YDSP Young Defence Scientists Programme

DSTA Defence Science & Technology Agency

DSO National Laboratories

MODULAR MULTI-MISSION AERIAL ASSISTANT FOR NATIONAL SECURITY

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INTRODUCTION

BACKGROUND

National security operations involve high-risk scenarios that pose significant dangers to officers, and civilians. The unpredictable nature of these operations, often in non-permissive environments or against advanced adversaries, increases the risk of conflict. Their unpredictability heightens conflict risks, necessitating advanced technology and strategic preparedness to protect personnel and national interests.

AIM

Creating a modular multi-mission interface for an unmanned aircraft to assist in National Security to...

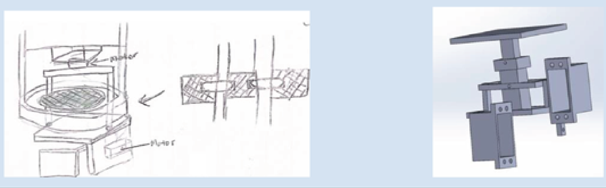
- Decrease the risk experienced by officers
- Decrease the manpower required for such operations
- Detain suspects through a modular, multi-mission quadcopter

1. MATERIALS

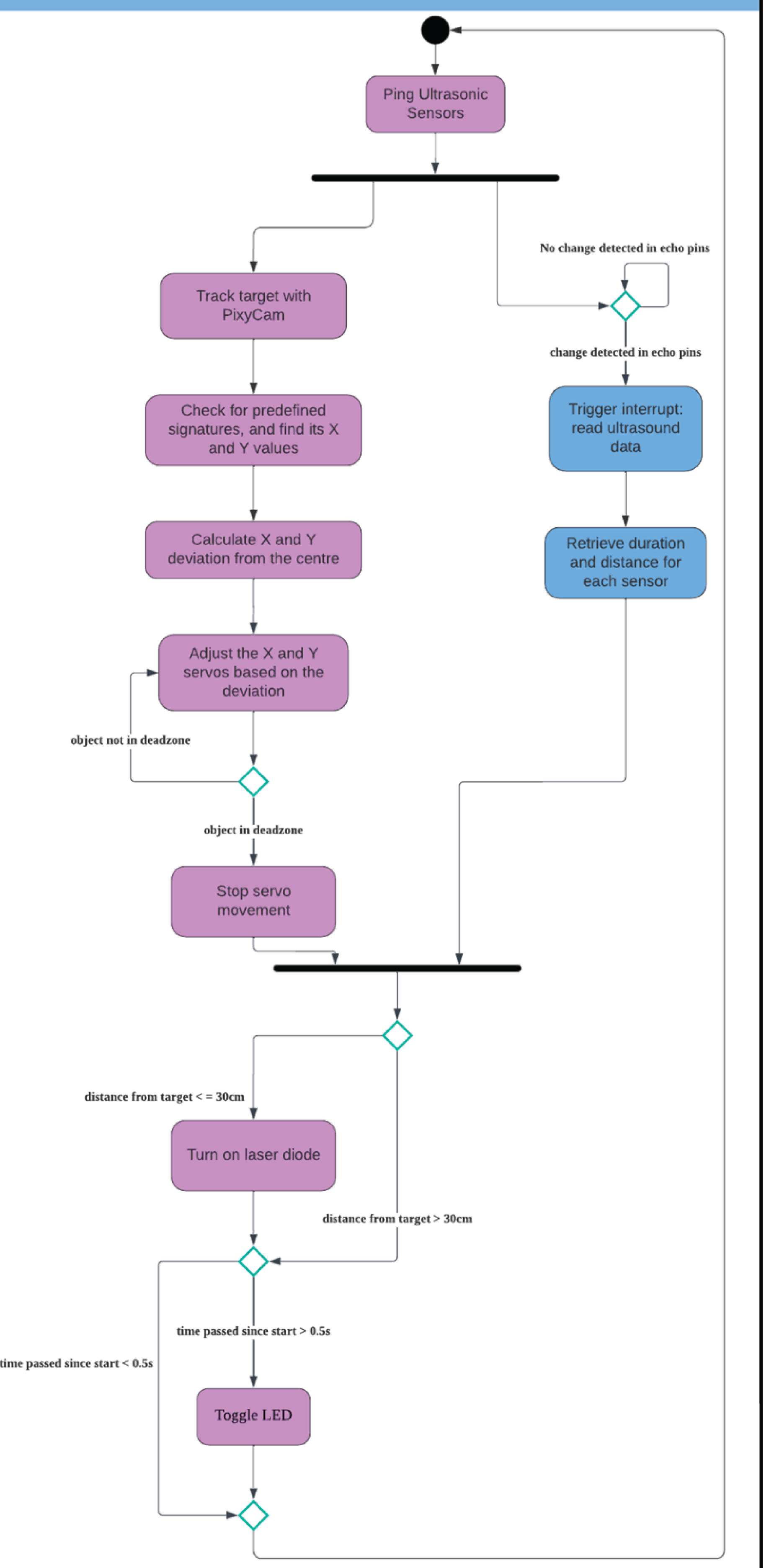
- THUNDERPOWER TP5000-4SPX25
- Baofeng Walkie Talkie BF-88E
- Dualsky AS549 Servo
- HC-SR04 Ultrasonic Sensor
- Pixy2
- MOD LED-100 Laser Diode
- Arduino Mega 2560
- 400 Tie Points Breadboard
- 5mm Red LED
- 5mm Blue LED
- HOLYBRO S500 V2
- Pixhawk 4 mini

