Development Of Autonomous Robot For Tunnel Mapping Using Raspberry-Pi Processor

P.Velrajkumar, P.Ramesh, C.Senthilpari, T.Bhuvaneswari, V.Chitra

Abstract: An autonomous robot plays an important role in the future of rescue operation in unknown environments. In this research a robot is capable of moving in tunnel and able to do operation in the tunnel. The robot is controlled wirelessly via Wifi communication using wifi router. The robot itself is equipped with a mini computer that is a Raspberry-Pi processor. The Raspberry-Pi is the brain for the robot as it gives out command on the movement of the robot and the data from the USB camera is collected and then transmitted to the computer. The robot is capable to go up 75 to 110 meters on Wifi signal. Once the connection is lost the robot will stop by itself. The robot is equipped with two batteries that last long and does run for more than 30 – 45 minutes. The robot is controlled via a computer that is programmed to run Ubuntu operating system. From the comfort of sitting in front of the computer the robot can be controlled from a distance and the live is then stream on the computer.

Index Terms: Autonomous Robot, Tunnel Mapping, Raspberry-Pi, Ubuntu, Wifi Module, QT Creator, Camera.

1 INTRODUCTION

In this era, the most of the communication lines and wires are done through underground or tunnel. We need a robot that able to lesser the work of humans even prevents any injuries of lives. This robot is a robot that able to move into the tunnel which can be controlled wirelessly. Attached with the robot is a camera that able to send back image to the computer about the surrounding in the tunnel. Knowing tunnel isn't a place where the surface is smooth, this robot is geared up with track tyres which able to go through hard surfaces and obstacle. This is to give a clear idea to person who controlling the robot about the surrounding to make sure that it is safe to go in. Basically it would be a remote controlled robot where the distance is limited by the wifi signal and able to go up to 75 to 110 meters. To make sure that the robot doesn't keep moving when the signal is lost, it has been programmed to stop when the signal is lost so that the distance estimation can be calculated and able to retrieve the robot. The purpose of this research work is to build and develop a autonomous mobile robot that is able to go through places that are small and it's hard to reach by human being. Where tunnels are known for being dangerous and dark, to have a robot like this ease the work of human being where it can be controlled from a distance without the need of being there. Where nowadays it's all about wirelessly technology, it creates an idea to control robot wirelessly.

2 REVIEW OF AUTONOMOUS ROBOT

The robot is designed in such a way where, it is small and mobile and able to go through small areas, for example tunnels and drains which is dry.

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SLAM is a structure of calculations that gives a robot the capacity to construct a guide of a situation for which no earlier data exists and at a similar time, decide its area inside that condition [1], [2]. Utilizing a guide with different methods for recording development, for example, odometry and natural detecting gadgets, gives the robot the capacity to recognize and recuperate from off base sensor information and all the more precisely plot its position inside a situation. SLAM has created critical outcomes in the previous decade, however primarily for single robots [3]. A generous measure of exertion has been exhausted on tackling the issue of confinement of a solitary robot, yet restriction of a group of robots ia as yet a generally new field. Co-agent mapping and localization presents extra issue of SLAM, for example, every robot's part, centralization, accumulation and correspondence techniques [4]. With respect to robot's part in co-agent mapping what's more localization, every robot in a group can be free substance running its claim example of a limitation calculation or, as on account of, there can be ace and slave robots where the ace robots perform SLAM and the slave robots go about as expanded eyes and ears. The slave robots encourage sensor information back to the ace robots to be utilized as apart of the confinement calculation, however don't perform SLAM themselves [5]. The specialized techniques utilized will rely upon what parts are performed by each of the robots in a group. Regardless of whether every one of the robots speak with as it were a solitary, controlling robot. The master robot as specified in or whether every robot is autonomous and speaks with each robot in its group to assemble its bit of the guide if and when it watches a robot [6], [7]. Encoders are specific engines that are utilized to catch odometry information by recording the revolutions performed by an engine. The robot's controller works the engine by means of the controller's inward PWM hardware to control its forward or in reverse speed [8]. There are numerous strategies that encoders use to record the turn of the engine's yield shaft. Mechanical encoders utilize magnets or metal brushes around the pole in standard positions that produce a tick each time they pass a stationary contact in the engine packaging. The quantity of ticks every second are recorded furthermore, speak to the measure of turn as far as rakish ticks [9]. For the sensor perceptions of the earth are caught by sensors which give extend what's more, bearing information for watched landmarks [10]. The historic point perceptions are go through a milestone affiliation calculation and at that point joined with the odometry information, gave by the encoders, so that a limitation

calculation can confine the robot in its condition and additionally produce new guide readings [11]. Laser sensors are generally utilized nowadays as they give precise estimations at the speed of light and their yield is effectively handled. The principle issue with laser sensors said in is their cost [12]. Sonar scanners utilize a range estimation strategy known as Time of Flight (ToF). The time taken between issuing the sound wave and recording the sound is recorded and this estimation is utilized to give range estimation, remembering sonar scanners work at the speed of sound.

