DEVELOPMENT & PERFORMANCE ANALYSIS OF AN AUTONOMOUS TENNIS BALL COLLECTING MACHINE USING MOTION TRACKING ALGORITHM

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ABSTRACT: *Sports should be fun. But I do not get the fun vibes when I see my neighbors play tennis. Because their fun is interrupted when they run out of balls and have to pause the game to collect the balls. During lawn tennis practice lot of balls are used. Once players run out of balls in stock, they have to collect the balls they used. This makes practice boring and exhausting. This machine is designed to overcome this problem. This machine collects balls and provide a little relief to the players practicing hard. The machine is a machine vision based two-wheel differential drive robot. It uses mobile phone camera for machine vision. For this purpose, a customized mobile app is created named "ABCMac". What make this project unique is the fact that no microcontroller is used. Instead, electronically designed circuits are used to control the robot. The robot is made out of wood and has a mechanism to drive the balls in. Once the app detects the ball, the robot rotates to align the ball to center and then move forward and sucks the ball in. All the processing is done inside the app itself as there is no microcontroller in use.*

Keywords: *Autonomous Robot, Machine Vision, Motion Tracking, Mobile App.*

I. INTRODUCTION

During lawn tennis practice lot of balls are used. Once players run out of balls in stock, they have to collect the balls they used. This makes practice boring and exhausting. Autonomous Ball Collecting Machine (ABCMac) is designed to overcome this problem. This machine collects balls and provide a little relief to the players practicing hard. Current means to collect the balls are not fully automated. Currently available meansare generally mechanically designed mechanisms, operated manually. They do ease the work but do not eliminate it. Pieterse and Olivier (2014) Heloise Pieterse, Martin S. Olivier (2014), in the paper titled, "Bluetooth Command and Control channel" explained Bluetooth configuration commands and communication modes. It explained that a Bluetooth can either work in slave state or master sate. In slave state, Bluetooth can only receive data and in master state it can only send data. For communication through Bluetooth, one Bluetooth must be in slave state and one must be in master state. Suárez et al. (2018)JosÃl' Ignacio SuÃa¸rez, Patricia Arroyo, JesÃžs Lozano, JosÃl' Luis Herrero, Manuel Padilla (2018), in the paper titled, "Bluetooth gas sensing module combined with smartphones for air quality monitoring" showed how to connect blue-tooth module to smartphone. They used Arduino to configure Bluetooth and to send data. Bluetooth is a serial device. Therefore, data pin of Bluetooth is connected to serial pin of Arduino to transmit and receive data. Oltean (2019) Stelian-Emilian Oltean (2019), in the paper titled, "Mobile Robot Platform with Arduino Uno and Raspberry Pi for Autonomous Navigation" explained how to control mobile robot using Arduino uno and raspberry pi. It explains ways to automatically navigated the environment. To do so it uses number of sensors such as IR sensor, LADAR, ultrasonic sensor and camera. It explains the advantages and limitsof each and tells when to use whichsensor. Zdešar et al. (2017) Andrej ZdeÅa¸ar,SaÅa¸o BlaÅ¿ic, Gregor KlanÄ ar (2017) , in the paper titled, "Engineering Education in Wheeled Mobile Robotics" explains various mobile robots such as two wheeled, four wheeled. It explains different wheel types such as omnidirectional wheel, castor wheel. Abdalla et al. (2015) Amin Mohammed Abdalla, Niranjan Debnath, M. K. A. Ahamed Khan, Hasimah Ismail (2015), in the paper titled, "Mobile Robot Controlled through Mobile Communication" explained how tocontrol mobile robot by smartphone. It gave a brief about mobile robotics and mobile apps. It explained that an app can be created to transmit data through wifi or bluetooth to a mobile robot. The robot can perform functions such as motor control based on command received. Chen et al. (2018)Peng Chen, Peijun Wang, Jindong Wang, Yingxue Yao (2018), in the paper titled, "Design and motion tracking of a strip glove based on machine vision" taught to identify color and patterns using machine vision. In this paper they identified strip pattern and used it to detect glove. It later showed techniques to track the glove. It also showed how

to draw the track over the existing image or over live feed from video camera. Guanjun et al. (2019)Bao Guanjun, Jia Mimi, Xun Yi, Cai Shibo, Yang Qinghua (2019), in the paper titled, "Cracked egg recognition based on machine vision" shows techniques to recognize an object based on reference images, in this case eggs. It also showed howto identify patterns on the identified object, in this case broken marks.

