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Methodological aspects of the formation and implementation of management strategy

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Abstract: Under consideration advantages and disadvantages use of control systems movement unmanned transport means of transportation passengers and cargo: via infrared (IR) channel; via radio channel; using DTMF; using Bluetooth. Under consideration Creation autonomous systems UAS control. As control unit for a robotic vehicle is being considered controller Arduino. Modeling is produced for the robot on the basis four-wheeled all-wheel drive chassis. Considered schemes management movement of UAS, their installation, as well as sketches that can be used for control unmanned transport means.

Keywords: modeling, unmanned transport means, systems management movement, controller Arduino, infrared (IR) channel, radio channel, DTMF, Bluetooth, autonomous management.

1. Introduction

Unmanned motor transport remedy (BAS) is transport means without driver, which equipped system automatic management and which Maybe move without participation human [1-5]. At present time already in two cities – Pittsburgh (USA) and Singapore – are used unmanned taxis [5-8], which Maybe take advantage of ordinary Human.

For modeling unmanned motor transport funds and workings off processes his functioning necessary system automatic management, which Can create on base standard Arduino design with boards extensions [8-13]. Constructive Arduino is electronic constructor and platform fast developments electronic devices (Fig. 1). Thanks to simplicity language programming , open architecture and software code_constructive Arduino uses huge popularity in to all world [9-15]. Device is programmable without use programmers via USB.

2. Subject of research

Purpose: scientific substantiation of the creation of an unmanned vehicle control system based on an Arduino controller.

3. Research

3.1 Systems remote management

The first stage of UAS modeling is modeling the running characteristics of the chassis. For these purposes, remote control is used, in which control commands can be transmitted in several ways:

- By infrared (IR) channel;

- By radio channel;
– c using DTMF;
- using Bluetooth.

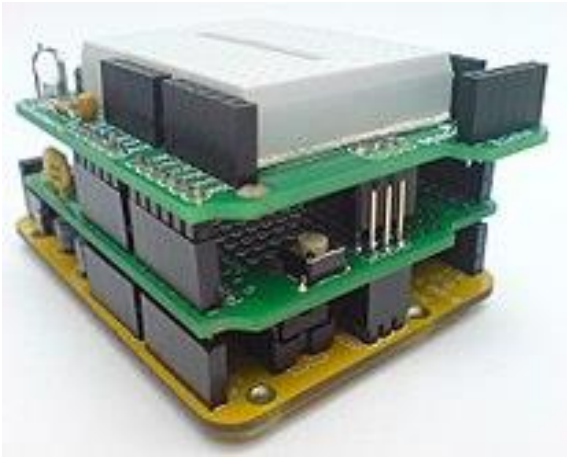

Fig. 1. Standard Arduino design with boards extensions.

3.2 Remote control via IR channel

Infrared (IR) system remote control (RC) – one from the most simple ways interactions with the controlled objects.

For transmissions teams is used remote controller remote management. Commands are transmitted using infrared beam. For increases noise immunity beam is modulated frequency 38 kHz, others are also used close frequencies. Team encrypted pauses in transmission. There are some various protocols encryption. Most often are used protocols Philips RC5 and protocol NEC companies with the same name title. So like IR rays are spreading rectilinearly, then For reliable connections necessary straight visibility between remote control control (emitter) and receiver of IR signals. However, IR rays Fine are reflected from majority materials (walls, furniture), therefore, in the room This requirement Maybe Not be performed. IR signal receiver few sensitive to IR radiation on others frequencies. Dedicated from received signal team transmitted on controlled device.

For Arduino is being released a set consisting of from remote control remote control, IR receiver, wires For connecting the IR receiver and IR diode (Fig. 2).

Fig. 2. Set For remote management.

For IR system organizations remote management necessary on chassis install IR receiver, connect his to Arduino and download corresponding sketch.

3.3 Remote control by radio channel

For management ALS is possible take advantage of radio kit containing (at single-channel option) FS 1000A transmitter and receiver MXR 5V.

Frequency transmissions data By radio channel – 433 MHz (there are options on frequencies 315 MHz and 330 MHz).

Modules can have different names, but All They have approximately same external type and numbering contacts (Fig. 3).

Advantage these radio modules is simplicity connections to boards Arduino and their cheapness.

