Radio Mobile Foxbot

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Concept of Operations

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for
Radio Mobile Foxbot

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1. Executive Summary

Radio fox hunting now more commonly known as Amateur Radio Direction Finding (ARDF) has always involved a hunter, with a directional antenna and a radio receiver, and a fox, which is a hidden stationary transmitter. However, a stationary transmitter limits the potential of ARDF training. Rather than a person acting as a mobile fox transmitter, we aim to provide an autonomous system that will transmit while still mobile. The Mobile Radio Foxbot will address this issue with a mobile robot chassis which will detect its environment and develop a path to follow while transmitting. The Mobile Radio Foxbot will provide different modes of training, each with varying degrees of difficulty. We also plan to have direct communication with the Mobile Radio Foxbot so that we can locate it and change the type of training. This will drastically increase the potential of ARDF training.

2. Introduction

This document is an introduction to the Radio Mobile Foxbot, an autonomous training tool that facilitates and encourages the practice of radio communication and transmission. The “fox” will be able to orchestrate different paths and place itself in discrete locations while providing different schedules of radio transmission for added difficulty that the user can determine.

2.1. Background

There are many different interest groups of radios out there that have been developing “Fox Hunts.” One of these interest groups is our own Amateur Radio Club at A&M, the W5AC. The W5AC was founded in 1912 and is [1] “one of the oldest student organizations [at] Texas A&M.” Throughout the year there are many events and meetings that W5AC will host, but one of their specific events is their weekly “Fox Hunts.”

The mobile radio Foxbot ushers in a new generation of "Fox Hunts" for W5AC and other radio clubs. This procedural-leveled Foxbot will allow further practice with a brand-new system of automation. The autonomous pathing structure that the Foxbot will follow allows a more dynamic and engaging experience for Fox Hunts. This system is not only for W5AC but other Radio Clubs interested in a fully automated hunt. [2] However, the user may need an FCC License at the technician level to operate the Foxbot based on FCC regulations and standards.

Civilian, military, and commercial interests are all served by the Foxbot’s capabilities, which offer an adaptable platform for ARDF training. There can be active usage of the Foxbot within emergency situations to simulate a real-world search. Furthermore, military personnel could benefit from a field challenge by using the Foxbot as a new tool to develop ARDF skills and techniques.

The Foxbot would allow more practice for self-interested users who want to enhance their radio receiver skills/knowledge. Those who are interested can obtain an [3] FCC License to utilize and manage their own Foxbot.

2.2. Overview

The system will transmit radio signals in the 446.050 MHz frequency range using a Baofeng UV-5R Radio for internal communication. Scheduling and autonomous operations are managed by an ESP32 microcontroller, programmed with C and the ESP-IDF Framework. The MCU controls the motor drivers through a UART system, facilitating serial data exchange, and also interfaces with the radio to deliver transmission signals to the user. To power all of our components we will be using two LiPo batteries - one for each motor - along with an additional power source to power the MCU and the Baofeng UV-5R itself. The Foxbot will be able to autonomously move and provide a chosen transmission signal to facilitate practice/Fox Hunts.

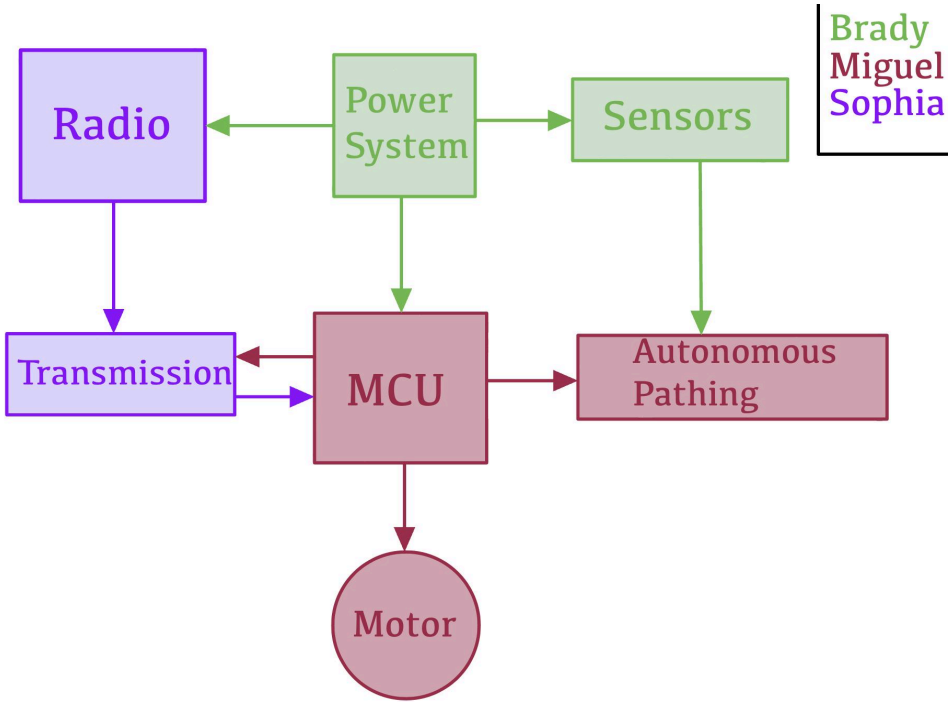

Figure 1: *Foxbot Description Block Diagram*

The block diagram above illustrates how the components of the subsystems interact with each other to complete the Foxbot's design and functionality. With a color correspondence of each individual working on their different subsystem.

