AN DISSEMINATE SYSTEM TO CONTROL AND COMMUNICATE UGV AND MAV

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Abstract— This paper represents a communication and control systems based surveillance for Unmanned Ground Vehicle (UGV) – Micro Air Vehicle (MAV). Radio Frequency (RF) relay based control and communication system is used to communicate between the vehicles and ground station. These control systems are meant to inscribe a large number of military and civilian applications counting reconnaissance, intelligence and surveillance in collusion with communication network. A First Person View (FPV) approach is employed to regulate the vehicles wirelessly. This paper discusses the on-board computation methodology of the vehicles and communication system with ground station through a custom interface. The integrated system concludes to present a technique to control and coordinate a robotic surveillance system.

Index Terms—Micro Air Vehicle, Relay Communication, Surveillance, Unmanned Ground Vehicle.

I. INTRODUCTION

Unmanned vehicles[1] are meant to accomplish the affair of reconnaissance, intelligence and surveillance. The control and communication between ground station and these vehicles is accomplished using a regulating operation and custom interface. Without a human pilot on board an unmanned vehicle, like UGV[2] and MAV[3], are autonomous or wirelessly controlled vehicle, having motion controlled either autonomously by computers in the vehicle, or under the remote control of a pilot on the ground or in another vehicle. The presented system in this research, as shown in Fig. 1, consists of an Unmanned Ground Vehicle (UGV), a flapping type Micro Air Vehicle (MAV) and a Base Station with communication devices and laptops.

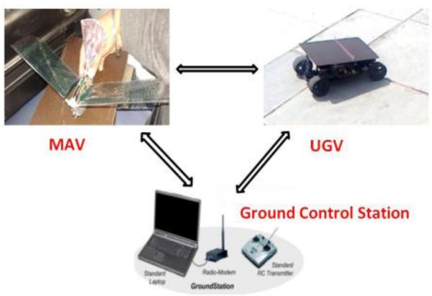


Fig.1. Developed system consisting of UGV-MAV-Ground Station

Unmanned system based surveillance entails long range data transmission and operation. The entire mission plan incorporates the execution of UGV as the launch vehicle for MAV and a relay with repeater on it. As RF modules issue an authentic method of communication, which is used between the above discussed systems. During the mission, the operation is to be performed for a range of 3 km and the wireless RF module available in India was not of craved range to control the MAV directly from base station. Accordingly, on the UGV a relay circuit subsisting of two RF modules was used. The task was accomplished by deploying the UGV up to the 500m range after which, the MAV was launched from it. In a system, these vehicles together extant various civilian and military applications in the field of surveillance and intelligence with a video camera and sensors equipped on both the vehicles.

II. CONTROL AND COORDINATION STRUCTURE DELINEATION

A. *UGV Control System*

The delineation of available UGV system was achieved by instrumenting the vehicle for computer controlled operation. The UGV consists of subsystems including drivetrain, 2-axis pan tilt system, on board camera, sensors and servo motors for navigation. The UGV has been developed to evolve relay system for communication and to take the MAV from Ground Control Station to the 500m mark. It is propelled by 5 Kg-Cm Torque DC Brushless motor, 1000 RPM and the rating of 12V and 2 Amps. To achieve UGV forward and backward motion the above mentioned high torque and high rpm motor. This motor is connected to the differential gear which propels the vehicle making it a 2 wheel drive. By using the steering system the direction control of the UGV is attained which is actuated by the Servo motor, providing precise steering, thus helping in maintaining the stability. These motors and servos is Arduino Mini Board consisting of Atmel's Atmega 328 microcontroller is controlled by the system hardware, which is considered to be compact, highly efficient and reliable. Fig. 2 shows the on-board circuit diagram of the UGV.

