TWO-WHEELED ACTIVE INERTIA CONTROLLED ROBOT FOR AGRICULTURE PEST CONTROL APPLICATION

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ABSTRACT

One of the processes for having products with better quality is agricultural pest control. One typical way is wrapping a medical band around the tree. Robots can take this responsibility without any problem. A two-wheeled balancing robot was chosen for this project. Robot’s structure is one of the important factors to design a two-wheeled balancing robot. Two different ways, for balancing the robot, are considered, which are: using the DC motors or sliding the weight across the robot’s base. For keeping the robot’s balance rapidly a quick response is required from microcontroller.

1. INTRODUCTION

Robotics has been an engineering focus in recent decades. Due to developing the technology, autonomous robots and intelligent machines have their own special space in many different fields. Robotics has drawn a lot of attention in agricultural systems to increase the quality of performance and productions. One of the processes for having products with better quality is agricultural pest control. There are many different methods to control the agricultural bugs and pests. One typical way is wrapping a medical band around the tree [1]. Doing this process for human is so tedious and it takes time, but robots can take this responsibility without any problem. An example of such robot can be found in Lee et al.’s work in [2] where a robotic articulator is mounted on a four-wheel autonomous vehicle. In field test, it was found that the vehicle needs space to turn and it was quite difficult for the vehicle to maneuver on tilted surface. The aim of this paper is to develop a two-wheeled, self-balancing robot to perform similar tasks. From literatures, actuation of two-wheeled balancing robots relies on controlling wheel motors for balancing [3-4]. But when a mechanical arm moves, the center of gravity will be changed. In this case, using the wheels and motors for balancing will produce extra dynamics and it’s not suitable. Therefore, the main focus of this paper is to design a new method for balancing, utilizing a sliding inertia to control robot’s center of gravity.

2. TWO-WHEELED BALANCING ROBOT

Having a robot with fewer wheels is a better choice in this project. So, a robot with two wheels was chosen. Navigation across the farm will be easier but balancing the robot is a challenge. The robot moves across the farm, detects and stops beside each tree [5]. The robot’s arm grabs one medical band from the band’s container and wraps it around the tree.

2.1 Specification and Requirements

A Basic Stamp microcontroller will be used in this project as a main brain of this robot. The reason of choosing this microcontroller is because it is user friendly. Two 12 volts DC gear-head motors will be used. These motors give 2.1 kg-cm of torque at 70 RPM and their gear ratio is 82:1. A tilt sensor will be used to measure the angle between the robot’s base and ground.

2.2 Robot’s Structure

To allow the robot to easily move in agriculture fields, a cylindrical shaped robot is chosen and developed as illustrated in Figure 1 below.

![Fig. 1 Schematic of the two-wheeled robot.](image)

3. BALANCING MECHANISM

Two different ways for balancing the robot are considered.

3.1 Using the DC motors

The basic idea for balancing the robot with motors is driving the wheels in the direction that the upper part of
the robot is falling. If the wheels stay under the robot’s centre of gravity, the robot remains balanced. This mechanism follows the inverted pendulum’s system. Therefore, two aspects of DC motors need to be controlled, namely speed and direction.

The speed control can be achieved by controlling the voltage or current. The simplest way is connecting a high power resistor in series with the DC motor. This method is not efficient due to high power loss at the resistor, which is heat. The most practical method to control the voltage is using the PWM (Pulse Width Modulation). In this method, constant DC voltage pulses can control the DC motor’s speed. Changing the pulse width can control the current, which is fed into the DC motor. In digital microcontroller, the pulse amplitude is always same and is equal to 5V. The DC motor can spin faster with the same period if the pulse width is longer. PWM is a technique to produce a logic output. Logic one is for period of time and logic zero is for the balance of the time. Also the motors’ speeds need to be calibrated as the function of pulse width. The only way to control the direction of DC motors is to change the polarity of them. This task can be achieved by using the H-bridge.

In this project, the robot has a mechanical arm on top of the structure for wrapping the medical band around the tree. Moving the arm will change the center of gravity and then motors try to balance the robot by driving the wheels clockwise or counterclockwise. These rapid movements produce vibration, which is not desired. Therefore, other option is considered.

3.2 Sliding the weight across the robot’s base

In this method, motors will be used only for navigation and balancing the robot will be achieved by sliding a weight across the robot’s base utilizing the mechanism as shown in Figure 2.

Fig. 2 Basic idea of sliding inertia system

In this method a sliding system is assembled on the robot’s base. This system consists of a Sliding rail, a weight and servo motor. A tilt sensor produces the raw inputs for servo motor according to the tilt angle. Servo motor moves the weight by a plastic chain to the opposite way of tilting and tries to keep the robot’s balance. By using this method the structure’s vibration will be reduced while the arm moves for wrapping the band around the tree.

4. SENSOR CALIBRATION

In this project, only tilting around one axis is considered. The pulse outputs from the tilt sensor are set to a 50% duty cycle at 0 g. The duty cycle changes in proportion to acceleration and can be measured by Microcontroller. Figure 3 shows that the sensor’s output voltage and G-force will increase by increasing the tilt angle.

Fig. 3 Measured accelerometer output vs. tilt angle.

5. DETECTING THE TREE

Ultrasonic sensor will be used to detect the tree. This sensor provides precise measurements from 2 centimeters to 3 meters. It only has one I/O pin and connects to any microcontroller easily. It works by transmitting an ultrasonic burst, which is above human hearing range and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the distance to target can easily be calculated.

6. CONCLUSION

A two-wheeled robot was developed to offer flexibility in maneuvering in engineered agriculture fields. A new active inertia control system is proposed in this paper to properly balance the robot. Through sensor calibration and mechatronic integration, it is found that the robot is feasible for performing required tasks and has potential in commercialization.

REFERENCES