Fig. 3. Set radio modules: transmitter FS 1000A and receiver MXR 5V.

Disadvantages follows to attribute availability noises from big quantities others devices (radio chandeliers, radio sockets, key fobs, radio-controlled models), working on this frequency and low speed transmissions signal.

3.4 Management using DTFM

This enough exotic but, quite real way remote management. To his advantages follows to attribute simplicity implementations, large quantity teams, stable work, but to the disadvantage Maybe be attributed That the fact is that at use DTMF as remote control and as receiver signals are used mobile telephones (Fig. 4).

Fig. 4. Chassis, remotely controlled by module DTMF.

For decoding DTMF signals developed microcircuits decoders. The MT8870 module allows decode tonal signals (DTMF) of the phone and set relevant logical levels on terminals Q1-Q4 (Fig.5).

Module Can connect to phone, set up his on auto answer and calling on this phone, you can manage module remotely from buttons phone.

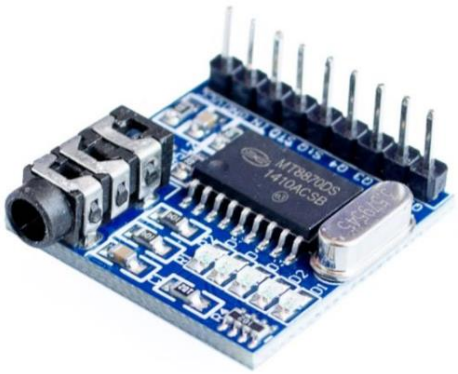

Fig. 5. Module For decoding signals DTMF.

DTMF decoder collected on chip MT8870. On payment there are five LEDs, for facilities checks states outputs. On conclusions Q 1- Q 4 is output binary coded decimal code received after decoding accepted signal.

For implementations control systems using DTMF on chassis need to install module DTMF and strengthen mobile phone that connects to the module special cable. On phone, reinforced on chassis, necessary install a program that provides automatic lifting tubes at admission incoming call.

In Arduino follows download sketch that provides execution five teams management movement: 1 – FORWARD, 2 – BACKWARD, 3 – LEFT, 4 – RIGHT, 5 – STOP (in the sketch Can lead additional commands.)

Process management has row Features:

- team is being executed Not By pressing buttons, and by her release;
- cancellation executable teams possible only By pressing / releasing buttons 5;
- change executable running teams Maybe only through button 5.

It is natural that specified peculiarities complicate and make less familiar and convenient process management. Some complication sketch allows enter some improvements.

3.5 Management with and with use Bluetooth

Most convenient and most universal is control using Bluetooth. In this in this case as the remote control is used smartphone or tablet, and as receiver is used Bluetooth module H C-06 installed on chassis and connected to Arduino.

On tablet or smartphone used For management, should be installed program simulating remote controller remote management. Such program Can create independently, using c erv c and c om RemoteXY. However, it is easier total use one from specialized programs by selecting her from sets existing ones. Taking advantage of service Play Market follows download and install selected program (Fig. 6).

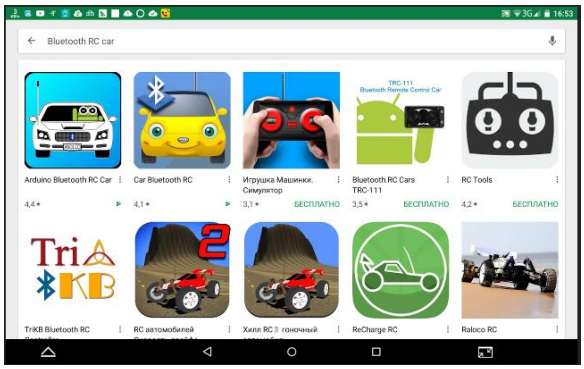

Fig. 6. Selection programs For remote control management on service Play Market.

It is advisable take advantage of simple and convenient program Arduino Bluetooth RC Car (Fig. 7) or Very on no similar program Car Bluetooth RC (Fig. 8).

