WiFi Mousr

Team 70
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1. Introduction

1.1 Objective

Pet care is one of the biggest aspects of our daily lives which has yet to be automatized. Recently, an issue has arisen with company animals spending too much time alone inside the house, and lacking a mechanism to let off steam and burn excess energy. This fact opens a new market focused on creating and updating pet toys to the automatic world, which gives animal owners the possibility entertaining and caring for their pets while away from home[1]. Realizing this, three electrical engineers from the University of Illinois with a common passion, cats, founded a company called “Petronics” in 2014 [2]. After years of designing products for cats, they came up with a toy based on an advanced artificial intelligence technology, the Mousr.

Our goal is to develop new upgrades of the Mousr in collaboration with the company, in order to succeed in the market of automatic cat toys and maintain their status as top smart pet toy seller (achieved in 2018)[3]. The new version is meant to increase the functionality of previous robots by replacing bluetooth connection with WIFI, which provides a stronger and more long-distance connection.

1.2 Background

Nowadays, the Mousr requires two microcontrollers, one in the head unit that communicates the robot with an app and processes sensor data and another in the body unit that works as a hub that controls wheel and tail movements. The toy is controlled by an Android or iOS app through the BLE functionality of the head chip. The use of Bluetooth in the microcontroller is inefficient in terms of cost and functionality.

Changing the head microcontroller to the ESP32 adds WIFI functionality as a form of communication with the app, giving us the opportunity to connect the Mousr to the internet and upgrading the interface between the user and the Mousr. For instance, it can be used to register the user’s work schedule or to check in on statics and battery life remotely.

1.3 High-level Requirements

- The Mousr must connect with the app by Bluetooth and then establish the WIFI connection with the home router.
- The user must be able interact with the Mousr remotely by WIFI.
- All the sensors must be working with the new microcontroller. This includes:
  - LED: must turn on when required and be perceivable by the eye.
  - Gyroscope: angular rate measurement range of 125 to 2000 dps.
  - Accelerometer: linear acceleration measurement range of ±2 to ±16 g.
  - Laser distance: must measure distances up to 200cm, as specified in data sheet.
  - Voltage regulators: must allow sensors to power off or enter low-powered states.
  - Pushbutton: microcontroller must register button state at all times
- The Mousr must maintain the same functionality as the previous versions.
2. Design

2.1 Block Diagram
2.2 Functional Overview:

The phone application represents the main interaction between user and product. First and foremost, it should allow the user to set or modify an automatic play schedule for Mousr. This information must be stored, and the microcontroller must be notified whenever a change of operation mode is required.

Once this is accomplished, we will focus on creating a battery level display on the app, which provides the user with essential product information. We also intend to remotely change the color of the LED through the phone. This functionality can later be used by Petronics to remotely control the engine. However, our project will not interfere with the mechanical body components as we specify in the block diagram.

The data transfer between the application and microcontroller are possible through a WIFI connection, which we will be implementing as a novelty to Mousr. This process begins when the phone pairs with the Mousr using BLE. The user then sends the home router’s IP to Mousr over this connection, and then both Mousr and application will reach out to the router and begin the data transmissions.

Regarding the control unit, it includes the microcontroller as well as the LED and pushbutton. The LED status can be controlled directly through the app by way of the microcontroller, while the pushbutton is meant to allow the user to directly dictate power states and activate WIFI pairing.

Finally, the sensors block includes a IMU and a TOF module, as well as an IR receiver unit. They are essential in defining the Mousr movements. They must be connected to the microcontroller through either I2C or a similar protocol, as specified by their respective data sheets. The microcontroller must also provide the correct voltage and current quantities for the sensors to obtain valid measures.

Power consumption, which is important to optimize battery life, will depend on the operation mode selected by the microcontroller. For example, the IMU package can function in low-power mode, which drastically reduces the power input.