2. METHODOLOGY

1. Literature Review:
   - research existing modular interface standards in drones and other industries to identify design principles
2. Requirements Definition:
   - define the technical and operational requirements for the modular interface (eg size, weight, power supply, and communication protocols)
3. Design and Prototyping:
   - use CAD software for design
   - 3D print prototypes
   - program an Arduino microcontroller (MCU) in C++
4. Testing and Evaluation:
   - assess durability, connectivity, and integration through lab and field tests
5. Iterative Improvement:
   - refine design based on test results for better performance and usability



LOGIC FLOW (CODE):

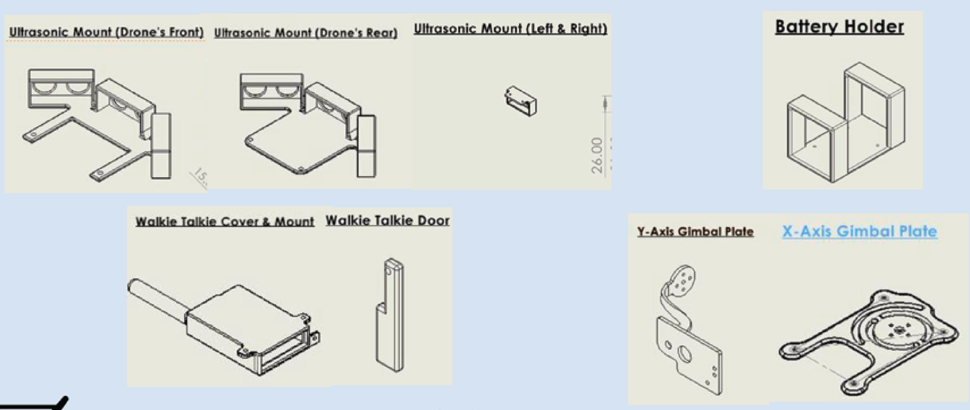


3. RESULTS

Electronic Test Results:

1. PixyCam
   - detected objects up to 1.30m away
2. Servo Motors
   - successfully kept the object in the dead zone 97.5% of the time when object was 30cm away from PixyCam
3. Ultrasonic Sensors
   - an accuracy of ±0.3cm
   - 2.3% average error over tests up to 1.30m
   - minimal effect on gimbal response time
4. Laser Diode
   - lit up correctly when
     - the drone was near the object
     - an object was within the PixyCam's deadzone

Components Mounts:



- ☑ drone can fly!
- ☑ our code is functioning properly!
- ☑ electrical wiring is correct!
- ☑ components are in good working condition!

4. PROBLEMS FACED ?

1. Ultrasonic sensor code slowing down the other components significantly
   a. rest of the code executed after sensor receives echo pulse
   b. servo tracking affected, slow to reorient the PixyCam
- Solution: ultrasonic sensors attached to interrupt pins, interrupt functions implemented
1. Power issues
   a. Arduino Vin port requires 7V-12V, while other onboard components only run on 5V
   b. insufficient current for the servos to function properly
- Solution: power 2 separate BECs with one battery: 8V powers the Arduino, 5V connected to breadboard

5. LIMITATIONS

1. Budget and legal constraints
   a. an actual Taser was unable to be acquired and used
   b. laser diode was used instead, as its method of activation was similar to that of an actual Taser
2. The quadcopter inherited was small and had a limited payload: 1.5kg
   a. design and setup of the quadcopter were altered multiple times to accommodate it
   b. all designs had to be scaled down to fit into the quadcopter
   c. accurate distance readings were partially sacrificed for efficiency (we could only use 4 interrupt pins)

6. FUTURE WORK

1. Make quadcopter autonomous
   a. reduces manpower
   b. increases efficacy
   c. prevents accidents
2. Include visual feedback
   a. transmitting PixyCam footage, ultrasonic sensor distance etc
   b. option of a manual override
3. Use a different board which has 8 interrupt pins
   a. use all 8 ultrasonic sensors
   b. orientation of quadcopter and detection of objects would be more accurate

7. CONCLUSION

1. Potential to use quadcopters to enhance law enforcement operations by providing real-time aerial support
2. Challenges were addressed with practical solutions to make the system operate more efficiently and reliably
3. Future work will focus on increasing the autonomy of the system and further improving sensor accuracy and operational range
4. Possible for dangerous conflicts to be de-escalated remotely, protecting personnel involved

8. REFERENCES

[1] B. Ekstrand, Equations of motion for a two-axes gimbal system, in IEEE Transactions on Aerospace and Electronic Systems, vol. 37, no. 3, pp. 1083-1091, July 2001