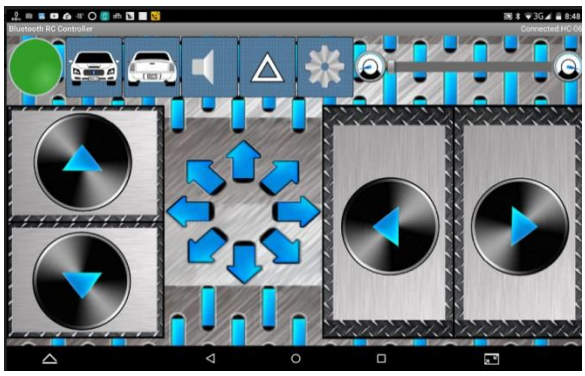

Fig. 7. Remote control control in the program Arduino Bluetooth RC Car.

For research opportunities UAS modeling using construct Arduino let's take advantage program Arduino Bluetooth RC Car. Program Car Bluetooth RC has small differences.

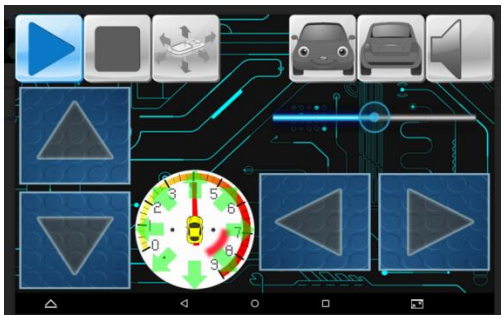

Fig. 8. Remote control control in the program Car Bluetooth RC.

After installation and launch programs Arduino Bluetooth RC Car will open screen, on which shown remote controller management, on background whom outlined request give permission on inclusion Bluetooth (Fig. 9).

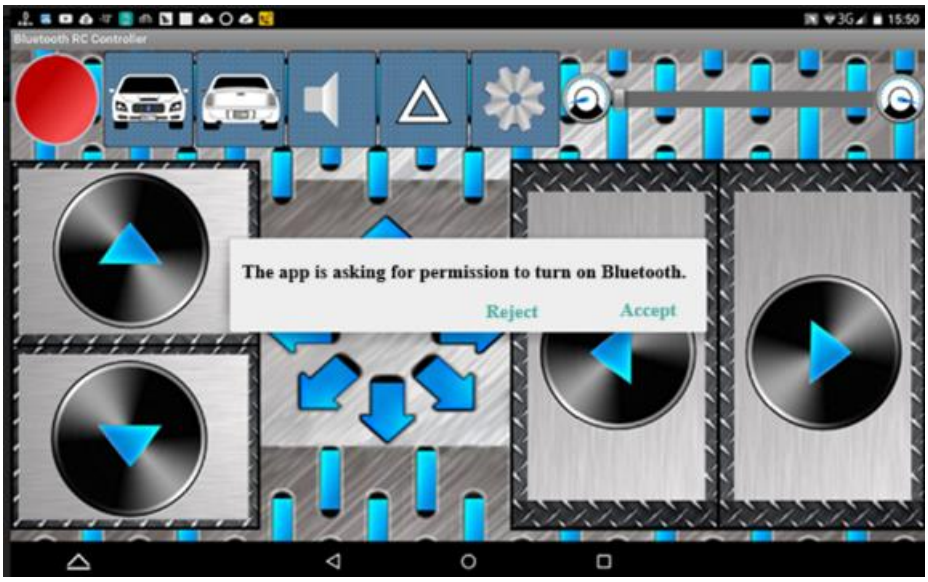

Fig. 9. Request on permission inclusions Bluetooth.

At first launch programs it is advisable abstain from issuance such permissions, click on the " Reject " button and proceed to review opportunities programs (Fig. 10).