2.3 Block Requirements:

Phone Application:
- Able to establish WIFI connection with Mousr in under 30 seconds.
- Must inform user once connection with Mousr is complete.
- Must receive and display battery level.
- Must display current mode of operation (auto, manual, off).
- Able to set automatic play schedule. Protocols which allow the user to both input and modify at any time must be designed.
- Able to send instructions through the microcontroller. Necessary instructions include changing the LED color and the voltage regulators status.
ESP32:
- Power voltage supply of 3.6V with maximum output current of 1.2A.
- Voltage supply of 2.6-3.5V must be provided in the output pins for proper sensor functionality.
- WiFi and BLE modules connected by UART within the microcontroller.
- Analog/Digital/PWM pins to make the connections.

Button:
- It must not be exposed to values greater than 16V and 50 mA.

TOF:
- Performance should accomplish a FOV of 25 degrees and a range of 120mm to 1.2 m, depending on operation conditions and mode.
- Current consumption should fall between 3 and 19 microA.

IMU:
- Gyroscope angular rate measurement must fall between 125 and 2000 dps. Linear acceleration measurement should be within a range of ±2 to ±16 g.
- Angular rate sensitivity should be between 4.375 and 70 mdps/LSB, depending on test conditions. Similarly, linear acceleration sensitivity must fall within 0.061 and 0.488 mg/LSB.
- Current combustion should fall in the range of 0.65-0.29 A.

IR Module:
- The directivity angle should allow for a tolerance of 50 degrees.
- Typical current combustion is 0.8 mA, we will allow a tolerance of 0.2mA for non ideal testing conditions or measure noise.
- Power consumption should be 10mW, provided temperature is under 85 celsius degrees. We will allow a 2 mW tolerance to account for measure noise.

RGB LED:
- Colored light must be clearly visible, for all three colors.
- Led must turn on/off and change colors when the APP sends instructions to do so.
- Voltage should be within 2.2 and 5V (assuming testing conditions of 25C degrees and 20mA), and current between 10 micro and 150 mA (assuming testing conditions of 25C degrees and 5v)

2.4 Risk Analysis:

For us, the trickiest part of the project is the control unit block. This is mostly due to the code for the micro, which ties together all the other blocks. If the control unit fails to process transfer information correctly, all the other blocks loose their functionality.

In addition, the control unit is in charge of receiving the router’s IP and establishing a connection, which is essential to the project. It also contains two
3. Ethics and Safety

Our product is a household item, and as such it will work at direct interaction with not only pets, but also families and other electronics devices. It is then our responsibility to ensure no harm comes to the mentioned parties.

As a pet toy, it is not subject to a specific legislation. However, it must comply with the safety requirements established nationally by the Consumer Products Safety Commission. These regulations include respecting environmental standards [9], avoiding hazardous materials present in plastics such as phthalates and enabling customers to submit a public report of harm if the need arises [8]. Safety and durability standards are also essential.

However, this first set of requirements are to be handled by the company ‘Petronics’ and do not directly relate to our project. We will focus on the WIFI connection and APP regulations.

Any wireless or smart product needs to be FCC (Federal Communications Commission) certified in order to be sold in the US. To obtain Product Certification the product must pass all required testing and reviews. The two main aspects of this review are “General Emissions” and “Intentional Radiation” [5]. This is an expensive and lengthy process which can be avoided by utilizing a certified RF module [4]. This decision will be handled by ‘Petronics’.

Regarding the APP, privacy policies [6] are the main ethical issue to be considered. We will be connecting to the house router, and must ensure to the best of our ability that both the connection and the data stored in the device remain secure. This is clearly stated in sections II and VI of the ACM code of ethics, “do no harm” and “respect privacy” [7].

We will follow the principles stated by Maciej Ceglowski regarding data management. He claims personal data is similar to radioactive waste, and therefore easy to generate, dangerous if released and impossible to dispose of. Our app will discard the information it processes whenever possible. If we decide to distribute the app using iOS or Androids’ app store we must create a privacy policy document, specifying what data we collect and its purpose, as well as inform users that their data might be shared with an external party, under the Fourth Amendment’s third party doctrine.

Lastly, we are aware that if our APP is to be commercialized to other countries it is necessary to accommodate their privacy policies.
4. References


