CS-684-2018 Final Report

Pick & Placer Balance Robot

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1. Introduction

The aim of this project is to design and build a two-wheeled self balancing pick and placer robot. The basic two wheeled self balancing robot works on the principle of inverted pendulum device which utilizes forward and backward pitch/tilting angle as a control factor. The implementation utilizes both an accelerometer and a rate-gyroscope data ,wheel motor encoder output with PID algorithm for wheel motor direction and speed control in order to achieve a vertical balance. The fusion of both sensor data into a combined angle value was achieved through a complementary filter. Two servo motors are used to control the arm and grip movement. This project attempted to develop a two-wheeled robot with an arm attached for picking and placing the objects.

2. Problem Statement

There are many projects on building self-balancing robots - ranging from balancing bots to sophisticated self-balancing scooters. This project is intended to demonstrate capabilities of the pick and placer balance robot which is based on an Atmel ATMega16,8-bit microcontroller. Robot must maintain balance and stand upright during movement or lifting object by robotic arm. The robot can be used at various commercial stores/airports as pick and placer for material handling,

3. Requirements

3.1 Functional Requirements

3.1.1 Robot must maintain balance and stand upright during movement or lifting object by robotic arm.

3.1.2 Robot movement should be controlled remotely.

3.1.3 Arm and gripper should be remotely controllable.

3.3 Hardware Requirements

3.3.1 Gyroscope(L3G4200D) & Accelerometer(ADXL 345):

Gyroscope sensor measures angular velocity from which position is calculated by integration. The Accelerometer measures acceleration which we are using to infer orientation. The gyroscope develops a slow creeping tilt error due to integration. Gyroscope along with Accelerometer sensor combination will give a better estimate of absolute position, this combination allows Gyro to make accurate measurements even at rest.

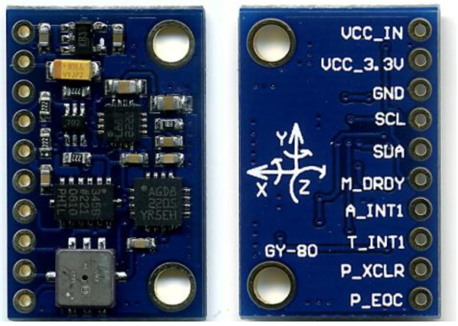

Fig: 3.3.1 GY-80 Multi sensor Board

3.3.2 Controller:

The processing unit used is Atmel ATMega2560 development board. It is an 8-bit high performance enhanced RISC (Reduced Instruction Set Computing) based microcontroller with low power consumption. Atmega2560 can work on a maximum frequency of 16MHz. It can be programmed easily with minimum hardware requirements.

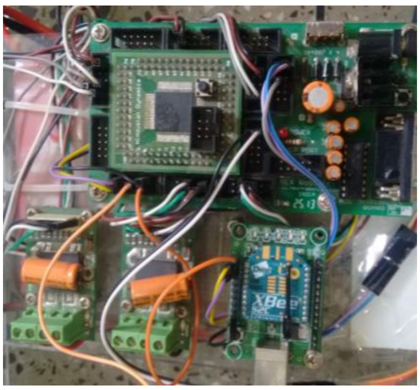

Fig:3.3.2 ATMega 2560 Development Board

3.3.3 Xbee module:

XBee (S2) module is used for wireless end-point connectivity to devices(PC to Controller). This module can give range of 40 meters indoor or 120 meters outdoor. This module supports data rates of up to 250kbps and high-throughput(35kbps).

3.3.4 **DC motor:** PMDC johnson motor

3.3.5 **Battery pack:** Power LI-Po Battery (2200mAh)

3.3.6 **Servo motor** :High torque metal gear standard analog servo motor.

(GOTECK GS 5515MG)

Torque: 13.2kg-cm,15kg-cm,Speed: 0.20sec/60deg 0.18sec/60deg

3.3.6 **Gripper**

3.4 Software Requirements

- **ATMEL studio 7.0-** ATMEL IDE to develop program for the microcontroller
- **X-CTU -**Next Generation Configuration Platform for XBee/RF Solutions
- **AVRDUDE** is a utility to download/upload/manipulate the ROM and EEPROM contents of AVR microcontrollers using the in-system programming technique (ISP).