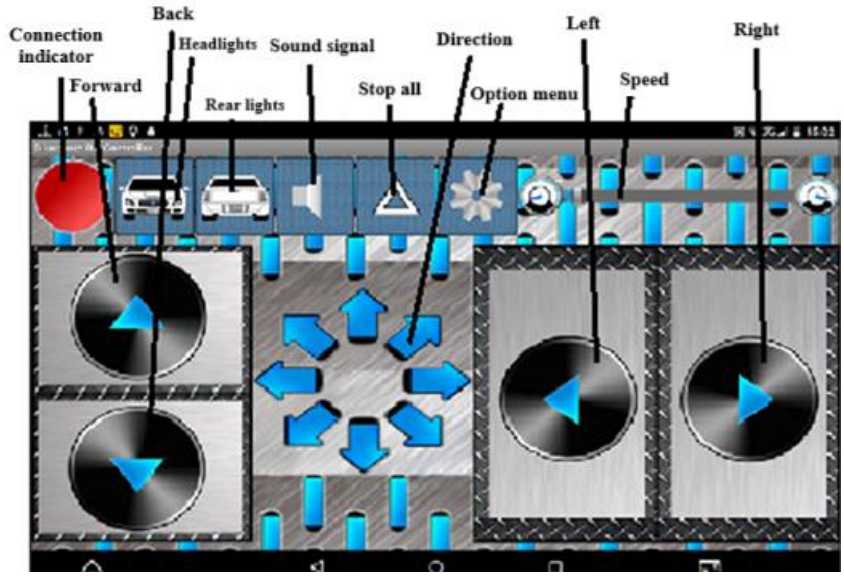

Fig. 10. Elements remote control management.

On the left top corner screen The CONNECTION INDICATOR with the controlled object is placed object. When absence connections He red colors, at established connections - green.

For management movement There are 4 buttons: FORWARD, BACKWARD. RIGHT, LEFT. Control signal issued By press and hold buttons. Selected direction at this celebrated red arrow. When releasing buttons issued STOP signal. Turn on front headlights is carried out by pressing corresponding buttons, turn off - repeat by pressing this same buttons. Indication inclusions is designated backlight buttons. Turn on rear lanterns and sound signal is carried out similar. Pictograms on buttons indicate on their appointment.

At pressing on button OPTION MENU opens corresponding list (Fig. 10).

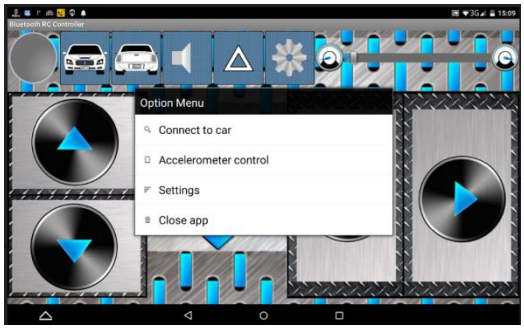

Fig. 10. OPTION MENU.

Paragraph CONNECT TO CAR intended For launch process establishments connections with the object management. Interest represents paragraph ACCELEROMETER CONTROL. It turns out that it is possible to control movement Can Not only at help buttons, but also using incline smartphone / tablet in tu or other side. When this For formations managers teams is used built into mobile device triaxial gyroscope (yes) Not in all mobile devices). Issued team corresponds direction tilt and for clarity illuminated respectively directed arrow on some changed screen (Fig. 12).

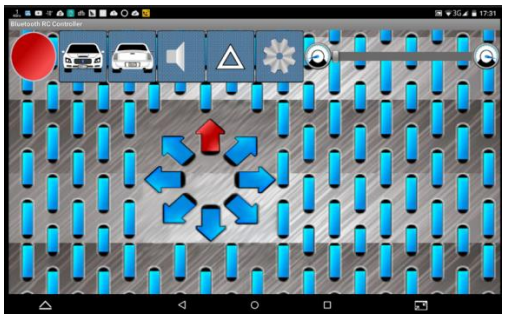

Fig. 12. Screen at management tilt corps smartphone / tablet.

At selection in OPTION MENU point SETTINGS, opens screen settings (Fig. 13).

Fig. 13. Screen settings.

Remote controller forms commands in the form characters that By channel Bluetooth are passed to the module Bluetooth connected to Arduino and from this module By consistent port are passed to the Arduino, where are decrypted and converted into commands management data device.

Like this Thus, the remote control management is universal, suitable For management various devices, so How teams management are formed in in itself controlled device software by way of.

Scroll main commands:

1. Forward (Forward) - F;
2. Back (Nasal) – B;
3. Left (Left) – L;
4. Right (Right) – R;
5. Stop (Stop) – S;
6. Front Lights On (Headlights incl.) – W;
7. Front Lights Off (Headlights off) – w;
8. Back Lights On (Stop signals incl.) – U;
9. Back Lights Off (Stop signals off – u;
10. Horn On (Sound signal incl.) – V;
11. Horn On (Sound signal off) – v;
12. Speed 0 (Speed) – 0;
13. Speed 1 0 (Speed) – 1;
14. Speed 2 0 (Speed) – 2;
15. Speed 3 0 (Speed) – 3;
16. Speed 4 0 (Speed) – 4;
17. Speed 50 (Speed) – 5;
18. Speed 6 0 (Speed) – 6;
19. Speed 7 0 (Speed) – 7;
20. Speed 80 (Speed) - 8;
21. Speed 9 0 (Speed) – 9;
22. Speed 10 0 (Speed) – 10;
23. Stop All (Stop all) – D.