II. EXPERIMENTAL SETUP

2.1 FRAME:

Figure 1.1: Frame

2.2 MOTORS:

The robot uses three motors, two for wheel and one to drive ball into the basket. The wheel motors, are 10Kg-cm, 500rpm each. These two motors are what drive the robot. Third motor is a high speed

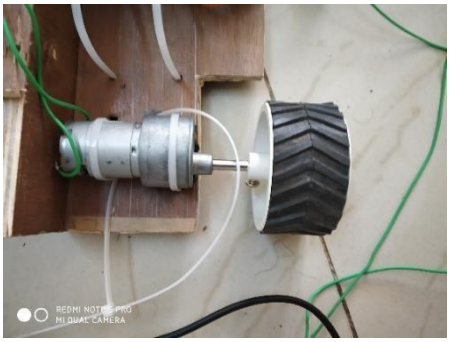


Figure 1.2: Robot Driving Motor

Figure 1.3: Ball Driving Motor

2.3 ROBOT CONTROL CIRCUITS:

Robot control circuits consists of two customized PCB. Each of these PCB is printed at home. First PCB is of the bluetooth data extractor circuit. This circuit is used to generate a clock pulse, synchronize the clock pulse with bluetooth and extract the eight bit data from bluetooth. It consists of the following:

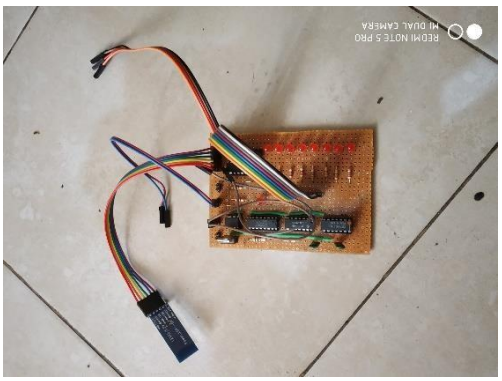
@ 555 Timer IC

@ 4250, 8-bit Counter IC@ 7408 AND Gate IC

@ 7404 NOT Gate IC

@ 74HC595 Serial to Parallel Converter IC

Figure 1.4: Camera Module



2.4 ASSEMBLY:

This project uses mechanical discipline to design the project's physical structure and uses electronic discipline to design control circuits for the project and uses software discipline to design mobile app for this project.

Figure 5: Order of Assembly

Nowadays anyone can make something like this project, with the help of easy-to-use microcontrollers. And that's what gives this project uniqueness. This project does not use any microcontroller. Instead, it uses custom designed electronic circuit and custom print Printed Circuit Board (PCB) as shown. It connects to mobile app using Bluetooth but no microcontroller. Also, instead of store bought L293D module, it uses a self-printedL293D PCB.

III. METHODOLOGY

3.1 WORKING:

Its working starts at mobile app. On switching ON the robot, the app connects to the robot. Then the app detects the green color balls. Based on ball position the app issues either of the two commands, rotate or forward. If the ball is not aligned to the center of robot then the app issues rotate command.

The robot rotates until ball is centered. Then the app issues forward command. Robot moves forward and ball enters the robot's channel. The ball then clash with the ball driving motor. This motor is rotating at high speed. On clash, it transfers it's momentum to the ball and pushes the ball with high speed. The ball then climbs the ramp and enters the ball collection basket.

Design control circuits for the project and uses software discipline to design mobile app for this project.