3 MATERIALS AND METHODS

The robot is designed in such a way where, it is small and mobile and able to go through small areas, for example tunnels and drains which is dry. The robot is controlled wirelessly using a wifi router that is connected to both the pc and also the Raspberry pi (R-Pi) that is on the robot which is shown in fig.1. With the command from the computer, the signal is then sent to wifi router which is then received by the R-pi. After receiving the command the robot will now move and also sent a live stream of the place that is facing. Raspberry pi is linux based so the program that used it to run is ubuntu. Remote correspondence is critical idea and it assumes a critical part in different applications like mechanical robotization, home mechanization and so on. Today the use of remote correspondences in mechanization field is expanding quickly. In a few applications people have been supplanted by unmanned gadgets that will gain information and hand-off the information back to the base. A single individual can screen and even collaborate with continuous work from a solitary base station. Remote based reconnaissance robot is a prime worry in our day-to-day life.

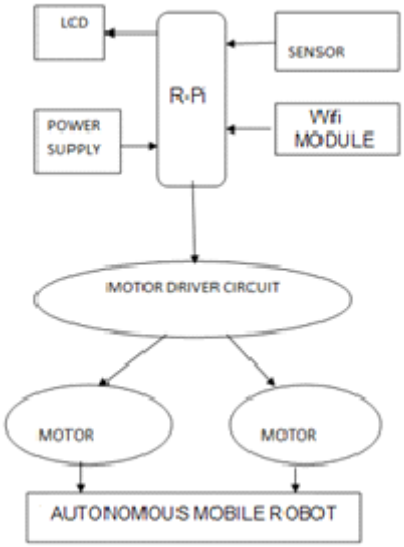

Fig 1. *Block diagram*

Development of mobile robot with R-Pi is shown in fig.2. The main thing about R-pi is a microcontroller kit. It comes with a ARM11 board that has Ethernet or internet connectivity, Two USB connector and a memory 512MB and it works on linux operating system. Audio and video output is provided as well for the board together with the onboard storage. The connectivity of the R-pi is at advantage because it has a built in Ethernet connection. Wifi can be easily plugged in to have a wifi connectivity. DC motors have some control capacities, which implies that speed, torque what's more, even bearing of turn can be changed at whenever to meet new condition. DC motors likewise can give a high beginning at low speed and it is conceivable to get speed control over a wide range. For controlling an engine in any framework, a controller is required which is to offer contribution to entryway driver. For engine incitation, the microcontroller does not specifically impel the DC engine. It will have a gadget that known as door driver which is capacity to drive the engine. For this frame work, it utilize engine driver as PWM enhancer to give variable yield voltage to controlling the speed of the engine and positive or negative voltage to control the course of engine pivots. The new strategy, which widely utilized as a part of engine controller, is PWM. PWM exchanging system is a best technique to control the speed of DC engine contrast with another strategy. The PWM in microcontroller is utilized to control obligation cycle of DC motor drive. PWM is a completely unique way to deal with controlling the speed of a DC motor.

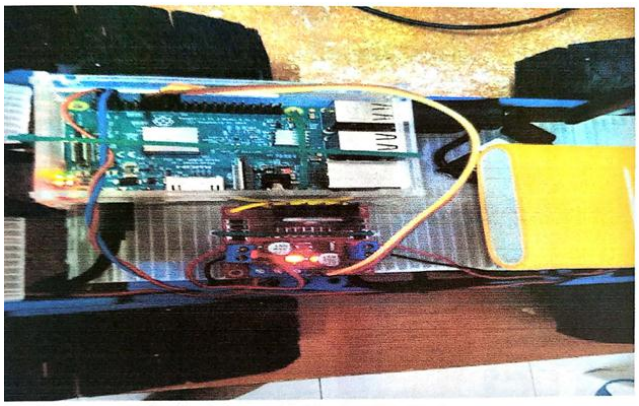

Fig. 2*. Development of Autonomous Mobile robot with R-Pi*

To choose a suitable design for the robot is very crucial. To determine all the components that have to be placed on the robot is important. The price of the robot is also taken into account as it needs to be reasonable. The components are 3D printed and it is light weight and fast. It comes with well gripped track tyres and two powerful 9v DC motors that able to support the movement of the robot with all the components on top of it. For this research, the tank type track tyres been used to overcome hard terrain and obstacles such as rocks, mud and sand. A tyre with a firm grip and tractions is needed. Especially in tunnels where the path is not smooth and it will affect the journey of the robot if it is stuck in rock or any obstacles which have to abort the mission of the robot. For the DC motors that works to move the robot and it is powered by lithium polymer (LiPo) battery that is 11.1V. The reason why LiPo battery is chosen for this research is because they are lightweight and available in all shapes and sizes. They have large capacity thus will hold bigger amount of energy inside a small sized package. The battery too have high recharge rate to fire up most electric motors. For this research project LiPo battery fits perfectly in between the robot body, which also protect it from falling out from the robot while its moving. Another advantage is that LiPo battery doesn't have to replaced such as normal carbon 9V batteries, as this batteries are rechargeable and can be used again after few hours of charging.

