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Li-Fi Data Transmission System Using Arduino.

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ABSTRACT-

In recent years, Light Fidelity (Li-Fi) has emerged as a promising alternative to traditional wireless communication systems, offering high-speed data transmission, improved security, and reduced electromagnetic interference. This paper presents a Li-Fi data transmission system that utilizes the flashlight of a mobile device as the light source, coupled with a Light Dependent Resistor (LDR) sensor module for light detection. The system leverages Visible Light Communication (VLC) technology, where data is encoded by modulating the light emitted from the mobile's flashlight. The LDR sensor, positioned to capture the transmitted light, converts the optical signals back into electrical signals, enabling data reception. This approach takes advantage of commonly available mobile hardware, providing an efficient and cost-effective means of implementing Li-Fi communication in real-world applications.

Key Words: Li-Fi, Light Fidelity, Arduino, Light-Dependent Resistor (LDR), Wireless Communication, Modulation, Data Encoding, Data Decoding, High-Speed Communication, Secure Transmission, Wireless Data Transfer.

I. INTRODUCTION

In recent years, the need for faster, more reliable, and secure wireless communication has mobile's flashlight to the development of new technologies. One such technology is Light Fidelity (Li-Fi), which is an alternative to traditional wireless systems that use radio waves, like Wi-Fi. Li-Fi uses visible light, such as the light from mobile flashlight, to transmit data. This method of communication offers many benefits, including faster data transfer speeds, better security, and less interference from other electronic devices, unlike radio waves, which can be disrupted easily.

One of the most exciting developments in Li-Fi technology is the ability to use smartphones and mobile devices for data transmission. With the help of mobile app (as Li-Fi project), Li-Fi can be easily integrated into smartphones by using the mobile device's flashlight as the light source for data transmission. These apps allow users to control and manage the communication process through the mobile device, sending and receiving data by simply modulating the light emitted from the flashlight. The light is captured by a Light Dependent Resistor (LDR) sensor, which converts the light signals back into data that can be decoded.

The use of a mobile app for managing Li-Fi data transmission makes it easy and cost-effective to implement in everyday devices, without the need for specialized equipment. This system provides an efficient way to transmit data, especially in areas where traditional radio-frequency (RF) communication systems may be unreliable or restricted. For example, in environments where Wi-Fi signals are weak or have limitations, Li-Fi using mobile apps offers a better alternative.

This paper reviews the current state of Li-Fi technology, focusing specifically on mobile apps used for transmitting data via a mobile device's flashlight. It looks at the advantages of using mobile app for this purpose, such as low cost, easy setup, and the potential to enhance security. The paper also explores the performance of Li-Fi system, discussing important factors like data transfer speed, range of transmission, and energy efficiency. Additionally, the review covers the challenges faced when using Li-Fi with mobile devices, such as dealing with ambient light interference and improving transmission range. Lastly, the paper will discuss potential solutions to these challenges and explore how this technology can be applied in real-world scenarios, such as indoor communication and secure wireless communications.

II. LITERATURE SURVEY

Li-Fi (Light Fidelity) is an innovative wireless communication technology that uses visible light to transmit data. Unlike traditional RF (Radio Frequency) communication systems like Wi-Fi, which rely on radio waves, Li-Fi leverages visible light (typically LED lights) for high-speed data transmission. Li-Fi has the potential to deliver high data rates, enhanced security, and immunity to RF interference, making it an attractive alternative for certain communication applications.

Arduino, a popular open-source microcontroller platform, has gained significant attention in the research and development of Li-Fi systems. Its versatility, ease of use, and cost-effectiveness make it an ideal choice for prototyping and testing various communication technologies, including Li-Fi.

In recent years, several researchers have designed and implemented Li-Fi systems using Arduino, where the microcontroller is employed to modulate and demodulate signals for data transmission using visible light.