3.2 CONTROL ALGORITHM:

```
package com . example . abcmac ;

import anroid . support . v7 . app .AppCompatActivity ;

import android . util . Log

import android . view . MenuItem ;

import android . view . SurfaceView ;

import android . view . WindowManager ;

import android . widget . TextView ;

import org . opencv . android . JavaCameraView ;

import org . opencv . android . BaseLoaderCallback ;

import org . opencv . android . CameraBridgeViewBase;

import org . opencv . android . CameraBridgeViewBase
.CvCameraViewFrame ;

import org. opencv . android. CameraBridgeViewBase.
CvCameraViewListener2 ;

import org. opencv . android. Loader Callback

Interface ;

import org . opencv . android.OpenCV Loader ;

import org . opencv . core .Core ;

import org . opencv . core . Type ;

import org . opencv . core . Mat ;

import org . opencv . core . Point ;

import org . opencv . core . Scalar ;

import org . opencv . core . Size ;

import org . opencv . imgproc . Imgproc ;

BluetoothAdapter bluetoothAdapter =

Bluetooth Adapter . get Default Adapter ( ) ; if (
bluetoothAdapter == null ) {

Toast . make Text ( this ," Bluetoothis not available!" ,
                Toast .LENGTH_SHORT) .show ( ) ; finish
        ( ) ; / / automatic close app if tooth service
        is notavailable !

}

if (!bluetooth Adapter. isEnabled ( ) ){ Intentenable
Intent = new
```

```
Intent(BluetoothAdapter . ACTION_REQUEST_ENABLE);
start Activity For Result (enable Intent,
REQUEST_ENABLE_BLUETOOTH);

}

y( ) ;

}

bluetooth Adapter .start Discovery ( );

filter) ; private final Broadcast Receiver discovery
Finish Receiver = new BroadcastReceiver ( ) {
@Override

public void onReceive ( Contextcontext, Intent

intent )

{

String action = intent. getAction ( ) ;

if (BluetoothDevice .ACTION_FOUND. equals ( action )
) { BluetoothDevice device =

intent. getParcelable Extra(Bluetooth Device.
EXTRA_DEVICE) ;

if( device. getBond State ( ) !=

Bluetooth Device . BOND_BONDED) {

discovered Devices Adapter .add ( device . getName ( ) +
" \ n " + device . getAddress ( ) ) ;

}

} else if

(\Bluetooth Adapter . ACTION_DISCOVERY_FINISHED.

equals (action )) {

if (discovered Devices Adapter . getCount ( ) == 0) {
discovered Devices Adapter. add ( g e t String (R.
string . non e _ found ) ) ;
}

}

}

} ;

Bluetooth Adapter = BluetoothAdapter .
getDefaultAdapter ( ) ; Set <Blueto othDevice >
pairedDevices = bluetooth Adapter . getB
ondedDevices ( )

< uses –permission

if (bluetooth Adapter . isDiscovering ( ) )

{ bluetooth Adapter . cancel Discover



android: name =" android. permission. BLUETOOTH"/ >

< uses –permission

android: name=" android. permission.
BLUETOOTH_ADMIN" /> android : name =" android. per

mission .CAMERA" / >

< uses –feature

android: name=" android. hardware. camera "android :
required =" false "/ >

< uses –feature

android: name=" android. hardware. camera. autofocus "
android

: required =" false "/ >

< uses –feature

android : name=" android . hardware. camera. front "
android : required =" false "/ >

< uses –feature

android: name=" android. hardware. camera. front.
autofocus"
```

android: required =" false"

IV. CONCLUSION & FUTURE SCOPE

The robot can collect balls autonomously. It can now be used in tennis fields to collect tennis balls. The introduction of this robot will reduce extra labor of players. Players can now focus on game. Players can take break and refresh themselves while the robot will collect balls for them. All they require to do is connect their phone to the robot and open app. The plan is to improve this robot to make tennis more fun and less hard. For this I want to integrate ball throwing mechanism in the robot. This way the robot can also help practice players

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