Control movement is carried out by pressing and holding responsible necessary direction buttons. When releasing pressed buttons issuance teams is terminated and issued team STOP. Installation speeds movements is produced moving slider. The rest teams turn on / off double by pressing on corresponding button.

At preparation for work BAS chassis in addition to the previously established equipment need to will add module Bluetooth, which installed and connected using mock-up boards. Mounting scheme connections module HC -06 shown on rice. 14.

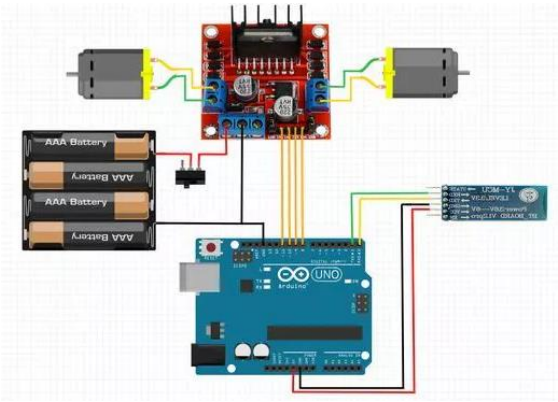

Fig. 14. Connection module HC -06.

Additionally on chassis Can install headlights, rear lights and sound signal.

After inclusions nutrition in addition to the usual turning on LEDs, will be added more one installed on module Bluetooth. After inclusions nutrition this LED will blink what testifies about absence channel connection with the remote control management.

Sketch Loads into Arduino ordinary in a way, on time downloads conclusions Rx and Tx should be are disabled. This one has sketch There is one feature: if in time execution running teams will be interrupted connection, then control will lost, but team will continue be fulfilled. Therefore, if danger losses connections is real, then need to use sketch that at breakup connections will stop engines.

For settings remote control management follows launch on mobile device previously installed program Bluetooth RC Controller, and in the opened screen press on button Allow (see Fig. 9).

Open « Option Menu », select item « Connect to car » and in the opened screen (see Fig. 11) press on the " Allow " button, after what nutrition Bluetooth turn on and you can proceed to connect to chassis, power whom should be included.

Opening " Option Menu ", you need choose item « Connect to car » and in the opened screen press on button " Scan for devices ". Through small time module NS-06 will be found and listed available devices (Fig. 15).

Fig. 15. Module NS- 06 found and listed available devices

Now need to press on title module and through small time Indicator availability connections will change color on green what indicates the presence connections between remote control control and chassis and it is possible start off control (Fig. 16).

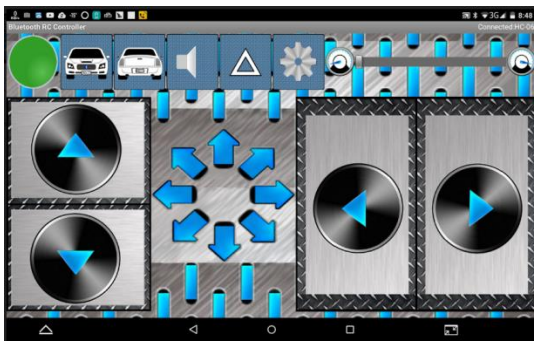

Fig. 16. Chassis connection installed, you can start off control.

After completion use Bluetooth, should Not forget disable in mobile device his nutrition in avoid useless expenditure charge batteries.

Need to note that Not Always All it turns out because about this told by one. from often encountered troubles is unstable connection By channel Bluetooth, which often breaks off. When filing teams connection is torn apart, about what testifies change colors indicator states connections. Reason usually lies in the source nutrition. At the moment inclusions engines from batteries is consumed big current that leads to short-term fall tension, however this enough to module HC -06 lost connection.

Exit from provisions Maybe become connection electrolytic capacitor big capacity (not less than 100 μF) as Can closer to conclusions nutrition module HC -06.

