*ANN based Performance Enhancement for Campus Free Space Optical Communication Links**

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ABSTRACT

Free Space Optical Communication (FSOC) allows us to develop wireless communication network like the KORUZA, which are more effective when Artificial Neural Network (ANN) error detection techniques Viterbi comparing with SBRNN method, and to improve the performance of the links. Studies of the systems such as KORUZA can make network accessibility easier also implementation and manufacturing it locally.

1 INTRODUCTION

Free space optical communication is a line-of-sight technology that uses a beam of light through the atmosphere to provide a high bandwidth connection [7], an innovative way of transmitting data in 1Gbps or 10Gbps wirelessly. This method is suitable in today's world of big data. FSOC links are easier to construct, they do not need any digging of the ground which contribute on making expenses and authorisation which is required by radio frequency as it uses lasers for communication also making the transmission medium traffic free from any outside interference. Despite all these good characteristics of FSOC, this technology suffers from environmental factors such as the weather conditions like rainfall and which may impair the LOS, human factors like buildings that might be in the way of a link to name a few.

This work focuses on Koruza system which makes it simpler to apply FSOC Links, KORUZA is an open hardware and open source FSOC transceiver system, which uses point to point LOS to transmit data, its links are meant to be used to develop a community wireless network that are constructed in high heights which are not impaired. KORUZA as a functional product is set on transforming wireless communication system, by using Koruza we sure to reduce cost of network access. Figure 1 shows the Koruza transmitter. The Koruza transceiver system only transmits up to 150 m. There is, therefore, a need to extend this transmission range for campus deployments. Increasing the transmission range will help to reduce deployment costs of FSOC.

Figure 1: KORUZA the on part of the FSOC link (transmitter).

2. LITERATURE REVIEW

2.1 Origin of FSOC

The Greeks were the first people to use free space optical communication early in the 8th century. They implemented their links by using fire as light source, the transmission medium was the atmosphere and the human eye was used as the receiver [1]. The technology of Optical Communication was also used toward the end of 19th century after the invention of photodiode by Alexander Bell, this servers as groundwork for wireless optical experiments throughout the years which is then discussed in detail in [1], [2], [3]. In today's implementation, FSOC technology makes use of high power high optical sources for instance light amplification by stimulated emission or radiation (LASER) or light emitting diodes(LED), together with a lens that can transmit light through the atmosphere to another lens receiving data/information sent [1]. Figure 2 shows the FSOC Communication link.

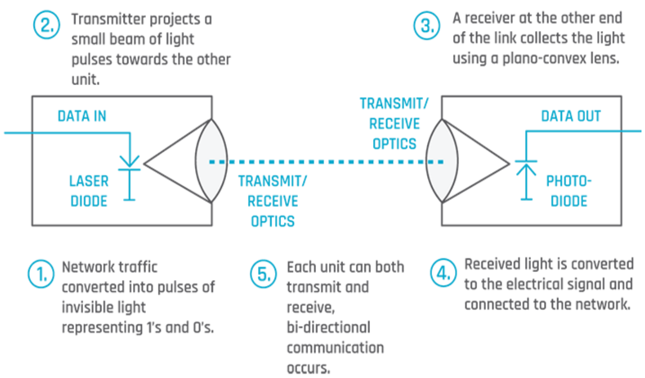

Figure 2: FSOC Communication link.

2.2 FSOC applications

The application of FSOC are as follows:

- **Last mile access**. It used to bypass local-loop systems with high-speed connections that are provided for businesses [1]. FSOC can also be used in high-speed links which connects end uses with internet service providers or other networks.
- **Tactical links in defense systems**. The quick respond, portability, high bit-degree and low risk of exposure that then provide military application with viable option for using FSO. It can be used to for communication purposes (between battle ships, tanks, unmanned aerial vehicle) [2].
- **Fiber back up**. FSO links can be used as redundant links backing up fiber when one fails.
- **Service acceleration**. FSO are applied to provide instant service to customers before second fiber link

2.3 Advantages of FSOC

FSCO has the following positive attributes:

- **Transmission rate**. FSOC transmit in high-speed, because it has its high carrier frequency it can transmits up to 10Gbps of data, voice and video [4], [14]**.**
- **Licensing**. A license is not required to make FSOC network because it operates at an area section which are not regulated by the Federal Communication Commission(FCC) [1], [3].
- **Installation.** FSO are easier to than that of fiber cable communication. The FSOC does not require digging of the ground that you need to get permission in order to dig or if is in a city shot distances are then made long because of areas where you have to go around, the more you did the more it gets expensive. In FSOC [1]you only need to be place on high grounds on points to transmit and receive [4].
- **Security.** FSO uses laser diode as transmission source the laser has intelligible beam of light which makes the FSOC system difficult to intercept, hence secure.
- **Cost.** FSOC technology require les budget than either wireless radio frequency in that you don't need to go for licencing and tacking of signals devices or fiber optics which needs digging the ground where you need contractors to dig for long distance which is costly.