- **Ghimire et al. (2016)** proposed a simple Li-Fi system using Arduino to control the modulation of an LED light for data transmission. The system employed Pulse-Width Modulation (PWM) for modulating the light, encoding binary data into light intensity changes. A photodiode was used on the receiver side to detect the modulated light signal, which was then decoded and displayed on a screen.
- **Bisht and Arora (2017)** designed a basic Li-Fi system with an Arduino-based LED transmitter and photodiode-based receiver. The system operated by using simple on/off modulation to encode data, with the photodiode detecting the light pulses and converting them back into electrical signals, which were processed by the Arduino. This study demonstrated the feasibility of building low-cost Li-Fi systems for short-range communication.
- **Ravi et al. (2018)** implemented an Arduino-based Li-Fi system using advanced modulation techniques such as Frequency Shift Keying (FSK) and On-Off Keying (OOK) to improve data rates. The system used LEDs for light transmission and a photodiode for reception, with Arduino managing the encoding and decoding processes. The researchers achieved data transmission rates of up to 2.5 Mbps, highlighting the potential for higher-speed communication with Arduino-based systems.

These studies show that Arduino is a suitable platform for building Li-Fi communication systems that can be customized and scaled for various applications. Additionally, the use of Arduino-based systems enables researchers to experiment with different modulation techniques to improve the performance of Li-Fi systems.

III. RELATED WORKS

The concept of Light Fidelity (Li-Fi) has gained substantial interest as a high-speed, secure alternative to traditional radio-frequency (RF) communication. Li-Fi uses visible light to transmit data, offering advantages such as reduced electromagnetic interference, higher data transfer rates and improved security. Recently, there has been increasing focus on integrating mobile devices, especially smartphones, into Li-Fi systems by using the built in flashlight as the light source. In particular, mobile applications are being developed to manage and control these systems, enabling the use of smartphones for Li-Fi communication.

One of the early works in the field of mobile based Li-Fi communication is by Challita et al. (2017), where they explored the use of a smartphone’s flashlight as a light source for data transmission. However, their system relied on photodiodes as the optical receivers, and it did not specifically address the role of Light Dependent Resistor (LDR) sensors in the system. Despite this, their study demonstrated that smartphones could be used as light transmitters for Li-Fi, setting the groundwork for future work incorporating LDR sensor modules for light detection.

A notable improvement in using LDR sensors in Li-Fi communication was presented by Singh et al. (2022). They proposed a mobile app-based system that used LDR sensors to receive modulated light from a smartphone’s flashlight. Their focus was on improving energy efficiency, where the system dynamically adjusted the transmission power of the flashlight based on the distance between the transmitter and receiver. The use of LDR sensors in this context helped reduce power consumption while maintaining a stable data transmission rate, making it more suitable for mobile devices. However, the challenge of ambient light interference remained a factor that could degrade system performance, especially in highly lit environments.

The work proposed in this paper aims to address several of these challenges by developing a mobile app specifically for Li-Fi data transmission using a smartphone's flashlight, coupled with an LDR sensor module for light reception. Unlike previous works that relied on photodiodes, the use of LDR sensors allows for a more cost-effective and energy-efficient approach while providing reliable data reception in both low-light and moderately lit environments. This project will focus on overcoming common obstacles such as ambient light interference and improving transmission range. Additionally, adaptive light modulation techniques will be incorporated into the mobile app to ensure optimal performance in real-world scenarios, offering a promising solution for efficient and secure mobile-based Li-Fi communication.

IV. MATERIALS AND METHODOLOGY

The design of the Li-Fi data transmission system to be controlled was divided into two sections; The software section and hardware section as shown in Figure1.

A. Background

Working of the Transmission System

The code provided is for a simple Arduino based receiver that detects data transmitted using Light Fidelity (Li-Fi) by an LDR sensor module (connected to pin 8). The transmission happens via the flashlight of a mobile device, which turns on and off at specific intervals to represent binary data.

Here's an explanation of the system:

1. **Setup Phase (Initial LCD Display):**

- The system initializes the LCD and displays a welcome message.
- The LCD first shows "LiFi Project" for 3 seconds, then clears and displays "Send any message" followed by "from LiFi App..." for 3 seconds.