Radical way eliminate this flaw is usage For nutrition Arduino separate source nutrition. For this Can use battery Krona, having connected her through stabilizer voltage, step-down voltage to five volt (Fig. 17).

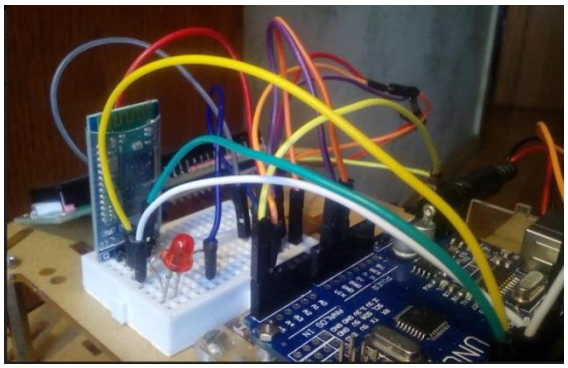

Fig. 17. Module HC -06 installed in a mock-up fee on top platform chassis.

Autonomous control

At autonomous management robot provided to myself to yourself and depending on from external conditions on one's own chooses line behavior. Externally is being created the impression that He has to some intelligence that helps to him to carry out " reasonable " behavior.

These properties robot acquires for check installations relevant sensors that transmit to him information about surrounding the environment and the program that processes received information and generates necessary teams management.

Convenient object For experimentation is automobile chassis, on which is being installed corresponding equipment.

Below reviewed three options devices:
- intended For detours obstacles;
- intended For movement along lines;
- intended For movement By given route.

Detour obstacles

For in order to successfully go around obstacles, on chassis should be installed additional equipment that can " see " the obstacle and determine distance to him. As such devices Can use ultrasonic rangefinder HC-SR04. He allows measure distance to Obstacles in the range from 2 to 400 cm and represents by yourself fee, on which posted emitter, receiver ultrasound and control electronic diagram. Sensor has simple interface - two output nutrition, one entrance and one output (Fig. 18).

Fig. 18. Ultrasonic rangefinder (sonar).

Transmitter radiates ultrasonic impulse that is reflected from object and is accepted receiver. Next pulse Maybe be emitted, only after disappearances echo from previous. This is time it's called period cycle. Recommended period between impulses must be Not less than 50 ms.

Rangefinder strengthens in the front parts top grounds. He Maybe be fixed motionless, but corner his review Not enough wide (about 20 degrees), which allows Not face obstacles but calls some difficulties at choice directions their detour (Fig. 19).

For liquidation this lack of rangefinder often install on movable platform (bracket) which Maybe turn horizontally planes on angle 180 degrees.

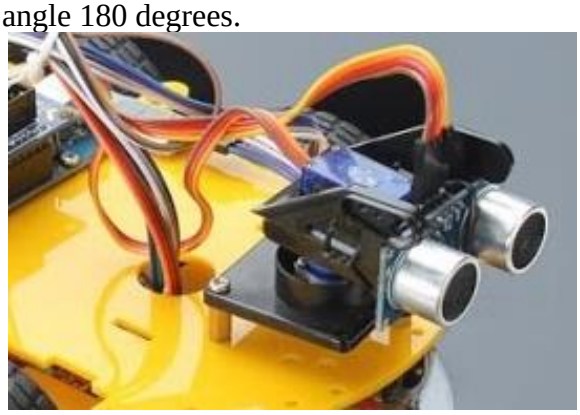

Fig. 19. Rangefinder, stationary fixed on top platform chassis.

Turn is carried out at help servomotor. Bracket with installed servo motors shown on Fig. 20.

Fig. 20. Assembled bracket.

Additional equipment should be connected according to the table.

Table 1. Additional equipment

Rangefinder HC-SR04	Servo motor SG 90	Arduino
+ 5V		+5V
GND		GND
Trig		12
Echo		11
	+5V	+5V
	GND	GND
	Data	9

In its simplest form case all route consists of from two recurring plots. On first plot chassis moves By direct, rangefinder is set to the original position and measures through every 0.5 seconds distance to possible obstacles. This is is happening to those until to emerged obstacles will remain installed in the program distance. After this chassis stops and starts second area - search directions further movements. Rangefinder turns around 90 degrees to the left, measured free distance (a). Then rangefinder turns around 180 degrees to the right and is measured free distance (b). Selected big from quantities (a) or (b) and it is checked that selected size more minimal distances. Then is produced turn 90 degrees to the side more distances and turns on first plot. Alternation plots continues to those until Not will come situation, when which (a) and (b) are less than provided minimal distance. At this will turn on STOP mode.

