WLAN TCP/IP ROBOT FOR MOVING BOMB AWAY FROM CROWD IN THE THREE SOUTHERN PROVINCES OF THAILAND

Sanon Chimmanee

Ph.D IT Faculty, Rangsit University, Thailand
schimmanee@yahoo.com

ABSTRACT

This paper presents a building TCP/IP robot for moving bomb from crowd in the three southern provinces of Thailand. This IP robot is built according to requirements of Royal Thai Army with simple machine which each element is in common use. Several machine designs are presented and compared their performance. Thus, one advantage of the proposed IP robot is that it is lower cost comparing to others robot especially robots from oversea. This enables Royal Thai Army to product the robot for moving bomb with high volume and low price. Typically, Radio jamming for disrupting the car bomb in the three southern provinces is in Low Frequency (LF) and High Frequency (HF). TCP/IP wireless is in 2.4 gigahertz (GHz) transmissions which are in the Super high frequency (SHF). Thus, another merit of the IP robot is that it can work conjunction with a jamming signal device. Additionally, several methods of WLAN (IEEE 802.11g) are compared and evaluated their performances in this paper.

Index Terms— Wireless LAN (WLAN), MIMO, TCP/IP Socket Programming, IP Robot.

1. INTRODUCTION

In five past years, many Thai solider and people in the three southern provinces of Thailand died due to bomb. Therefore, this paper presents a TCP/IP robot with wireless communication for moving bomb from crowd in the three southern provinces of Thailand since oversea robot is very expensive, large size, and heavy. From interview with Colonel Jatuporn Soonthonnont and his team on October 2007, they said that a weight of oversea robot is more than 80 kg and its width is larger than 75 centimeter. This results in trouble for carrying this robot. Moreover, there are about six bombs per day for their responsibility. Therefore, Thai soldiers typically have to move bomb by themselves.

The three basic requirements for robot are following: its weight is lower than 50 kg, its width is lower than 75 cm, and able to lift up and carry on 12 kg. It should be note that bomb's weight in the southern provinces is about 5-12 kg.

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Moreover, the robot should be simple machine and its elements should be easy to buy in Thailand. Convenience for maintenance and repair is preferred.

The proposed robot is built according to above all requirements. Several machine designs are presented in order to compare their performances. Additionally, a jamming signal device which produces a noise signal for troubling a remote signal of car bomb is preferred for avoiding damage caused by remote bomb. From some report of Thai solider found that remote signals for car bomb are basically in a Low Frequency (LF) and a High Frequency (HF) [1],[2]. Thus, the proposed IP robot with a technology of TCP/IP wirelesses in 2.4 gigahertz (GHz) transmission which is in Super high frequency (SHF) [1] is desired in order to enable IP robot to support the radio jamming device.

Nowadays, wireless TCP/IP network is becoming increasingly popular for data communication. TCP/IP wireless service is normally available in apartment, hotel, airport, and other residents [3],[4]. IEEE 802.11g is a popular standard for Wireless LAN (WLAN) communication. MIMO (multiple-input multiple-output) is one of popular technology that increases the capacity of mobile radio systems [5],[6]. Multiple transmit and receive antennas allow increased data rates and enhanced reliability in future wireless communication system [5],[6]. In this paper, the performance evaluation of the several methodologies of WLAN IEEE 802.11g is presented.

The rest of this paper is organized as follows. In section 2, objective and background are stated. In section 3, the detail of the proposed robot is explained. In section 4, author presents performance evaluation. Section 5 provides discussion. Section 6 gives conclusions and future work.

2. OBJECTIVE AND BACKGROUND

2.1. Objective

An objective of this paper is to build an IP Robot according to Thai army requirements as follow: its weight lower 50 kg, its width less than 75 cm, able to move a bomb with 12 kg, simple machine, and its cost is lower than 100,000 bath.

The figure 2.1 displays moving a motorcycle bomb of Thai solder in three southern provinces of Thailand, which is endangered. Many Thai soldiers are injured due to moving the bomb.

