Implementation of Li-Fi Technology in Classrooms

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Abstract—In this paper the implementation of Li-Fi technology in classrooms has been investigated. It is well known that the visual information is better perceived by the brain as compared with the textual information. Using visuals to explain a concept helps student get a better perception about the topic. To ensure the best of the visual experience, there is a big need of an efficient way of communication between the devices used by students and the teacher. The traditional methods like Wi-Fi or wired connections are not much efficient due to the speed limitation and other factors. Light fidelity, also known as Li-Fi is a type of data transmission technology which uses light rays to transmit data. By implementation of this technology, high volume of data can be transmitted at extremely high speed as it gives higher bandwidth. It also ensures efficiency, security, as well as the mobility of the device. Hence, we are looking to implement this technology to enhance the learning experience of the students. Every student gets a visual input on what, when, where and how anything happens and the concepts are understood easily and thoroughly. Also, it is cheap and safe to the human body.

Keywords: Li-Fi (Light Fidelity), Spectrum Crunch, LED (Light Emitting Diode), Orthogonal Frequency Division Multiplexing (OFDM).

1. INTRODUCTION

This system will encourage both visually challenged person and illiterate person to perform their work. In the current time, the wireless technology has become an integral part of our life. We are constantly connected to some form of wireless instrument. Internet plays a very important role in data exchange in our day to day life. With the improving technology, the demand of high speed data is constantly increasing. Now the radio frequency based networks are not sufficient for the bandwidth intensive application. Hence it often leads to a situation called as spectrum crunch. So we need to move on to a better method of transmission of information. With the development of Light Fidelity or Li-Fi, we can meet this high demand of extensive amount of data transfer at efficient rates. This term was first coined by professor Harald Hass at 2011 TED.
global talks. The light fidelity system uses visible spectrum of light to transmit the data. It has been observed that the Li-Fi provides an efficient data transfer with high security.

The basic principle in this Li-Fi system is that the data will be sent through an LED and will be received by the photodiodes which convert the light signals into electrical signals. The data will be transmitted in the binary form (0, 1) by blinking of the LEDs. Due to its advantages Li-Fi finds its application in many fields like vehicle to vehicle communication, vehicle to infrastructure communication, data transmission in a place with high security and even in common places like hospitals and schools, etc.

In this paper, a design to implement the Li-Fi technology in the classroom has been done to enhance the learning experience. It is observed that the visual information is more likely to stay in our mind rather than reading it from a book. The crux points of the topic can be easily explained, zoomed in to show the relevant visuals, stopped and annotated when and where it needs to be emphasized along with appealing animations, colours, and sounds. Thus, the teachers gain complete attention and interest of every child in the class. Every student gets a crystal clear idea of the topic explained.

In our current wired technology, all the devices are connected either by wires like optic fibre, twisted cables or a Wi-Fi connection. But there are many disadvantages of using LAN as it is wired; hence it requires proper installation procedures such as drilling holes properly, fitting sockets and redecorating. It gets worn and torn if it is kept in open space. Maintenance of wires is quite difficult and most important of all, it clutters the workspace. These methods require complex circuits for transmitting and receiving data. Also, it can cause a tripping hazard. Installation needs to be done by skilled technicians, and even a virus can spread more easily.

In case of Wi-Fi, the RF communication system this harms human body because of its constant radioactive radiation. These communication systems cannot give a high data transfer rate. Li-Fi does not harm our human body because the radiations are not harmful as it mainly consists of light waves, which are not even of that high intensity which would hurt the human eye.

2. THEORY

The Li-Fi system consists of key components like LED array, LED driver circuit, and a receiver. The LED array acts as a light source. It can be dimmed up and down at an extremely high speed without being visible to the human eye. The data is received from the server to the LED driver. Then the data is sent to the LED by the LED driver, which uses Signal Processing Technology to convert the message signal into binary codes that can be further transmitted. The LED blinks and transmits data which is embedded in its beam at rapid speed. The transmitted light wave is received by a photo detector. The rapid change in lights intensity of LED bulb is converted into electrical signal by the photo detector. The signal is converted into binary data by decoding and then amplified. This binary data is generally a web video or audio application that runs on internet. Li-Fi uses orthogonal frequency division multiplexing modulation method to optimize data rates, multiple access and Energy Efficiency.

The RF communication system can provide frequency up to 300 GHz whereas Li-Fi can provide a frequency of 790 Terahertz. Li-Fi can give up to 224 gigabytes per second which is quite higher than the highest speed achieved by RF communication systems yet.

