Design and construction of an infrared aerial dogfighting game

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Introduction

A standard laser-tag game consists of two or more parties using infrared lasers to try and "tag" other players. All players wear infrared receivers on their bodies that can detect the lasers being fired by other players to simulate combat while remaining entirely safe. This concept was taken and modified to be applied to a new system, an aerial combat game, known colloquially as dogfighting. This project was built as part of a larger system in partnership with Sean McNamara, who constructed a portable control station for the game. Basic aeronautic concepts were combined with principles of infrared modulation and communications to create a game in which two or more parties control separate aircraft with unique signatures, and engage in aerial combat until one of the aircraft detects another's transmission, signifying a successful strike on target.

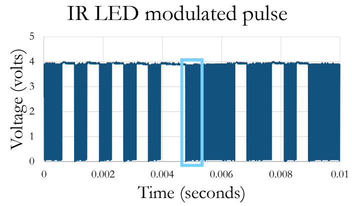
Materials and Methods

The body of the aircraft was constructed of foamboard with a thickness of approximately 3/16th inches. The design for the body was the FT Flyer, the plans for which were sourced from FliteTest™, a hobbyist website for radio-controlled aircraft. A six-channel RC transmitter/receiver set was used to move the two control surfaces and the motor, as well as trigger the IR pulses that represent firing.

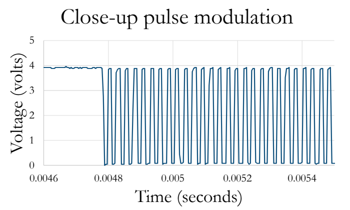
Figure 1 (left): Displays the FT Flyer, the plane model used. The servos in the center of the body control the rudder and elevator, and are connected to the motor controller, RC receiver, and Arduino Nano, which are housed behind the motor in the fuselage of the plane.

To implement the infrared connection, an infrared LED was pulsed by using a system of NOR gates connected to the TX (transmit) pin of the Arduino and a 38 kHz pulse clock (jmknapp, 2008). This wiring allowed the binary ASCII value of anything in the serial port to be transmitted as modulated IR pulses, shown in Graphs 1 and 2. The pulse was then detected by the receiver, which was mounted on the aircraft. The receiver demodulated the pulses sent from the transmitter and sent them to the receive pin and into the serial port. The packet was confirmed to be a real identifier, which was preset by the operator, and from there a hit was registered by the aircraft's microcontroller, signifying a hit from the opponent.

Materials and Methods (continued)

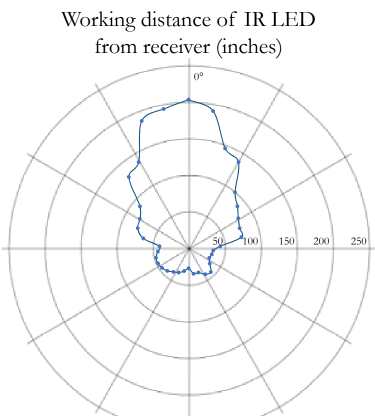


Graph 1 (left): Shows part of the modulated square wave that the IR LED pulses to transmit the identifier. Each bit is actually a series of 38 kHz pulses that is decoded by the receiver as a square wave shaped like the modulated pulse. The light blue box shows a close up of the pulse in Graph 2.



Graph 2 (left): Close-up view of the modulated pulses in the box in Graph 1. It can be seen that each modulated bit consists of a series of 38 kHz pulses that the receiver will read as a regular square wave.

Results



Graph 3 (left): Shows the distance of consistent reception with the receiver turned to various angles and the LED pointed directly at the receiver. While the shape of the graph is similar to the expected shapes, minute differences in angle and vertical angle and height of the transmitter are likely responsible for the irregular shape of the graph, instead of the smoother curve that would have been expected.

Both the IR transmitter and receiver modules work independently of one another on separate microcontrollers.

Triggering a "fire" command by using the transmitter of an RC transmitter/receiver set was successful, as the operator was able to initiate a firing sequence while simultaneously controlling the motor speed, rudder, and elevator on the aircraft.

Range and angle testing on the transmitter and receiver module can be seen above in Graph 3. Separate range data is unnecessary as the

Results (continued)

zero degrees point on the graph shows that the maximum range of the transmitter/receiver system with both components having direct and unobstructed line of sight is only 218 inches, about 18 feet.

Conclusions

While the full implementation of the design was not completed, there was a significant degree of success in the individual components. The transmitter module works as intended and can easily be programmed to give individual identifiers to multiple participants. The receiver also works as designed, but the LED beam loses intensity over ranges past about 18 feet that causes packet loss and incomplete bytes to be detected. When only a partial byte reaches the receiver, the wrong identifier, or possibly no identifier, is compared to the preprogrammed identifiers that are accepted, and what should be a hit is not properly registered. This packet loss significantly reduces the maximum range of play, but is a problem that could potentially be rectified with the addition of a lens over the LED to aid in maintaining beam intensity over a longer distance.

For the purposes of testing the functionality, individual microcontrollers were used for the receiver and transmitter modules so they could be separated for range and angle testing because of the limited number of parts, and the unwanted interference between the connected components. A necessary follow up to the current state of the project would be full integration of the transmitter and receiver modules into a single microcontroller so that they do not interfere, and can then be mounted onto the aircraft for in-flight testing to begin.

Eventually this project will be integrated with the portable control set-up that was designed and built by Sean McNamara, and will be able to communicate with its own ground station as well as all other ground stations to fully synchronize play. The end result will be a fully functioning aerial combat game to be marketed to the public.

A potential path for this project to follow is to progress from a game to a form of flight training for UAV pilots to simulate more realistic combat encounters without the significant risk of expensive government equipment.

References

jmknapp. (2008, May 21). Serial comm using IR [Msg 1]. Message posted to http://forum.arduino.cc/index.php?topic=10555.0