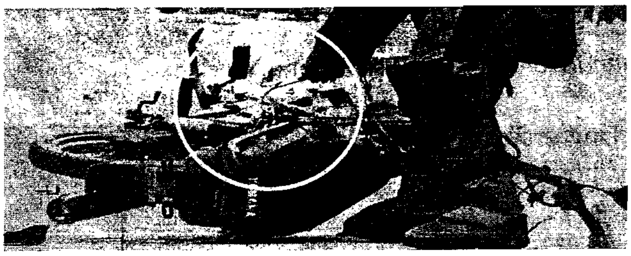


Figure 2.1 shows moving a motorcycle bomb of Thai solder in three southern provinces of Thailand which is dangerous.

2.2. Background

There are two major parts. One is a socket for remote control IP robot via TCP/IP wireless, the other is microcontrlloer and driver circuit.

2.2.1. TCP/IP Socket Communication

Communication between Application Program in TCP/IP network will connect each other by using socket programming [7]. In this paper, IP robot is controlled via wireless by using socket between Ubuntu notebook and RS232toEther device. RS232toEther has two interfaces. One is RJ45 female that has IP address and other is RS232. Thus, it is responsible for converting between TCP/IP and RS232 protocol. Additionaly, IP address of the IP robot is IP address of RS232toEther device.

2.2.2. Microcontroller and Driver Circuit

The ULN 2803 IC contains eight NPN Darlington connected transistors (often called a Darlington pair) [8].When 5V input is applied to any of the input pins (1 to 8), this input current will increase and resulting in higher current gain of output voltage at corresponding output pin (11 to 18) which is very much required to meet the higher current requirements of devices like motors, relays etc [8]. A relay is an electrically operated switch. A cicuit for control motor can be built from relays. MSC-51, IC ULN2803, and Relays as shown in figure 2.2 are a basic circuit for controlling motor which uses in the proposed robot.

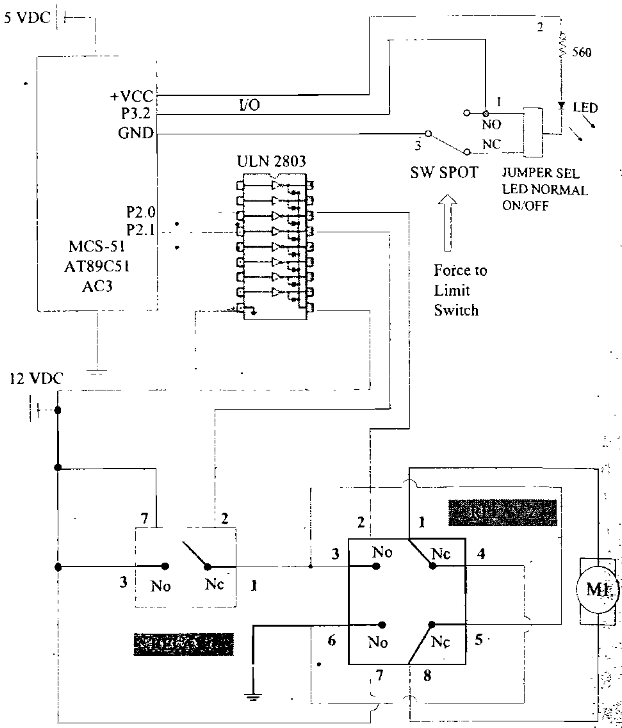


Figure 2.2 shows connecting among MSC-51, ULN2803, Relay, Motor, and Limit Switch.

3. MACHINE DESIGN AND PROGRAMMING OF IP ROBOT

3.1. System Overview

The proposed IP robot consists of major 7 box diagrams as shown in the figure 3.1. Communication between an IP robot and an Ubuntu [9] laptop (notebook) is TCP/IP protocol via wireless 2.4 GHz. A socket programming is required for application communication between them. Wireless Access Point is only wireless transmission. IP address of the IP robot is IP address of the RS232toEther. IP camera is also required IP. Thus, remote notebook can see/monitor all pictures via the IP camera. Access to the IP camera is using Http application. Two major elements of Driver Circuit are IC ULN2803 and Relay. Hand, Arm, and Moving system are controlled from MSC-51 and then feedback from limit switches will be sent to MSC-51 to stop the process of the hand or/and arm robot in order to avoid damage of motor. The figure 3.2 shows the proposed robot. Its size is 64 (width) × 140(length) × 60(height) cm.