2. **Main Loop (Receiving Data):**

- The loop() function constantly reads the LDR sensor (pin 8) for changes in light intensity.
- If the LDR detects light (binary 0) (i.e., the flashlight is off), it enters a while loop.
- As the flashlight flashes, the system reads the light pattern and appends the corresponding binary value (0 or 1) to the duration string.
- For example, if the light stays on for a short period (binary 1), it appends a 1 to the duration.

3. **Message Decoding:**

- The program checks the accumulated duration string and matches it against predefined binary patterns (such as "001" for "hi", "0001" for "hello", etc.).
- If the duration matches one of these patterns, the corresponding message is displayed on the LCD and printed to the serial monitor.
- If the light is off for a longer period (i.e., val2 == 1), the system clears the duration and stops reading further data.

4. **Message Examples:**

- For a light signal pattern of 001, the system will display "hi"**.**
- For a light signal pattern of 0001, the system will display "hello"**.**
- Similarly, different patterns represent different messages, such as "how are you?", "I am fine", "good morning", and so on.

App Development for Message Transmission

1. **User Interface:**

- The app provides an interface where the user can input a text message**.**
- The user taps on a "Send" button after entering the message.

2. **Text to Binary Conversion:**

- The app converts the text into a series of binary values.
- Each character is converted into its ASCII binary representation**.**
- The message is then encoded into on/off light signals (where 1 corresponds to the light on and 0 to the light off).

3. **Control the Flashlight:**

- Using Java's Camera2 API (for Android), the app controls the smartphone's flashlight to emit light pulses corresponding to the binary data.
- The app needs to control the timing of the flashlight (on/off) to match the pattern of binary data for each character in the message.

4. **Transmission Process:**

- The app uses timing to represent the binary data**.**
- A short flash (turning on the flashlight for a brief period) corresponds to a 1 (binary "on").
- The flashlight stays off for a brief period (binary "0").
- The timing intervals between flashes determine the speed of the transmission.

5. **App Features:**

- **Speed Control:** The app should allow users to adjust the transmission speed (by modifying the duration of light pulses) to match the capabilities of the receiving system (Arduino with the LDR sensor).
- **Message Acknowledgment:** Once the Arduino receiver successfully decodes the message, it displays the message on the LCD and sends a response. The system involves two main components: the Arduino receiver with an LDR sensor that reads the light pulses and decodes them into messages, and the mobile app that encodes the message into binary data and transmits it via the flashlight. By leveraging the camera API for controlling the flashlight and implementing simple binary encoding, this system can be used for low-cost and secure communication via Li-Fi.

B. Hardware Section

This section outlines the materials, components, and methodology used to design and implement the Li-Fi data transmission system based on the Arduino platform. The project aims to build a simple Li-Fi communication system that can transmit data using visible light, with the data encoded on a mobile flashlight and received by Light Dependent Resistor (LDR). The process involves both hardware and software implementation to achieve successful data transmission