Sketch that implements given algorithm movements chassis, given below.

```
#include " Ultrasonic.h "
#include " Servo.h "
Servo myservo;  // create object type Servo and give to him Name
 int led = 13;
Ultrasonic ultrasonic( 12, 11); // Trig - 12, Echo - 11
int In1 =2;
int In2 =4;
int In3 = 7;
int In4 = 8;

void setup( )
```

```
{
  Serial.begin (9600);
  pinMode ( led, OUTPUT );
  myservo.attach (9); // specify port to which connected servo
  myservo. write (90);
}

void loop ( )
{
  float dist _ cm = ultrasonic. Ranging ( CM );  // reading distances to obstacles
  Serial. println ( dist _ cm ); // output to serial port distances
  if ( dist_cm > 15 )
{ digitalWrite ( led, LOW);
   digitalWrite (In1, HIGH ); // FORWARD
   digitalWrite (In2, LOW);
   digitalWrite (In3, HIGH);
   digitalWrite (In4, LOW);
   delay ( 500);
}
  else { / / If distance less acceptable
  digitalWrite (In1, LOW ); / / STOP
  digitalWrite (In3, LOW);
  digitalWrite ( led, HIGH);
  myservo.write (0); // Rotate rangefinder to the right
float dista_cm = ultrasonic.Ranging (CM); // Measurement  distances (a)
Serial. println ( dista _ cm ); // Print results
  delay (200);
  myservo. write (180); // Rotate rangefinder to the left
  float distb_cm = ultrasonic.Ranging ( CM ); // Measurement  distances ( b )
  Serial. println ( distb _ cm ); // Print results
  delay(200);
  myservo.write (90);
if ( dista_cm > distb_cm )
{ digitalWrite (In 1,HIGH ); // RIGHT
delay(200);
    digitalWrite (In 1,LOW ); // STOP
}
    else

{ digitalWrite (In 3,HIGH ); // LEFT
delay(200);
    digitalWrite (In 1,LOW ); // STOP
}
}
}
```

Works this program next way.

1.Checked, installed li rangefinder to the FORWARD position, and if no, then is installed in this position.

2 Measured distance to obstacles. If it exceeds 20 centimeters, issued command FORWARD and it happens back to top programs. In time movements continues happen measurement distances to obstacles.

3. If distance less established, then issued the STOP command is carried out search free paths.

4. The rangefinder rotates to the right 90 degrees and is measured distance to obstacles (a), then rangefinder turns around to the left 180 degrees and is measured distance to obstacles (b).

5. The larger one is selected from two measured distances and is checked..

6.If it turns out that a> b > is minimal established, then issued command LEFT and it happens return to the beginning programs.

7. If it turns out that b > a > is minimal established, then issued command RIGHT and it happens return to the beginning programs.

8. If it turns out that a & b < minimum established, then further movement impossible.

Movement along lines. The KY -033 module – line sensor (Fig. 21) must be installed on the chassis.

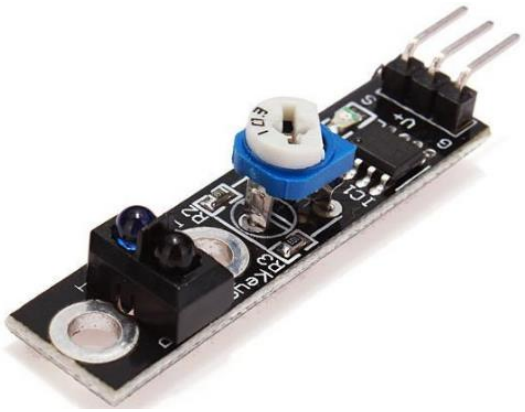

Fig. 21. Module KY -033.

On payment module located IR emitter, receiver and indicator triggering. Adjustment sensitivity Can produce with the help of potentiometer At absence reflected signal on exit high level, at availability reflected signal - low level.

Sensors need to install so that difference between white and black was How Can more. If difference less than 30, sensors follows install below.