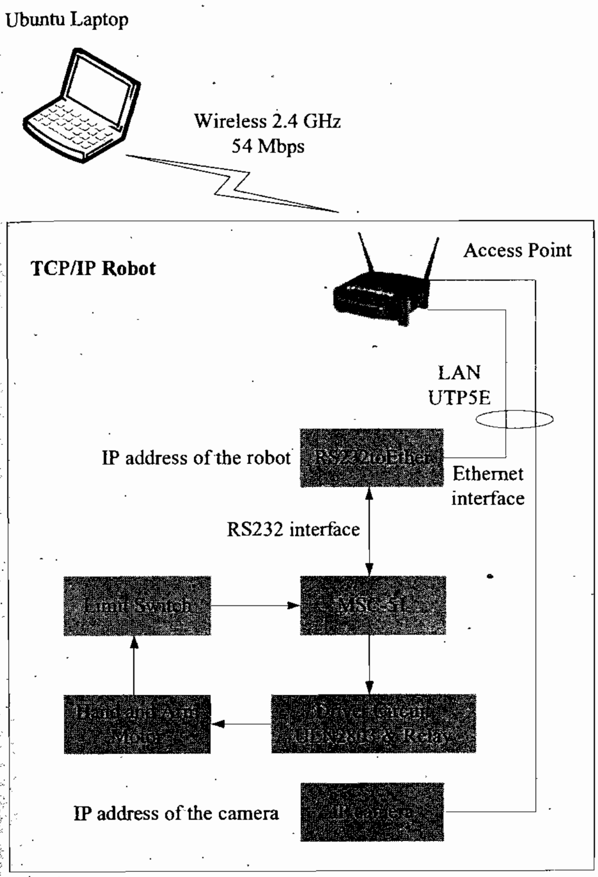
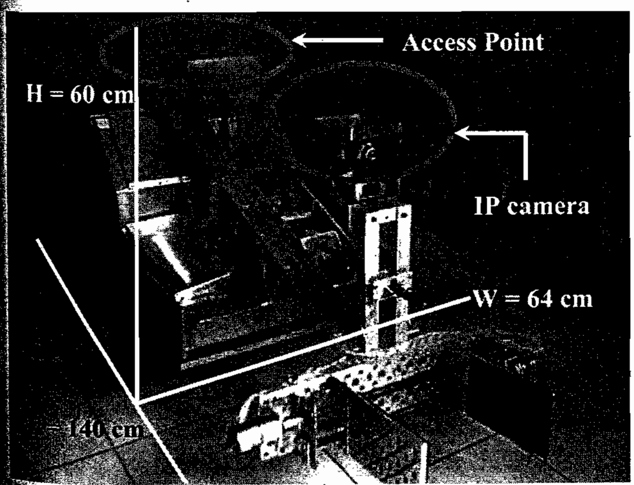


Figure 3.1 displays a diagram of the proposed IP robot which is remote controlled by Unbuntu Laptop.



igure 3.2 shows the proposed robot which is used to move omb

3.2. Control System

Control consists of two parts. One is a microcontroller on the IP robot and other is a notebook (Laptop) which runs a socket programming (Perl Script) [10] for remote control.