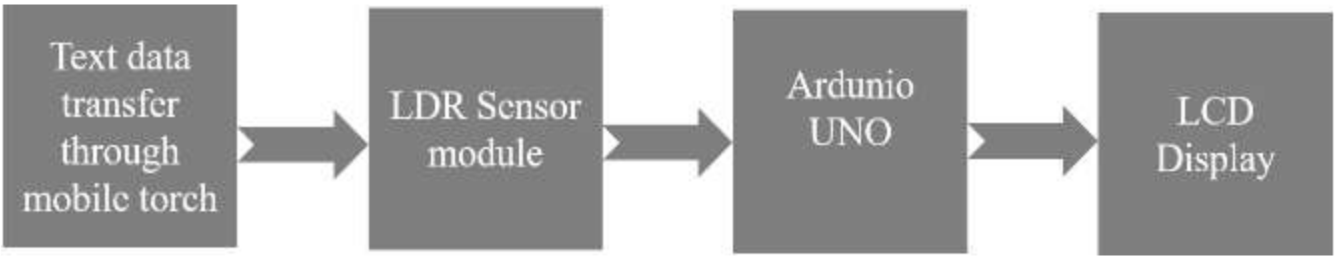


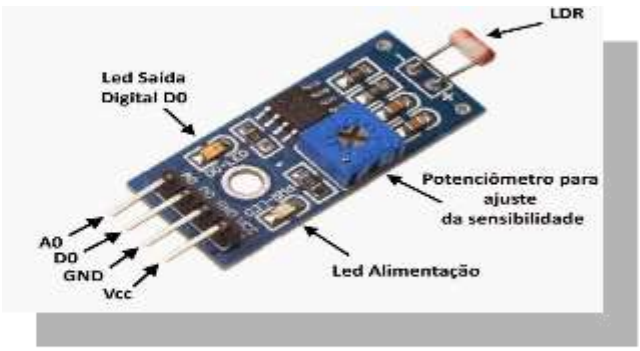
Fig. 1. Block diagram of Li-Fi Data Transmission System

V. COMPONENTS:

1. Arduino UNO

By using an Arduino UNO with an LDR sensor module for receiving light signals, and a mobile app for transmitting text via the smartphone's flashlight, you have created a Li-Fi-based communication system. The Arduino UNO decodes the light pulses into text and displays them on the LCD. By using an Arduino UNO with an LDR sensor module for receiving light signals, and a mobile app for transmitting text via the smartphone's flashlight, you have created a Li-Fi system. The Arduino UNO decodes the light pulses into text and displays them on the LCD. The system provides a simple and effective way to transmit data using light, leveraging commonly available components like the Arduino UNO and mobile phones.

2. LDR sensor module



The LDR sensor module is a simple and effective way to detect light signals in your Li-Fi system. It detects the light emitted by the mobile flashlight and converts it into digital signals that can be read by the Arduino UNO. The Arduino processes these signals and decodes them into meaningful data (like messages), which can then be displayed on an LCD or transmitted further.

By adjusting the flash rates and using the LDR sensor module in a voltage divider circuit, you can successfully implement a Li-Fi communication system based on light signals.

2. LCD Display 16*2

The LCD plays a crucial role in the Li-Fi data transmission system by providing a clear, visible display of the received messages. It works by receiving data from the Arduino and showing it on the screen using simple commands. Integrating the LCD into the project enhances its interactivity and usability, making it easier for the user to view and understand the decoded messages transmitted through light pulses. This addition improves the overall user experience by allowing real-time visualization of the transmitted data.

VI. ALGORITHM:

1. Start

2.**Initialize Arduino System:** Set up serial communication, Initialize LDR (Light Dependent Resistor) and LCD

3. **Activate Mobile Application:** Input data (e.g., text), Convert input data into binary format

4. **Control Mobile Flashlight:** Modulation), Emit modulated light pulses from the flashlight

5. **Transmit Light Pulses via Flashlight**

6. **Detect Light Pulses:** LDR detects the emitted light pulses, Convert detected light pulses into an electrical signal

7. **Arduino Receives Electrical Signal from LDR:** Arduino receives and processes the electrical signal