In its simplest form case For in order to chassis could move along lines enough one sensor.

```
int In1 =2;
int In2 =4;
int In3 = 7;
int In4 = 8;
int sensor = 9;   // датчик линии
 void setup() {
  pinMode (In1, OUTPUT);
  pinMode (In2, OUTPUT);
  pinMode (In3, OUTPUT);
  pinMode (In4, OUTPUT);
  pinMode (sensor, INPUT);
}

void loop() {
if ( digitalRead (sensor) == HIGH) { // if sensor sees black
    digitalWrite ( In1, HIGH); // rotation right
    digitalWrite ( In2, LOW);
```

```
    digitalWrite ( In3, LOW);
    digitalWrite ( In4, LOW);
  delay(500);
  }

  else { // otherwise
    digitalWrite ( In1, LOW); // rotation left
    digitalWrite ( In2, LOW);
    digitalWrite ( In3, HIGH);
    digitalWrite ( In 4, LOW );
  delay (500);
  }
  }
```

Robot with one sensor lines moves By black strip on white field slowly and zigzagging. With two sensors robot moves faster and more smooth for check what increases speed movements and savings energy batteries.

Algorithm will next:

- If both sensor see white color - move forward;
- If one from sensors sees white and the other black - turn to the side black;
- If both sensor see black color - we on at a crossroads (for example, let's stop).

```
  int m11 = 7; // contact INPUT 1
  int m12 = 8; // contact INPUT 2
  int m21 = 5; // contact INPUT 3
  int m22 = 6; // contact INPUT 4
  int Lsensor = 9; // left sensor lines
  int Rsensor = 10;     // правый датчик линии
  int l;
  int r;
  void setup() {
    pinMode (m11, OUTPUT);
    pinMode (m12, OUTPUT);
    pinMode (m21, OUTPUT);
    pinMode (m22, OUTPUT);
    pinMode (Lsensor, INPUT);
    pinMode ( Rsensor, INPUT);
  }
  void loop( ) {
  l = digitalRead ( Lsensor );
  r = digitalRead ( Rsensor );
    if ((l == 0)& &(r==0)) { // if both sensor see white - movement forward
      digitalWrite(m11, HIGH);
      digitalWrite(m12, LOW);
      digitalWrite(m21, HIGH);
      digitalWrite(m22, LOW);
    }

  if ((l== 1)& & (r==0)){ // if left sensor sees black - turn left
      digitalWrite ( m11,LOW);
      digitalWrite ( m12,LOW);
      digitalWrite ( m21,HIGH);
```

```
    digitalWrite ( m22,LOW);
  }

if ((l== 0)& & (r==1)){ // if right sensor sees black - turn right
   digitalWrite ( m11, HIGH);
   digitalWrite ( m12,LOW);
   digitalWrite ( m21,LOW);
   digitalWrite ( m22, LOW);
  }
}
```

5. Research methods

Methodology: the methodological basis of theoretical research is based on the use of systematic, scientifically based analysis in the field of creation of control systems for unmanned vehicles (robo cars) based on the Arduino controller.

6. Research results

An analysis was performed and control systems based on the Arduino controller were created for modeling unmanned vehicles (robo cars). The methods of modeling the control systems of unmanned vehicles were tested on a four-wheel all-wheel drive chassis. **Scientific innovation:** The mathematical model of control systems for robot cars has been further developed (development of sketches) based on a four-wheeled all-wheel drive chassis using an Arduino controller. **Practical significance:** Designed, manufactured and practically tested in simulated conditions of a vehicle control system using an infrared channel, a radio channel, using DTMF, using Bluetooth on the basis of a four-wheel all-wheel drive chassis. The developed hardware and software complex allows you to create unmanned vehicles using the Arduino controller and makes it possible to quickly evaluate the effectiveness of control systems for unmanned vehicles.

7. Conclusions

1. Development and creation unmanned cars (robomobiles) is promising direction development transport funds transportation cargo and passengers.
2. To simulate the behavior of vehicles, it is possible to use various remote control systems: via IR channel, via radio channel, using DTMF, using Bluetooth.
3. Usage autonomous management on base Arduino boards allows unmanned autonomous means depending on from external conditions on one's own choose line behavior.
4. The following systems management movement of the BAS, blocks nutrition, as well as sketches For checks their performance and management can be used at modeling and further research unmanned cars.

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