4. System Design

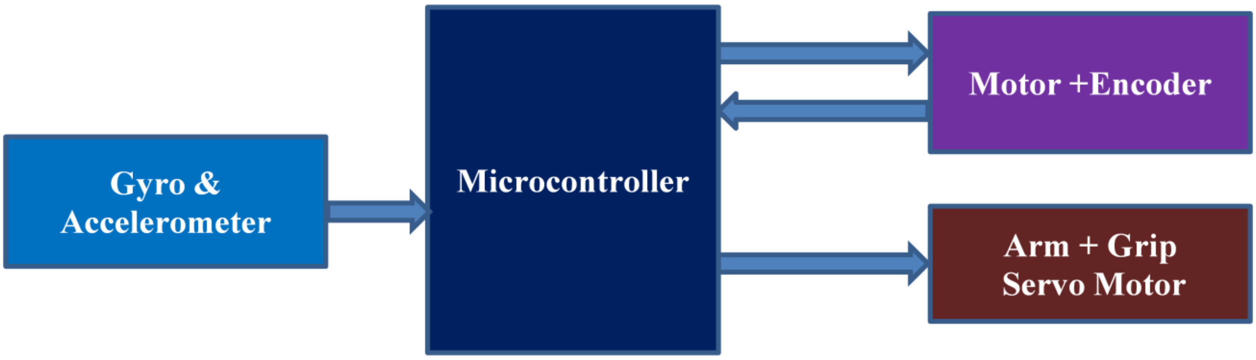

Fig:4.1 Hardware Block Diagram

S.No.	ATmega2560 pin no.	Pin Assignment
1.	PORT H.4	PWM of Right motor driver
2.	PORT H.5	Right motor fwd control
3.	PORT H.6	Right motor backward control
4.	PORT B.4	PWM of Left motor driver
5.	PORT B.5	Left motor fwd control
6.	PORT B.6	Left motor backward control
7.	PORT K.0,1	Left DC motor Encoder
8.	PORT K.2,3	Right DC motor Encoder
9.	PORT E.4	Arm Servo motor
10.	PORT G.5	Grip Servo motor
11.	PORTD.0	SCL pin of GY80
12.	PORTD.1	SDA pin of GY80
13.	PORTD.2	DO pin of XBee
14.	PORTD.3	DI pin of XBee

Table:4.2 Port Map

5. Working of the System and Test results

The basic idea for a two-wheeled dynamically balancing robot is to move the actuator in a direction to counter the direction of fall. The robot consists of following parts: sensors (Gyroscope, accelerometer and Quadrature Encoder), logical processing unit (ATMega2560 microcontroller) and Actuators (DC motor and Servo motors).

The two inertial sensors: a Gyroscope sensor and an accelerometer to calculate the tilt angle of the robot. These two measurements are passed though complimentary filter and fed to PID loop which in turn produces the counter torque required to balance the robot.