4 RESULTS AND DISCUSSION

Normal personal computer runs on windows, R-Pi would not run as it uses linux. To access linux, virtual box serves as a platform to run linux and to everything while on windows, it is a great tool since it helps run efficiently and simultaneously. After it has been set up, ubuntu system which is shown in fig.3 is used to do programming together with QT creator which serves as a C++ platform for GUI creation.

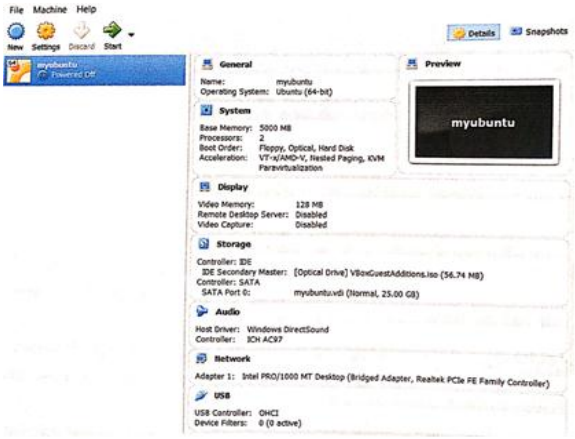

Fig.3 *Ubuntu system*

The fig.4 shows how the computer tries to link with R-pi. The main thing about this is that since it is running on wireless communications, IP address needed to be matched in order to get the recognition from both the R-Pi and also the computer.

```
#include <stdio.h>
#include <opencv2/opencv.hpp>
using namespace std;
using namespace cv;
VideoCapture cap;
VideoWriter rec;
Mat img;
char IP_ADDR[50] = "http://10.42.0.103:8080/?action=stream";
int main()
{
  cap.open(IP_ADDR);
//  cap.open(0);
  int count = 0;
  namedWindow("mjpg_stream");
  while(1)
  {
    Mat img;
    if(cap.grab())
    {
      cap.read(img);
      if(!img.empty())
      {
        imshow("mjpg_stream", img);
      }
    }
    else
    {
      if(count < 100) count++;
      else{
        cap.release();
        if (cap.open(IP_ADDR));
        count = 0;
      }
    }
    char key = waitKey(1);
    if( key == 27) return 0;
  }
```

Fig. 4 *Link with R-pi*

The fig.5 shows the part that is GUI done with QT creator to make it easy for the controlling to be done. The control is done according to the alphabets that needed to be press on the personal computer.

```
QT += core gui
CONFIG += c++11
greaterThan(QT_MAJOR_VERSION, 4): QT += widgets
TARGET = controller
TEMPLATE = app
SOURCES += main.cpp\
mainwindow.cpp
HEADERS += mainwindow.h
FORMS += mainwindow.ui
INCLUDEPATH += /usr/include
INCLUDEPATH += /usr/local/include

LIBS += -L/usr/lib
LIBS += -L/usr/local/lib
LIBS += -lopencv_core
LIBS += -lopencv_imgproc
LIBS += -lopencv_highgui
```

Fig.5 *QT creator*

After successfully running the code on the QT creator, a small GUI will appear with showing two statuses that is shown in fig.6. One is bind IP meaning that the IP address between router, R-pi and the computer has been successfully binded and match. The connection which shows a green box in figure tells that the connection is ready to go and the status is ready. While the key in boxes W, A, S and D is for the movement of the robot. W represent for moving forward, A represent for moving left, S represent for moving in reverse direction and D represent that the robot moves in right direction. The function of mjpeg streamer is to refresh the status of the camera since sometimes it can be stuck while streaming. By clicking, it would be able to get back the image easily.

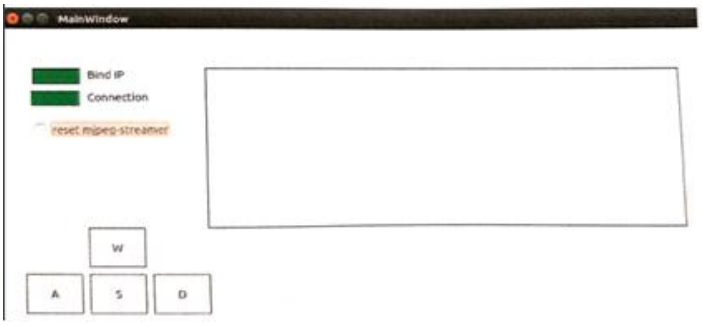

Fig.6 *GUI*

Fig.7 shows that after running the code a small window will appear showing the image from the direction that is facing. For it to able to run the IP binding must be able to be done in all three places if not this step would be continued. In result the screen will show a blank page and a status of not connected to the host of the computer.

Fig.7 *Autonomous robot*

5 CONCLUSION

In this work, a design of autonomous mobile robot for tunnel mapping has been presented. The R-pi based autonomous robot for tunnel mapping was designed and constructed and it is able to control wirelessly and also with the LAN cable. The camera is used to capture the image. The robot was designed to send back the captured image/live stream. The GUI was designed to achieve the user friendly and maximum flexibility. The GUI allows the user to control the mobile robot's movement in the unknown environment. The mobile robot was successfully able to go through the hard surfaces.

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