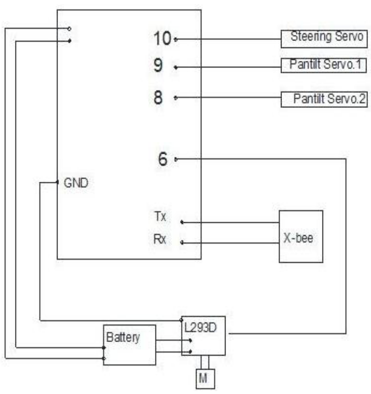


Fig.2.On-board circuit diagram-UGV

As shown in Fig. 2 circuit diagram, motor M the main drivetrain motor controlled by L293D controller. Also, the steering system drives by a servo motor and two servo motor combines to make a pan-tilt system, which are attached to the microcontroller. The programme code to control the vehicle wirelessly from base station is done using Arduino 1.0.5 Software as shown in Fig. 3 below.

Fig.3. Programming code in Arduino 1.0.5

```
*/
#include <Servo.h>

Servo myservo;
Servo myservo1;
Servo myservo2;
int motorPin = 6;
int m2 = 7;
int pos = 130;
int inByte = 0;

int pos1=100;
int pos2=100;
void setup()
{
  Serial.begin(9600);
  myservo.attach(9);
  myservo1.attach(10);
  myservo2.attach(11);
  myservo.write(130);
  myservo1.write(100);

Continue.....
void loop()
{

  digitalWrite(12,HIGH);
  if (Serial.available() > 0) {
  inByte = Serial.read();
  if (inByte=='q' &&
pos<=160){
  pos=pos + 10;
  myservo.write(pos);
  delay(05);
  }
  else if (inByte=='r' &&
pos> 100){
  pos=pos - 10;
  myservo.write(pos);
  delay(05);
  }
  else if (inByte=='o' &&
pos1> 60){

pos1=pos1 + 10;
myservo1.write(pos1);
delay(05);
}
else if (inByte=='u' &&
pos2> 60){

pos2=pos2 - 10;
myservo2.write(pos2);
delay(05);
}
else if (inByte=='i' &&
pos2<140){
pos2=pos2 + 10;
myservo2.write(pos2);
delay(05);
}
else if (inByte=='z'){
digitalWrite(motorPin,1);
}
else if (inByte=='c'){
```

Table1. UGV Motor control key allotment on base station keyboard

Motor Type	Forward	Stop	Left	Right	Up	Down
Drive Motor M	Key Z	Key X	N/A	N/A	N/A	N/A
Steer Servo S	N/A	N/A	Key Q	Key R	N/A	N/A
Pan Servo P	N/A	N/A	Key O	Key P	N/A	N/A
Tilt Servo T	N/A	N/A	N/A	N/A	Key I	Key U

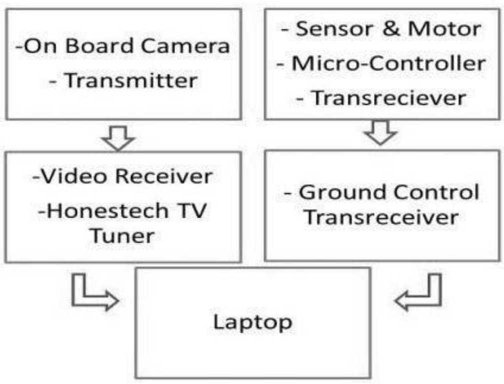
Software for UGV microcontroller

To control the UGV system from base station, a custom interface of X-Bee transceiver with X-CTU software was defined with allotment of Keyboard keys for various functions as discussed in Table 1 below. The vehicle was controlled for forward motion and stop. The other servos involved in steering and pan-tilt is controlled for left-right and up-down motion.

B. MAV Control System

The system design for proposed combination requires a robust methodology and flow to define the control and communication architecture. Inspirations were taken from birds which create lift by flapping its wing and navigate through its tail. System to control and communicate was developed with the efforts of mechatronics. The design of MAV resembles bottom-up approach enhanced with bio mimicry to develop a flapping wing MAV.