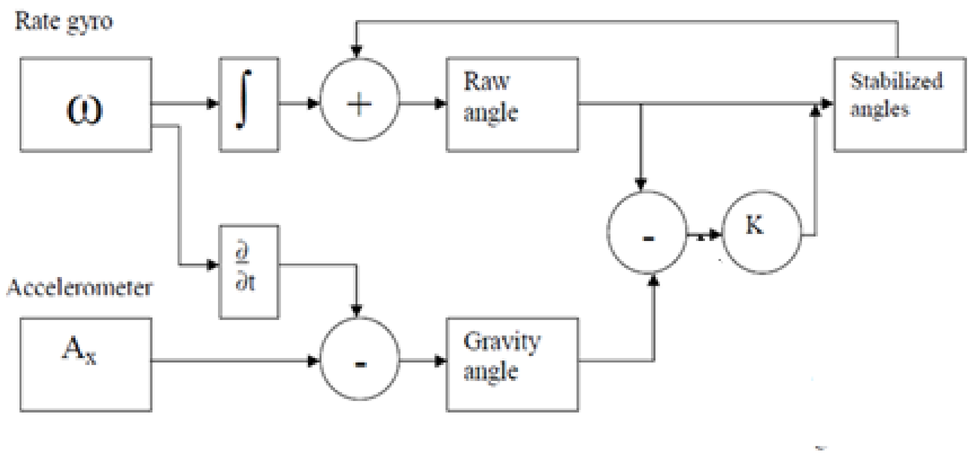

Fig:5.2 Angle Determination using complementary filter

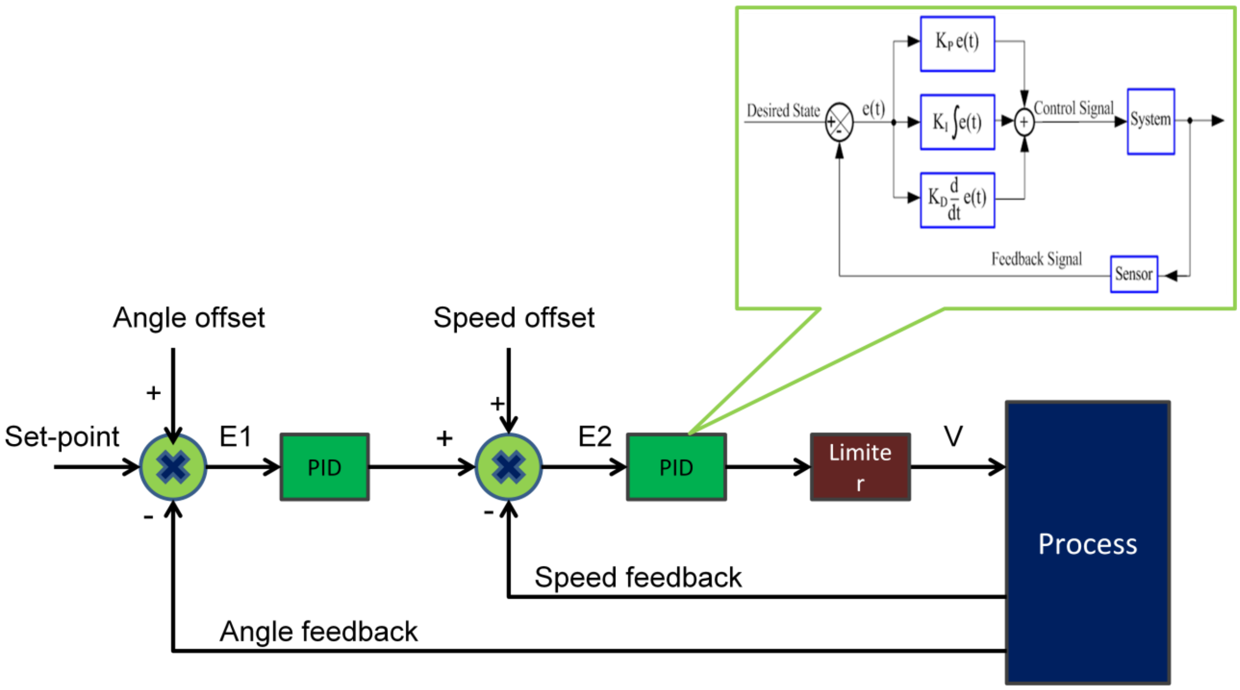

Fig:5.3 PID controller

Fig:5.4 Flow Chart

Software Process Flow: Four Processes running concurrently

Process#1	Process#2	Process#3	Process#4
Read Sensors (Gyro+Acc) ⇩ Complementary filter ⇩ Angle Calculation	Read Encoder ⇩ Moving Average filter ⇩ Find Speed and direction	Calculate set point ⇩ Compute PID ⇩ Drive Motor	Read control command via Xbee ⇩ Operate Arm and Gripper

7. Future Work

- Additional PID loops are required for real-time set point adjustment during gripper operation
- Proper fixtures required to mount Arm assembly to avoid undesired vibration & instability
- Development of android application for robot operation via cell phone.
- Arm should be of min. 4 DOF with object detection for proper pick and place.
- Counter weight balancing servo mechanism required for dynamic balancing during gripper up-down movement.
- Obstacle detection and avoidance can be an added feature for bots safety.

8. Conclusions

Self balancing robot with Arm and gripper is a challenging project in which dynamic balancing was required to achieve stability during robot movement that too with Arm & gripper operation. Initial tests were conducted to verify the balancing of bot without arm and with varying load on its head. After this we have demonstrated the self balancing capability of the bot with arm and gripper movement. Manual disturbances were forced on system and verified the capability of system.The main factor was dynamic variation in CG point based on tilt. Picking and placing requires additional counter weight balancing mechanism.

9. References

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