3.2.1. Mictocontroller on IP Robot

The following is some section of the main program on AT89C51AC3 Microcontroller.

```
'################################################################
$regfile = "reg51.DAT"
$ramstart = 0
$ramsize = 256
$crystal = 29419200
$baud = 19200
Dim Inctrl As String * 1
Do
  Inctrl = Inkey
  If Inctrl = "x" Then
            Gosub Mainmsg
  Elseif Inctrl = "a" Then                        'Turn left
            P0.4 = 0 : P0.3 = 1 : P0.6 = 1 : P0.5 = 0
            Waitms 250
            P0.4 = 1 : P0.3 = 1 : P0.6 = 1 : P0.5 = 1
  Elseif Inctrl = "d" Then                        'Turn Right
            P0.4 = 1 : P0.3 = 0 : P0.6 = 0 : P0.5 = 1
            Waitms 250
            P0.4 = 1 : P0.3 = 1 : P0.6 = 1 : P0.5 = 1
  Elseif Inctrl = "s" Then                        'Backward
            P0.4 = 0 : P0.3 = 0 : P0.6 = 0 : P0.5 = 0
            Waitms 250
            P0.4 = 1 : P0.3 = 1 : P0.6 = 1 : P0.5 = 1
  Elseif Inctrl = "w" Then                        'Forward
            P0.4 = 1 : P0.3 = 0 : P0.6 = 1 : P0.5 = 0
            Waitms 250
            P0.4 = 1 : P0.3 = 1 : P0.6 = 1 : P0.5 = 1
  Elseif Inctrl = "r" Then                        'Arm Lift up
            Gosub Switch1
  Elseif Inctrl = "t" Then
            Gosub Switch2                         'Arm Lift down
  Elseif Inctrl = "v" Then                        'Hand Seize
            P2.5 = 1 : P2.4 = 0
            Waitms 250
            P2.5 = 1 : P2.4 = 1                   'Hand Leave
  Elseif Inctrl = "b" Then
            Gosub Switch3
  Elseif Inctrl = "f" Then                        'Hand Hold up
            Gosub Switch5
  Elseif Inctrl = "g" Then                        'Hand Hold down
            Gosub Switch6
  End If
Loop
'Sub switch
Switch1:
Switch Alias P3.2
  If Switch = 1 Then
           P2.1 = 1 : P2.0 = 0
           Waitms 250
           P2.1 = 1 : P2.0 = 1
  Elseif Switch = 0 Then
           P2.1 = 1 : P2.0 = 1
           Waitms 250
  End If
Return
'################################################################
```

3.2.2. Remote control the robot via Wireless TCP/IP

In order to save cost, this paper use ubuntu[9] as OS for the notebook and Perl [10] for programming, which are free. The following is a main program for remote control the IP robot via TCP/IP wireless.

```
# By Dr.Sanon Chimmanee
# 16/10/08
use IO::Socket::INET;
use Term::ReadKey;

# Create a new socket
$my_socket=new IO::Socket::INET-
>new(PeerPort=>1470,Proto=>'tcp',PeerAddr=>'192.168.14.20');

$server_addr = $my_socket-> peerhost;
$date = `date`;
print "Robot Control Program : Start on $date";
print "<< Terminate by enter 'q' >> ";

# Send messages
$msg="Enter action to control robot($server_addr) : ";
print "\n",$msg;
$i = 0;
$j = 0;
while(1)
{
        $i = $i+1;
        ReadMode 4; # Turn off controls keys
        while (not defined ($msg2 = ReadKey(-1)))
        {
                # No key yet
        }
        if($msg2 ne 'q')
        {
            print "\n Action [",$i,"] >> " ;
            if($my_socket->send($msg2))
            {
            #------ moving robot-------------------
                if ($msg2 eq 'a'){print "turning left";}
                 elsif ($msg2 eq 'd'){print "turning right";}
                 elsif ($msg2 eq 'w'){print "forwarding";}
                 elsif ($msg2 eq 's'){print "backwarding";}
            #------hand robot-------------------
                 elsif ($msg2 eq 'v'){print "hand is seizing";}
                 elsif ($msg2 eq 'b'){print "hand is leaving";}
                 elsif ($msg2 eq 'f'){print "arm is holding up";}
                 elsif ($msg2 eq 'g'){print "arm is hold down";}
            #-----arm robot--------------------
                 elsif ($msg2 eq 'r'){print "hand is lifting up";}
                 elsif ($msg2 eq 'b'){print "hand is lifting down";}
                 else {print "No keys\n";}
            }
            else
            {
                # Send an "end" message to server and termianl
                $my_socket->send('q');
                $date = `date`;
                print "--Terminated on $date";
                print "\n";
                exit 1;
            }
        }
        ReadMode 0; # Reset tty mode before exiting
}
```