2.4 Limitations of FSOC

FSOC limitation are as follows

- **Physical obstruction**. FSO requires transmitter and receiver to properly be aligned on a line of light directly path between sender and receiver, things as small as flying birds my block transmission [6]
- **Absorption.** This is when the atmosphere is impairing the laser energy to reach the receiver end due to molecular or atomic level [2], [15]. To reduce this, we can use appropriate power, based on atmospheric condition and use spatial diversity [3], [11].
- The exposure to lase my damage skin and eye of all species [2].
- **The Signal to Noise Ratio** in FSOC which changes with distances, due to accurate alignment of transmitter-receiver, ambient noise, among other factors [2].

2.5 The Koruza System

2.5.1 KORUZA History

Koruza system was developed by a student at University College of London called Luka Mustafa, the Koruza was formed during his masters researching thesis about FSOC. It was during a project he had in Slovinjia that Koruza started to be something more interesting, it then evolved into something useful after a conference in Kazakhstan where more ideas about implementing FSCO were arising. Koruza as it uses optics it needed a combination of individuals from different fields from the physics, telecommunication and computer science in order to a fully functional system, this became more simpler because the of the Photo Phone which removes the need for other individuals. On the face phase [5]. The development of Koruza revealed problems that affected the FSOC the most, weather conditions to be checked [Mustafa], the implementation of high-powered LEDs made transmission more effective. The Koruza now is a functional system which is open source and open hardware, it needs some alteration that will make it more effective also reduce the cost of installing it as it currently uses expensive hardware. More research is required for Koruza to make a Global system as is a high bandwidth transmission.

3 The Open Culture of Koruza

The current deployment of the Koruza system guarantees a transmission range of 150 m at 1 Gbps and 10 Gbps. The Koruza system as an open hardware and open source system offers researchers and developers to learn how to develop FSOC systems swiftly. The system has been left deliberately open to allow researchers and developers to implement new functionalities on the system in order to improve performance. The Koruza team provides tools [10]to enable researchers in the following ways:

- Complete experimental setup with real-time monitoring, cloud integration, direct measurement import in Matlab, Python, etc.
- Customizable experimental deployment with weather stations, accelerometers and other sensors for free-space optical channel research.
- Pointing and tracking algorithm implementation and custom algorithm testing.
- Integration with routers and other networking devices for fail-over switching development and research.
- Integration with custom optics elements and optical performance evaluation
- Large-scale multi-hop FSO deployment and monitoring.
- Testing and integration in custom applications and environments
- Customizable hardware for testing of transmitter, receivers, lenses and other optical elements

4 BACKROUND OR PROBLEM

4.1 TRANSMISSION RANGE

Koruza as a functional product has some it's on own limits as it can only be implemented between links which are in distinct range of 100m to 150m. It makes Koruza expensive to construct because many links will be needed to cover large areas.

4.2 Cost of construction due to the lack of knowledge of the technology.

Because Koruza links are not yet available in in most countries, they are therefore shipped from outside the country with the material used to construct it not yet available., it roughly cost about R25 000 to get one link that coverup to 150m how much it will cost to connect a city.

5 OBJECTIVES

The objectives of this project are as follows:

5.1 AI based Bit Error Correction Algorithm

One of the objectives of this experiment is to develop an Artificial Neural Network based bit error correction algorithm for the Koruza system. Since the Koruza can only transmit date on a between several ranges before the data start to lose partiality. We aim to implement some detection methods like Viterbi detection [8], [12] and SBRNN [9], [13] methods to correct the errors on the signal.

5.2 Comparison of the modified and the original Koruza

The other objective is to compare the modified Koruza system with the traditional system at various transmission range under different weather condition as these normally affect FSOC system performance.

6 Requirements

6.1 Use requirements

- Transmission range should increase
- Transmission bandwidth should not decrease
- The addition should not consume memory

6.2 Functional requirement

- The system should be able to correct errors efficiently at the extended distance.

6.3 Non-functional requirement

- Availability: must respond fast
- Reliability: must be error free data

6.4 Software requirement

- Python
- Mat-lab

6.5 Hardware requirement

- FSOC (KORUZA) link; raspberry pi, laser, etc..
- Extender: poles

7 Significance of the project

In Through the project, it can help reduce the implementation cost of FSOC links in a campus setting by reducing the number of FSOC transceivers needed to cover an area comparing with the unimproved one.

In completion of the project, studying the Koruza, we can eventually create a platform for learning in order to build it using locally accessed materials, which reduces even further the price of the system

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