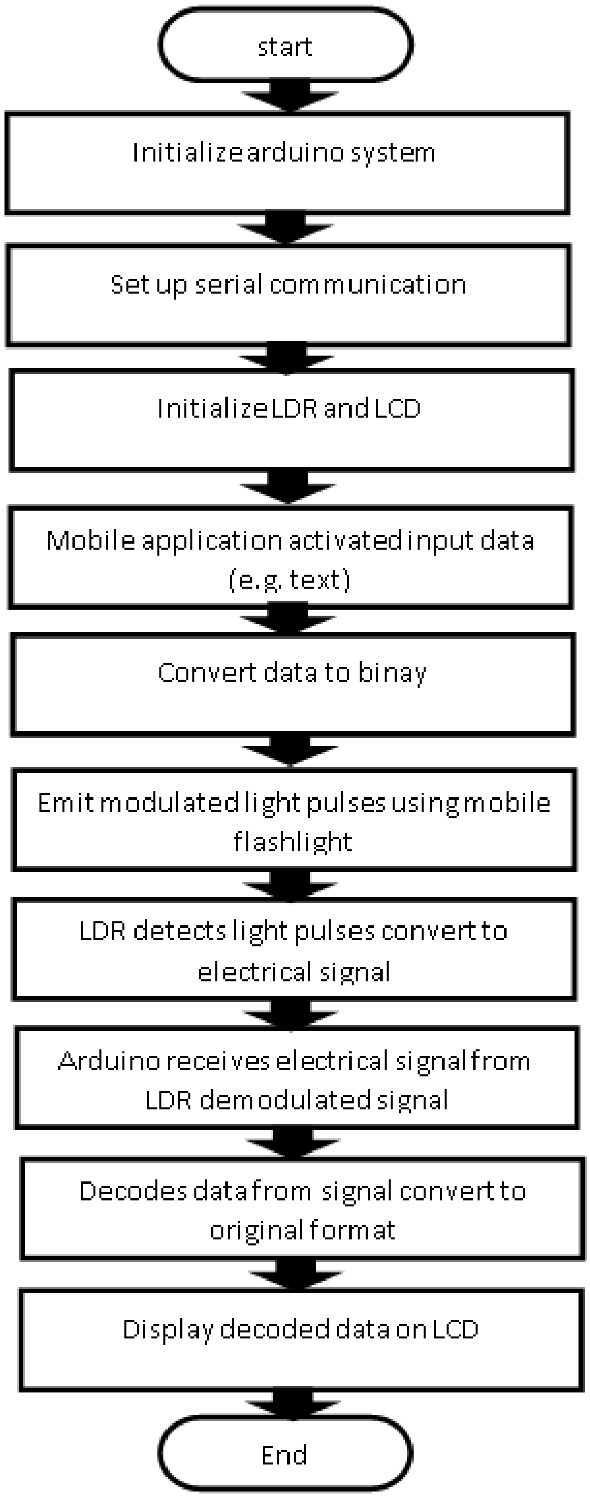
8. **Demodulate Signal:** Demodulate the electrical signal to extract the binary data

9. **Decode Data from Signal:** Convert the binary data back to the original format (e.g., text)

10. Display Decoded Data on LCD

11. End

VII. FLOWCHART:



VIII. ADVANTAGES:

- **High-Speed Data Transfer**: This system may offer faster communication speeds for short-range data transmission.
- **Security**: This makes the system more secure compared to Wi-Fi, which can be accessed by anyone within the signal range.
- **Interference-Free**: It does not interfere with radio-frequency communication, ensuring safer operation in such environments.
- **Cost-Effective**: The Arduino system is inexpensive and easy to set up for small-scale communication systems.

IX. LIMITATIONS:

- **Limited Range**: The signal strength diminishes rapidly with distance, and it requires direct or near-direct alignment between the transmitter (flashlight) and the receiver (LDR).
- **Line of Sight Requirement**: This limits its practicality in environments where constant mobility.
- **Speed Dependent on Lighting Conditions**: Daylight or ambient lighting conditions may interfere with the accuracy of the system unless a controlled lighting environment is maintained.
- **Hardware Limitations**: LDR may have slower response times compared to more advanced optical sensors, potentially reducing data transfer reliability.

X. APPLICATIONS:

- Indoor Networking and Communication.
- Internet of Things (IOT) Devices.
- Visible Light Communication for Accessibility.
- Text message transfer.

XI. Conclusion:

Li-Fi technology using Arduino and a mobile flashlight offers a unique and efficient way to transmit data through light. It provides benefits like secure, high-speed communication, especially in environments where traditional wireless methods may not be ideal. While it has limitations, such as a limited range and line-of-sight requirement, its potential for applications in smart homes, secure environments, and even underwater communication makes it a promising area for future development.

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