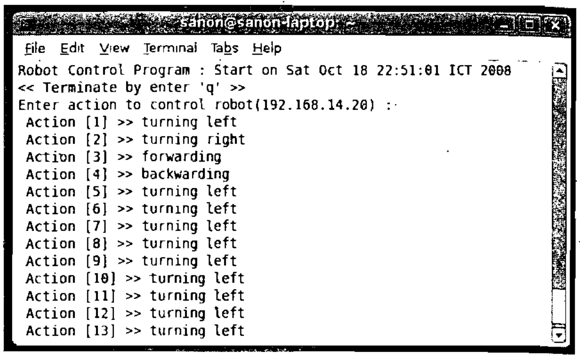


Figure 3.3 displays running the socket program on Ubuntu (8.04) notebook for remote control the robot via TCP/IP wireless

3.3. Hand Robot Design

Hand robot consists of 2 motors and one limit switch as shown in a figure 3.4

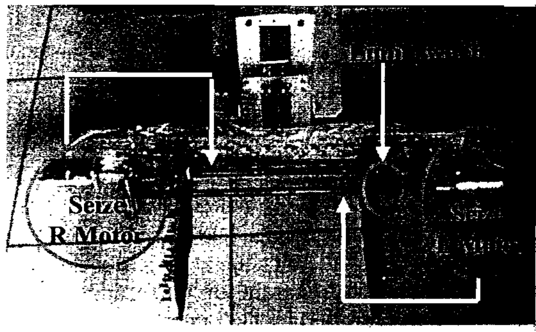


Figure 3.4 displays two motors of hand robot for seizing and leaving the object.

3.3. Arm Robot Design

There are two arm machines for comparing their performance. One is 3 degree of freedoms (DOFs) including one DOF of hand and the other is 5 degree of freedoms including one DOF of hand.

3.3.1. Arm robot design with 5 DOFs

Four degree of freedoms (DOFs) of arm and one DOF of hand, which totally is five DOFs are designed as shown in figure 3.5 and a figure 3.6.

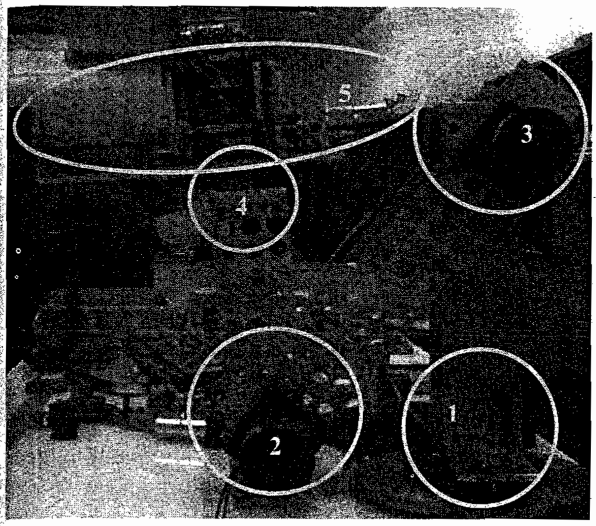


Figure 3.5 displays a side view of the arm robot with five DOFs including one DOF of hand.

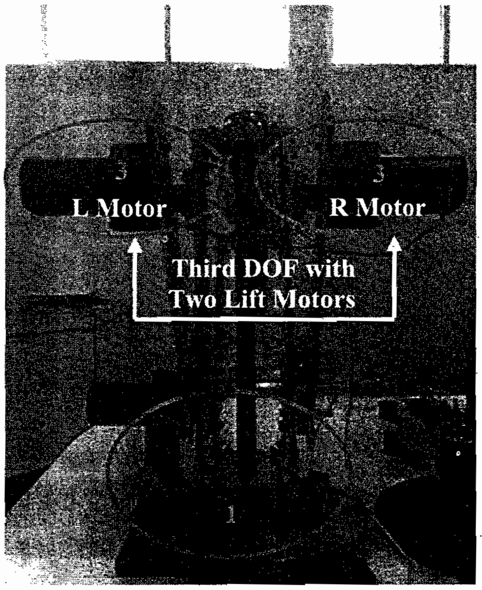


Figure 3.6 displays a behind view of the arm robot with five DOFs including one DOF of hand. Two motors for third DOF is shown.