(a)



(b)

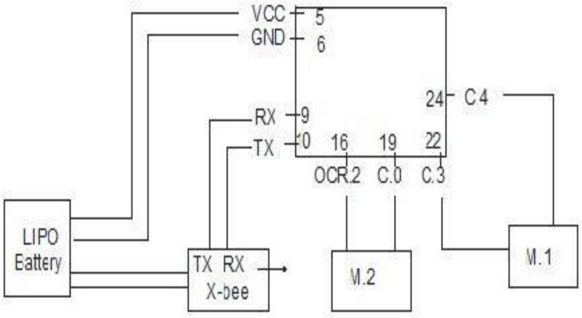


Fig.4. (a) Control loop diagram; (b) MAV on-board circuit diagram

The control loop diagram, as shown in Fig. 4(a), for both FPV system and control of MAV, starts with collecting all the sensor and video data which are streamed back to the ground control station from on-board computer. Control commands are sent back to the MAV by a custom interface after processing these data and the trainer function on X-bee transceiver which allows switching between human control and computer. As shown in Fig. 4(b) circuit diagram, the motor M1 drives the flapping mechanism and M2 controls the tail navigation. These motors are controlled using Atmel's Atmega 16L microprocessor for its inbuilt PWM ports and small size, resulting into elimination of motor controlling IC causing weight reduction of circuit board. The Micro-controller is interfaced to a 2.4GHz X-bee transceiver to provide data link with ground station at up to 250kbps data rate. Using BASCOM software, the programmes need to be burnt for computation and functioning of microcontroller. Further this programming was burnt on the microcontroller with AVR Dude Software. The codes for the mentioned programmes are shown in Fig. 5 below.

```
$regfile = "m16def.dat"
$crystal = 2000000
$baud = 9600
Config  Timer2  =  Pwm,
Pwm = On, Prescale = 1,
Compare Pwm = Clear Up
Start Timer2
Config Portc.0 = Output
Config Portc.3 = Output
Config Portc.4 = Output
Dim A As String * 1
Do
Cls
A = Waitkey() Continue....

Continue.....
If A = "a" Then
Ocr2 = 255
Portc.0 = 0
Elseif A = "s" Then
Ocr2 = 200
Portc.0 = 0
Elseif A = "d" Then
Ocr2 = 130
Portc.0 = 0
Elseif A = "f" Then
Ocr2 = 70
Portc.0 = 0
Elseif A = "g" Then Cont...

Continue...Ocr2 = 0
Portc.0 = 0
Elseif A = "b" Then
Portc.3 = 1
Portc.4 = 0
Elseif A = "n" Then
Portc.3 = 0
Portc.4 = 0
Elseif A = "m" Then
Portc.3 = 0
Portc.4 = 1
End If
Loop
End
```

Fig.5. Programming code in AVR Dude software for MAV microcontroller

Motor Type	Maximum	Medium	Slow	Slowest	Stop	Clockwise	Anti-Clockwise
Drive Motor M1	Key A	Key S	Key D	Key F	Key G	N/A	N/A
Rear Motor M2	N/A	N/A	N/A	N/A	Key N	Key B	Key M

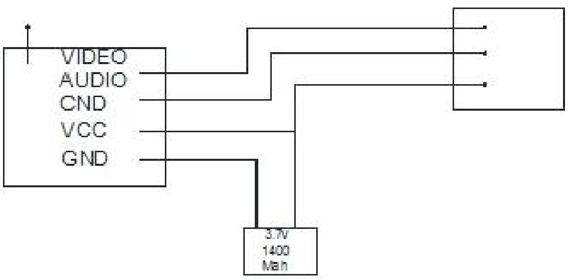
Table2. Motor control key allotment on base station keyboard

To control the MAV motors from base station, a custom interface of X-Bee transceiver with X-CTU software was defined with allotment of Keyboard keys for various functions as discussed in Table 2 above. The speed of flapper was controlled in four steps as maximum, medium, slow and slowest. The rear motor involved for direction control was provided for clockwise and anticlockwise motion for left and right turn respectively.

