Optical Wireless Communication: How Infrared Light May Be the Best Form of Communication for an Internet of Things System

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Abstract

The Internet of Things (IoT) has been around since 1999, and it is a system in which different machines and technologies can talk to each other using sensors. Some existing IoT includes WIFI, Bluetooth, Zigbee, and many more. Each of these have downsides such as shortness of range, high power consumption, high latency, etc. Optical Communication uses infrared light to carry data, and my research team built a small model using Arduino to demonstrate what the system would look like. The data sent via Arduino's infrared light network showed promises for Optical Communication. However, this technology is highly subject to interferences, and future work is needed to ensure that the multi-communication network does not suffer packet loss. Scaling the system to test longer distances would also be required.

1. Introduction

The IoT allows inanimate objects to communicate with one another. One classic example of such a network is a Smart Home. Every device in a Smart Home is able to exchange data via a communication network. When a resident comes back to his house late at night, as soon as the door is opened, the network communicates the door status to other devices, prompting each to perform certain actions. Without needing human interaction, the lights can turn on, followed by the TV, air conditioner, and many other devices.

However, the current connectivity medium that IoT systems use is not the most optimal. Bluetooth can only connect a small number of devices, and WIFI can be very slow when there are multiple users on the same network. Optical Communication bypasses all those restrictions because it uses light as a medium. It is also easily scalable and does not suffer from physical interferences.

2. Related Works

One of the biggest obstacles in an optical wireless communication (OWC) system is the shadowing effect, which Hosseinianfar (2019) models for moving objects. One proposed solution is to predict the behavior of the object and change the trajectory of the VLC channel accordingly. A research project conducted by the Electrical Engineering department at the University of Virginia proposes exploring the use of Optical Communication as an optimal solution to most of these problems (Hosseinianfar and Brandt-Pearce, 2022).

3. Proposed Design

To simulate the visible light communication, we constructed a mini circuit board using Arduino, which we chose for its open-source libraries as well as its ease of use in implementing sensors. IoT relies heavily on sensors for each device to communicate with one another, and Arduino provides easy interfacing between sensors and programming. The Arduino Nano 33 BLE board was used for this project because of its small size and simplicity in interface. The board also comes with multiple built-in sensors that can be used later on for additional data gathering. One small problem we immediately faced was soldering. The Arduino Nano 33 BLE board came in with many headpins, and the connection onto the breadboard would be very poor without soldering the headpins onto the breadboard.

The initial approach is to simply set up a peer-to-peer connection between two boards using a serial communication. One board act as the transmitter, and the other acts as the receiver. After ensuring the communication can be established and the transmission is clear, we then moved on to the actual IR communication. We considered using a built-in IRremote library on Arduino that can simulate the necessary medium for transmitting IR signals. However, there were once again compatibility issues and so we decided to manually program the required frequency to send out an IR signal. The transmitter will be programmed in such a way that it sends a signal at 38kHz frequency to emit an infrared beam. The data relating to distance traveled and clarity of the signals are then recorded and analyzed.

The Arduino IoT Cloud was considered for capturing data and uploading to the Cloud as the data is being recorded. However, there were many configuration problems with the Cloud as well as version issues with the Nano 33 BLE board. My research team decided to move forward with the optical research as opposed to spending more time on the Cloud. Instead, we ended up use an excel sheet for data recording, and offloading data to the Cloud will be a to-do list that we go back to later on.

4. Anticipated Results

My research team expects Optical Communication will be able to accurately transmit data across an average sized room in quick successions. The data will be tracked in real time and recorded onto the Cloud. From there onward, we will further implement a multi-sensor system incorporating interference prevention methods. We expect to be able model a real world IoT system within a small room before scaling up.

5. Conclusion

This research demonstrates the possible implementations of an Optical Communication IoT system. Infrared Light can become a new alternative that replaces WIFI or Bluetooth in an IoT, and data can be transmitted in large quantity and without faults. Infrared Light is also fast and can travel far distances which can very easily scale up the IoT system. As society moves towards automation, IoT will be an important aspect of peoples' lives because it allows for automated data capturing in real time.

6. Future Work

The sensors used in the initial model of the system are not powerful enough to handle long distances. Hence, more work using better sensors and circuits must be conducted later on. Furthermore, in order to simulate an actual IoT system, more sensors must be added to test the latency and reliability of data transfer in addition to finding ways to prevent interference. Currently, the three approaches we have considered are: Time Division Multiple Access, dividing transmission of data into multiple time slots, Code Division Multiple Access, distinguishing the different signals among different transmitters, and ALOHA random access, which data is sent at random times. We have to decide which solution is the best for our current model as well as tracking data on the Cloud. The next milestone is to be able to send and receive multiple signals across a single room.

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2. UVA Professor of Electrical Engineering: Maite Brandt-Pearce

References

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