3.3.2. Arm robot design with 3 DOFs

Three degree of freedoms including one DOF of hand are designed as a figure 3.7 and 3.8. First degree of freedom as shown in figure 3.8 contains a lift moter and a bevel gear. The bevel gear lifts up and down the robot arm.

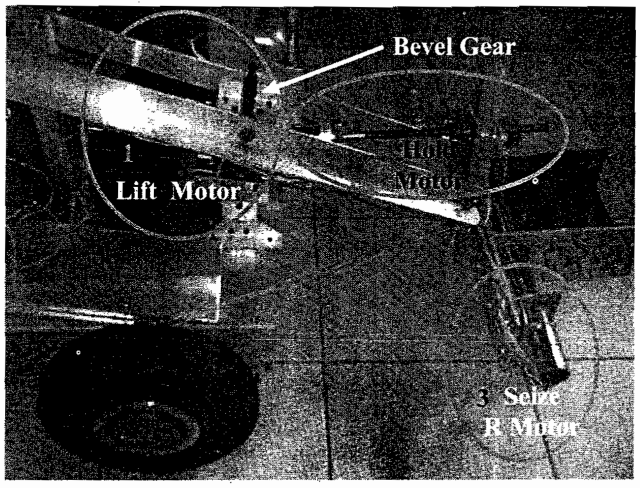


Figure 3.7 displays a side view of the arm robot with three DOFs including one DOF of hand.

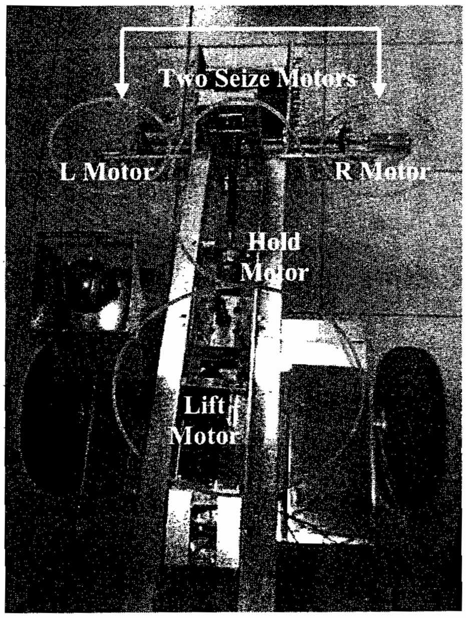


Figure 3.8 displays a top view of the arm robot with three DOFs

3.4. Machine design in moving of robot

There are two machine designs of the driving system for comparing their performance. One is four wheels and the other is two caterpillar tractors.

3.4.1. Four wheels

Figure 3.9 shows a driving system with four 12VDC motors for each wheel

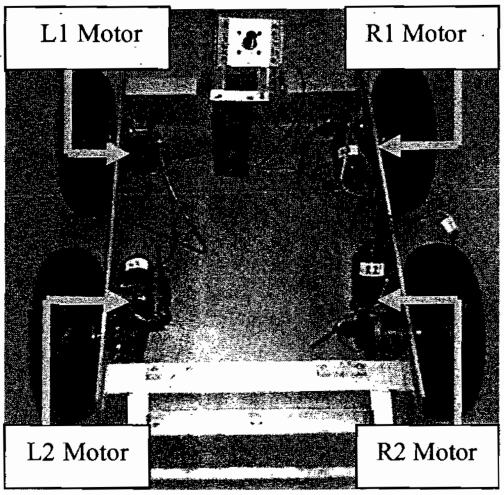


Figure 3.9 displays a top view of 4 wheel struture.

3.4.2. Caterpillar Tractor

There are only two 24VDC motors for caterpillar tractor as shown in a figure 3.10 due to a limitaiton of its struture. A motor of the caterpillar tractor structure is a higher power motor than the 12VDC motor used in the 4 wheels struture. Machine design in the caterpillar is displayed in a figure 3.11.