C. FPV Data Transmission

As both UGV and MAV are piloted manually using FPV camera system, they are equipped with light weight camera system transmitting real time data to base station. Both the vehicles (UGV and MAV) are equipped with a 5.8 GHz wireless camera which has an about 3.5 km of range. This camera has an overall weight of 1 gm. and with video transmitter the total weight is 4 gm. It is also compatible with a microphone which is placed for surveillance. Fig. 6(a) shows the on-board camera circuit on the vehicle and Fig 6(b) shows the receiver circuit at the base station.

(a)



(b)

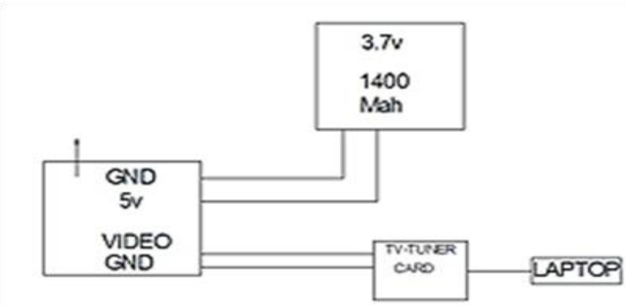


Fig.6. (a) On-board Camera circuit on vehicle; (b) Base station camera data receiver circuit

For electronic power sources LiPo batteries are used on the vehicles as they have a long life and better power to mass ratio. The pan-tilt system drives the UGV camera. TV Tuner card with Honestech TVR 2.5 Software is used on Ground Control Station, paired with laptop for receiving the video and Audio.

D. MAV Relay Based Communication Channel

A relay system was implemented between UGV and MAV subsystem .As the mission to be accomplished using the developed system demands a range of 3 Km for MAV, with the implemented X-Bee system providing only 1.6 Km range. The X-Bee 2 and X-Bee 3, is made to act as a relay system providing a combined effect of 3.2 Km range of MAV. The relay system, as shown in Fig. 7 below, consists of a twin X-Bee transceiver on UGV.

To make it possible, as shown in the diagram, the transmitter pin of X-Bee 2 was joined with the receiver pin of X-Bee 3. The transceiver of 2.4GHz coupling created a relay system for MAV and PAN ID 23 was provided to the wireless module for functioning. When the MAV was in 1.6 Km range, the MAV is directly controlled by the base station, but when the MAV is out of 1.6 Km range, the relay system starts working on UGV and the coupled transceiver communicates with MAV. For this, the X-Bee 1 from ground station gives command to X-Bee 2, which is approximately 1.6 km away from base station. Then the received data is communicated by X-Bee 3 to the MAV which is approximately again 1.6 Km from UGV and 3 Km from base station. Thus a 3.2 Km of range is acquired for surveillance using the developed system.

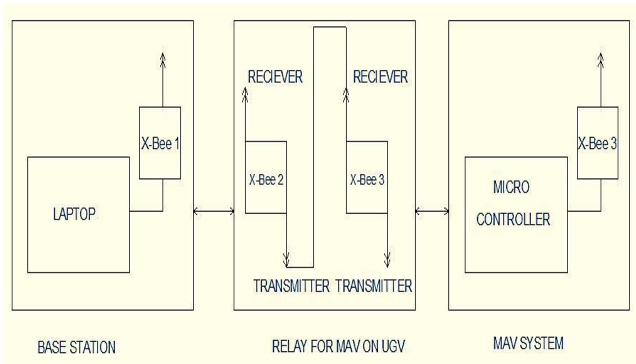


Fig.7. MAV System-Relay based communication channel

A robotic surveillance system based in FPV provides by the integrated approach of designing the control system for unmanned system and ground station together. The relay network as discussed above magnified the range of operation for the developed system.

III. Conclusion

With an overview of communication system architecture for an UGV-MAV based surveillance control system, (RF) radio frequency based data transmission methodology is discussed to perform various FPV based civilian and military operations. The use of microcontroller and its programming is an area of thirst for unmanned system development. Further, it is observed that the range of communication remains a major concern with these systems which can be tackled by designing relay network between multiple systems in a controlled and coordinated behavior. Thus it can be concluded that with recent advancement in on-board computation methodology among robotic surveillance system, a stable and secure communication channel can be demonstrated between ground control stations and unmanned systems.

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