model of the Spherical Mobile Robot. PIC18F4520 is the micro controlling unit of the Central Control Board used with a system clock of 8 MHz. The Geared DC Motor is interfaced to the Central Control Board via an H-Bridge interface which not only allows bidirectional control of the motor but also excellent speed control using Pulse Width Modulation. Servo Motors are directly controlled by the Central Control Board using an Interrupt Driven Method to generate pulses of 50 Hz with variable duty cycle.

The most important constraint and also an advantage in the Spherical Mobile Robot is that the suspended weight should be more than the weight of the exterior shell of the robot. This issue is a constraint because if not met, the inner assembly rotates instead of the outer shell. It’s an advantage because if the exterior shell is extremely light, it does not a high torque motor to drive the entire robot even if the suspended weight is more than the carrying capacity of the driving motor. Hence, additional weights are used here to solve the problem of weight ratios.

III. H-BRIDGE DESIGN

An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC

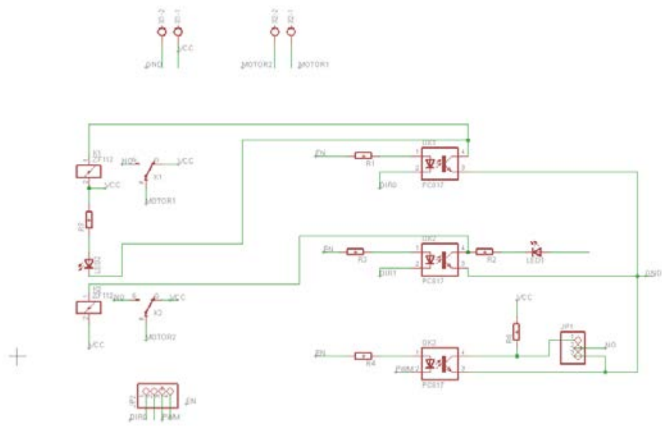

Fig. 2. H-Bridge Schematic

motors to run forwards and backwards. H bridges are available as integrated circuits, or can be built from discrete components. In this H-Bridge, we use the concept of motor direction changing by relay and give this output to the N-channel MOSFET.

In this H-Bridge, we use 4 control signals:

- EN pin is the main control pin to the H-Bridge.
- DIR1 and DIR2 pin decide the motor direction.
- PWM pin is use for giving PWM to motor.

3 Opto-couplers are used which provide isolation to the circuit from input side to the output of motor and thus avoiding noise effect caused by the motor vibrations. Relay is also used for isolation. In addition, it provides switching with electrical field by the available control signals. This switching changes the motor terminal from drain to power supply and vice-versa and thus effectively connecting and disconnecting the motor. MOSFET is used as a voltage control device and as a current driver to motor. PWM signal is connected to the gate of MOSFET, thus providing effective speed control of the DC motor.

IV. Mechanical CAD Design

A 12 inch diameter sphere is purchased and is used as constraint dimension for designing the internal structure to scale.

Mechanical CAD software BS Solidworks has been used for designing each and every component like flywheels (future scope), pendulum assembly, bevel gears etc. and configuring the maximum space available for DC and Servo Motors, PCBs and batteries.

The CAD design is illustrated as follows:

(Dark bodies-Servo motor; Yellow bodies-DC motor; Green bodies- Batteries)

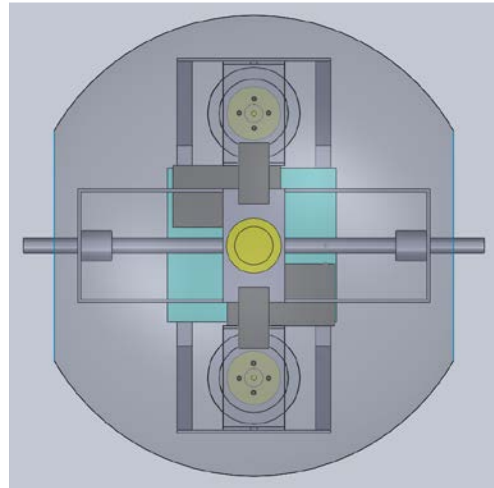

Fig. 3. Top View

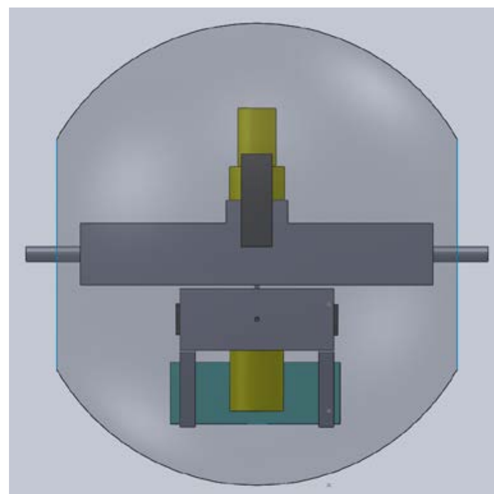

Fig. 4. Front View

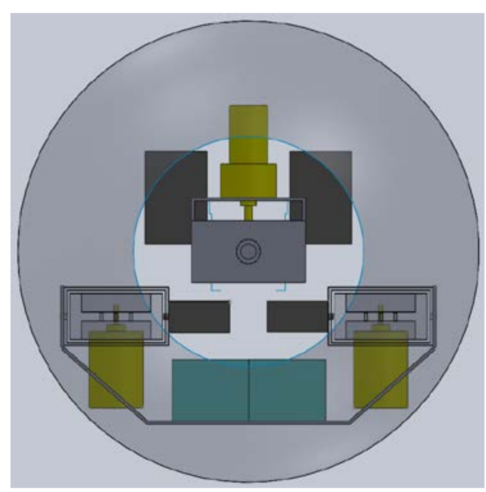

Fig. 5. Side View

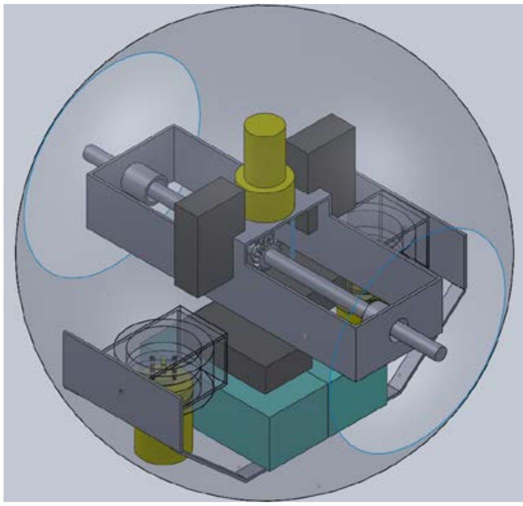

Fig. 6. Isometric View

V. CONCLUSION

A Spherical Mobile Robot was successfully designed and assembled and tested using a wireless interface. The torque limitations were overcome to an appreciable extent using geared motors and PWM control. The weight ratios of internal and external body were met according to the constraint of having a heavier inner weight. Although there are still many balance and torque issues that can more effectively be dealt with, our model serves as a foundational structure for future works.

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