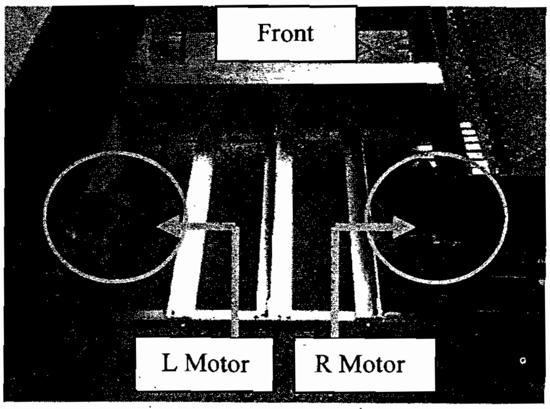


Figure 3.10 displays a sturture of caterpillar tractor which can use only two 24VDC motor.

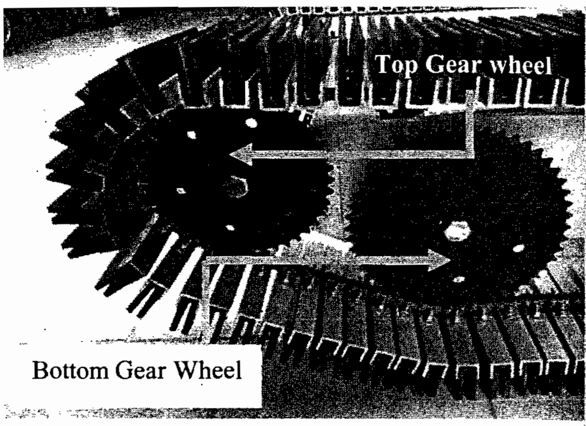


Figure 3.11 displays a top gear wheel and bottom gear wheels which are desgined in order to clime staircase.

4. PERFORMANCE EVALUATION

There are three parts for performance evalution as follow: performance evalution in arm robot, driving system, and access point.

4.1. Performance in design of arm robot

There are two machine designs of the arm robot which are decriped in subsection 3.3.1 (5 DOFs) and 3.3.2 (3 DOFs). Experiment of first arm robot with five DOF was done on Febury 12, 2007 at rangsit universtiy. Experiment of second arm robot with three DOF was done on October 12, 2008 at rangsit universtiy.

Arm Robot Experiment

item	Type of arm robot	Weight (kg) of arm robot	Weight (kg) can lift up
1	Rangsit robot with 5 DoFs	16	3
2	Rangsit robot with 3 DoFs	8	15
3	Kasat robot [11]	-	5
4	Lanna robot [12]	-	80

Table 4.1 lists performance evaluations in their capability of lifting up objects.

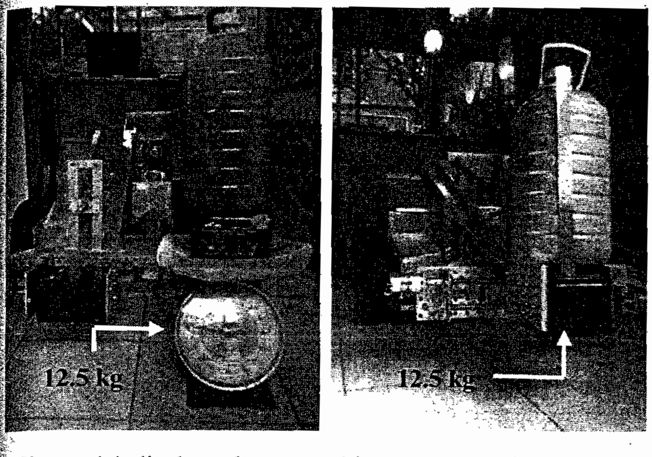


Figure 4.1 displays that two objects with totally 12 kg can be lifted up according to the Thai army requirment

4.2. Performance in design of the driving system

There are two machine designs of driving system which are decriped in subsection 3.4.1 (four wheels) and 3.4.2 (two caterpillar tractors).

Experiment of driving machine with 4 wheels was done on December 12, 2007 at rangsit universtiy. Experiment of driving with caterpillar tractor was done on Febury 12, 2008 at rangsit universtiy.