3. DESIGN

The Infrastructure needed to build a smart class contains main components like a server, transmission source, receiving element, device to interface with common devices and interactive board for lecture. The server
is used as a database of smart class and to access contents from internet. Transmitter source is used to transfer data. It contains two main components, namely LED driver circuit and the LED grid or array. The LED array contains high brightness LED that can be controlled by the LED driver circuit. These LED grids will be installed at the ceiling so that it can provide light at every point of the class. The receivers will be installed on every table. Accessing by the general devices can be done by using wires between receiver and the devices or attaching a separate compatible device to the main device (example Li-Fi dongle) to ensure continuous reception of data to the receivers. In our design, LED grid is installed with a slight inclination to expand the field of light signals. A projector can also be installed so that the teachers can demonstrate thing to the class. Since, the student get instant access to the notes, they do not need to waste time by copying the notes. The internet can be accessed by a computer and a projector in case the teacher wants to show something from internet or from the database. The pictorial representation of the proposed model is shown in figure 3.

4. WORKING

![Fig.4 Block diagram of working of the Li-Fi system](image-url)
LED array will be installed on the ceiling of the class. The information will be fed by the server to LED driver circuit which will transmit data. The LED will send the data by blinking at a very high speed and thus, binary data in form of 0s and 1s will be sent to the receiver. The LED driver circuit controls the working of the LED thus controlling the data flow. The receivers installed at each table will receive the data and convert it into electronic signals. The electronic signals will be sent to the general devices from the receiver using a data cable. In case of the Li-Fi dongle, it can directly receive the data and feed to the device the user is using like phones, tablets or computers, etc. Since, the led matrix is slightly inclined to increase the field of light signals, so even if there is an obstruction in the way for one LED the other LED can compensate for the loss of signal. The projector displays data over the smart board. When the projector is being used the intensity of light can be decreased so that the communication will still happen and the projected data can be seen easily. The smart board can also detect what is being written on the board and that can be transferred to the students thus saving time for students.

**ADVANTAGES**

- It will enhance the learning experience for the students by interactive learning.
- The data transfer can be done in much faster way compared to the traditional wired networks or Wi-Fi.
- It can handle heavy network traffic.
- The soft copy of the data can be shared with students easily.
- There will not be any harmful effects from the signals as they constitute of medium intensity light waves unlike the radio waves.
- The design ensures the signal to be uniformly spread in every direction as it will help to ensure continuous flow of data at every point.
- The devices can be easily installed without much need of external structure. Hence it is less labour intensive and also cost effective.
- It is ideal for the students who are working in groups. Every student in class gets the same interactive experience.
- It provides a wireless means of communication hence no need of installing extra wires that clutters the workplace.
- The mobility of the devices is increased since it can be accessed all over the room.

**DISADVANTAGES**

- External sources of light like sun and other bulbs can create interference in the communication.
- If the sources of light are even slightly blocked, the transmission and reception cannot happen properly since it is a line of sight communication.
- It is only a one way connection as the receivers cannot send back the data.
- The reception of data to general devices can be done by Li-Fi dongle. If, the interfacing to the common devices is done by wires, there can be a limitation in the volume of data being transferred.

5. **PRACTICAL EXAMPLE**

Since, this technology is quite new, there are not many real life examples present today. The world’s first Li-Fi enabled classroom has recently been implemented in Hegel-Gymnasium, Stuggart, Germany. This installation is a trail by the Fraunhofer Heinrich Hertz Institute and is funded by the City of Stuggart. In Britain, a school in Kent has also implemented this technology.
6. CONCLUSION

As the technology is expanding, the students have to be educated well to understand these things. Some topics cannot be explained by the conventional system of teaching so we need an interactive place so that the students can have a clear insight of the knowledge. Evolving technologies like 3D printing and nanotechnology can be easily understood visually. Traditional teaching methods cannot give a deeper insight about it. So, digital technology is much needed to make students understand well. An efficient data transmission technology can easily accomplish a difficult task of transmitting heavy data. There is a continuous development happening in communication methods in many areas, so to keep it up with the time we also need to implement these new methods in the education field as well. Also, traditional methods of teaching required very skilled teachers so that the student can have better knowledge. Which visual technology teachers with a little less knowledge can also teach students efficiently? Hence, it does not give much work load to the staff as well. We hope that the design proposed in this paper will be implemented and will work efficiently.

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