2.3. Referenced Documents and Standards

[1] Texas A&M Amateur Radio Club (W5AC) - https://w5ac.tamu.edu
[2] FCC Standard Policies - https://www.fcc.gov/media/radio/public-and-broadcasting
[3] FCC License - https://www.fcc.gov/obtaining-license

3. Operating Concept

3.1. Scope

The radio Foxbot system is designed as a tool for amateur radio hunting and developers. This system will allow fox hunters to practice tracking transmissions and for developers working with transmission signals to better engineer their equipment. The Foxbot shall be able to avoid detection from a foxhunter.

3.2. Operational Description and Constraints

3.2.1 Operational Description

To operate the system, the user must turn on the bot in the desired starting location. The bot will formulate the route it will take based on the level of difficulty selected by the user. The way in which the user will select different modes will be determined by DTMF tones that will come from a repeater radio held by the operator. The repeater will send a tone which the radio on the foxbot will decode. The bot will begin moving in its path while simultaneously following transmission patterns. The FoxBot will operate until the duration of the hunt is over or until it has been caught by the HoundBot. Since this is a relatively new method of ARDF, the exact operation specifics will be determined based on the measured performance of the FoxBot . The necessary rules/guidelines will be formulated so that beginner to expert users can operate the system.

3.2.2 Operational Constraints

The bot will only be able to operate in a generally open environment with no stairs or sharp inclines. The ground must be generally easy to traverse as mud, rocks, and water will disturb the integrity of the electronics.

3.3. System Description

The Foxbot is divided into 3 main subsystems: Power, MCU/Autonomous Pathing, and Transmission.

Power Subsystem: Responsible for driving the motors, MCU, and radio systems. There will be batteries specific to the motor and another lipo battery system solely for the MCU and transmission system. Voltage regulators will be monitoring batteries to ensure the system is sustained at safe operating levels. In the event that voltage levels become unsafe, the power will shut off. Also responsible for providing power to all the sensors, and how the sensors will be connected to the other subsystems.

MCU/Autonomous Pathing Subsystem: Responsible for creating the basis on which the bot will formulate its path. Flight Controller and Mission planner will be used to program the operation that the foxbot will follow. Based on the location and difficulty of the operation, the MCU will control what and when the radio will transmit.

Transmission Subsystem: Responsible for emitting a signal for the foxhunter to track. Based on the location of our foxbot, the radio will be in either transmission or reception mode. When a signal needs to be emitted, the radio on the foxbot will listen for a DTMF signal from a repeater. This signal will be decoded and correspond to a certain pattern of signals to emit.

3.4. Modes of Operations

Training: The Foxbot generates waveforms for faulty line training and can be calibrated for technician training.

Deployed Modes: Includes continuous radio transmission with the bot being stationary, intermittent radio transmission with the bot being stationary, continuous transmission with the bot being mobile, and intermittent transmission with the bot being mobile.

3.5. Users

Users of this system must hold an FCC license at the technician level or higher to legally transmit signals.

One target user for the Foxbot is the user controlling the “fox”. This user will be responsible for configuring the signals that will be transmitted, the mode that the fox will be in (ie. training, sedentary, or active), and the starting location of the “fox”. A general understanding of radios and computer literacy is needed to operate the system.

Another user is the adversary trying to find the location of the Foxbot. They will be able to test their receivers and must have a good understanding of radio waves to operate the system effectively. The Foxbot system can also be used by antenna engineers trying to read certain frequencies under certain conditions.

3.6. Support

To aid the user, an instruction manual will be included with the bot. This will walk the user through the setup and maintenance of the bot. The code will be neatly and thoroughly commented on, so the user can follow the thought process of the program.

4. Scenario(s)

4.1. Fox Hunt

The Fox will move and hide in different locations for the User/Users to search. A starting location must be predetermined before the Fox Hunt can begin. After, the fox will move from space to space creating a more diverse and heightened difficulty Fox Hunt. The User who reaches the bot first will be crowned the winner. Only one person must have an FCC License to start the Fox for the Fox Hunt.

4.2. General Radio Transmission Search Practice

Users can place the Foxbot in a predetermined location with a scheduled radio transmission system for the Fox to operate. This setup allows the practice of learning how to receive transmission signals and how to properly locate the Fox.

5. Analysis

5.1. Summary of Proposed Improvements

- The system will have on board navigation so that it can move around autonomously, or we can have it follow a predetermined route.
- Different modes of operation will allow for different types of ARDF training, which can all be controlled remotely.
- System will be able to send status reports back to us.

5.2. Disadvantages and Limitations

- System will be battery operated, thus the duration of training could lead to system failure in the sense the battery could discharge and not provide enough voltage to operate.
- Doesn’t know when it has been caught
- Because communication with our system will be done via radio transmission, our system won't be able to provide a visual image.
- Conditions of the environment have to be viable, meaning our system will struggle or won't be able to go up steep or muddy pathways, and won't work in precipitation weather conditions.

5.3. Alternatives

- A person can act as the mobile transmitter
- The system could be powered via solar cells, which would allow it to train much longer
- This system could be mobile via air flight
- Controlled via RC controller

5.4. Impact

- Not hurting environment
- Popularize hunting robots