Experiment of the driving machine of Robot

item	Type of driving system	Height of Staircase (cm)	Weight (kg) can be moveable
1	Rangsit robot with four wheels	4	29
2	Rangsit robot with two caterpillar tractors	18	15

Table 4.2 lists performance evaluation in their capability of moving an object and climbing staircase.

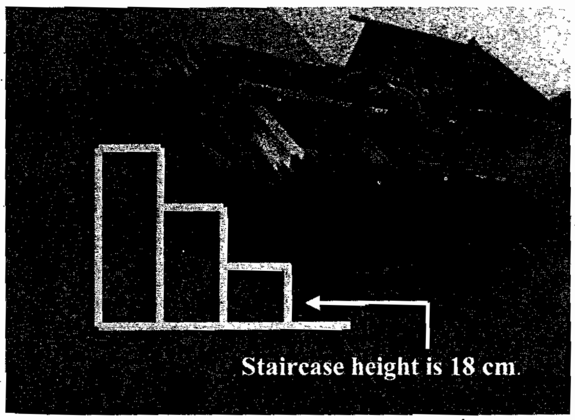


Figure 4.2 displays that a driving system with caterpillar tractor can climb staircase with height eqaul to 18 cm.

4.3. Performance in remote distance of access point

There are three methodologies of Linksys access point as follow: Typical Linksys WRT54 G (best seller), Linksys WRT54 G with two Linksys 7 dB anntenas, and Linksys WRT54Gx ver.2 that is MIMO technology with there are three antennas.

Experiments of remote distance measurment were done on Octerber 14, 2007 at the field of Prachanivate 2 village, Nontaburi, Thialand.

Experiment of Remote Control

item	Type of access point	Distance (m)
1	Typical Linksys WRT54 G	123
2	Linksys WRT54 G with two Linksys 7 dB anntenas,	138
3	Linksys WRT54Gx ver.2 (three anteanas)	174

Table 4.3 lists performance evaluation in remote access of access point

4.4. Cost comparison in Robot Building

The cost comparison for building the robots for moving bomb in Thailand are listed in a table 4.4

Cost comparison

item	Type of access point	Budget (bath)
1	Rangsit robot	80,000
2	Kasat robot [11]	-
3	Lanna robot [12]	150,000

Table 4.4 lists comparative cost of building robot by universities in Thailand.

5. DISCUSSION

5.1. Discussion in the arm robot design

From subsection 4.1 (performance in arm robot), it found that althoung the arm with 5 DOSs uses two 24VDC motors (Third DOS as shown in the figure 3.6) for lifting up the object while the arm with 3 DOSs use only one motor 24 VDC (First DOS as shown in the figure 3.7 and 3.8), the arm with 3 DOFs can lift up the object whose weight equal to 12 kg. This is because of good at machine design. Another reason is that less motor means less weight. Note that the lift motor of five and three DOF is the same product and version.

5.2. Discussion in design of the driving system

From subsection 4.3 (performance in drving system), it found that the driving with caterpillar tractor can move lower weight than the driving with wheel because a totally weight of two caterpllar tractors is heavy than a totally weight of four wheels. One wheel weight is equal to 2.2 kg and one caterpillar tractor is equal to 7 kg. Another reason it that there are 4 motors for driving in the driving system with wheels while there are only 2 motors for driving in the driving system with caterpillar tractors.

6. CONCLUSION

From Thai Army requirments, it is found that IP robot with 4 wheels and 3 DOF are appropriate since it can be satified all requirements. Addiotnally, it is a simple machine. This allows maintenance and repairs the IP robot to be easy. The weight of the proposed IP robot is equal to only 42 kg. Its width is equal to 64 cm including width of wheels. This enables to move the IP robot pass the typical door whose width equal to about 75 cm.

An electrical system and power supply of IP robot will be developed in order to allow IP robot to work more than 60 minute. Jamming signal device should be built in the IP robot in the furtherwork.

7. ACKNOWLEDMENT

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Last but not least, Author would like to express my deep appreciation to Ladda Soonthornnont for her precious love. Also deeply thanks some girl who is my "beautiful mind" for her actual love.

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