Investigate the optical FBG sensor to monitor the alignment of human body

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In recent times, the true potential of Fiber Bragg Grating (FBG) Sensors is discovered that, it can be used to determine the physical parameters of a structure like: Strain, Temperature, corrosion etc. Researchers across the globe has also started to look for the usage of FBG in the healthcare department to monitor the different parameter of human body like blood pressure, glucose level, sugar level heart beat rate etc. Taking the research to its new heights, this research paper proposed the use of FBG optical sensor to monitor the alignment of human body. As it has been observed that when a human suffers from the Spine Dislocation or some other structural imparity, it's one of the major symptoms are the abnormality in walk and uneven strain on feet. If these symptoms detected at initial stage, then the cure is much easier. This paper shows the potential use of Fiber Bragg Grating Sensors to monitor Alignment of Human Body. In the research, two sensors were mounted at the bottom of both the feet of the person. The person walked for a few seconds and the readings of wavelength change due to strain on feet. Experiment was done on 3 persons with sensors mounted at the bottom of their feet and the readings were observed.

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1. Introduction

Alignment of human body is of great significance, many may tend to ignore it, but it determines on how the body parts such as head, shoulders and spine are inter-related and line-up with each other. If body alignment is in proper shape as per clinical standards, then the body will be stress-free and you will be able to maintain a good body posture. Although, Exercise suggestion floats with hearsay and people also suggest some body posture corrector belt to get relieve from stress but many a times, it's hard to identify the disparity. There are various equipment's were available in the market such as upright posture device, stack smart posture corrector, neck and back pain support device with app, etc. to improve the body posture and support the body alignment but not to detect the dislocation or bad posture of the body.

FBG Optical sensors can be used to determine the bad body posture with the help of feet and it's also observed that from previous researches on these sensors show that these sensors are being under-utilized for only Civil Structure Health Monitoring and not Human Health Monitoring. Torres et al. [1] analyzed the strain transfer in a new FBG sensor for Structural Health Monitoring, Engineering Structures. Kaur et al. [2] proposed the optimization of fiber Bragg grating optical sensor using genetic algorithm to monitor the strain of civil structure with high sensitivity, showing that the FBG sensors are also used in civil structural health monitoring. Sahota et al. [3] also reviewd the use of FBG sensors to monitor the physical parameters. Quintana et al. [4] showcased that Optical sensors can be used for SHM(Structural Health Monitoring) and evaluation of concrete pavements. Song et al. [5] also give the same results, proposing the use of Optical sensors in Corrosion Monitoring of Reinforced Concrete Structures. Zhu et al. [6] observed the use of FBG in detecting damage in composite material, under low frequency cycling. Li et al. [7] shows how sensors' sensitivity can be enhanced to get accurate readings of physical parameters. Kaur et al. [8] too experiments on a highly sensitive fiber Bragg grating optical sensor to monitor strain and corrosion in civil structures. Vandana et al. [9] reviews the usage of Fiber Grating sensors in medical department: Current and emerging applications, Sensors and Actuators. From the other articles it was observed that [10-13] before using FBG sensor in any application it ensure that the sentiivity level of sensor is higher. To increase the senstivity various authors has been reported different schemes such as Long Period grating, reduce the cladding thickness and refractive index of material.

From the lierature survey it is observed that FBG sensors are mostly being used to monitor the physical parameters like strain, temperature and structural strength of manmade structures but not in alignment of human body. So, this paper is based on to monitor the alignment of human body using FBG sensor.

2. Experimental setup

In this paper experiment was conducted on three persons, the FBG sensor is mounted at the bottom of the feet as shown in Fig. 1. After implementation of FBG sensors on human feet then asked to walk for a few seconds while sensor is in active mode. From Enlight software it was observed that when the persons change its position after walking then deflection was occurred in the wavelength chart which is screening by personal laptop. From Fig. 1 it is observed the experimental setup used two FBG strain sensors (FBG_A1 and FBG_B1) fabricated by Micron Optics. These wavelengths are running on wavelength: 1572 nm and 1576 nm. These sensors are temporarily mounted at the bottom of the feet, and are in-turn connected with a SM130 Optical Sensing Interrogator, which is built upon the x30 optical interrogator core, featuring a high speed swept wavelength laser realized with Fiber Fabry-Perot Tunable Filter technology.

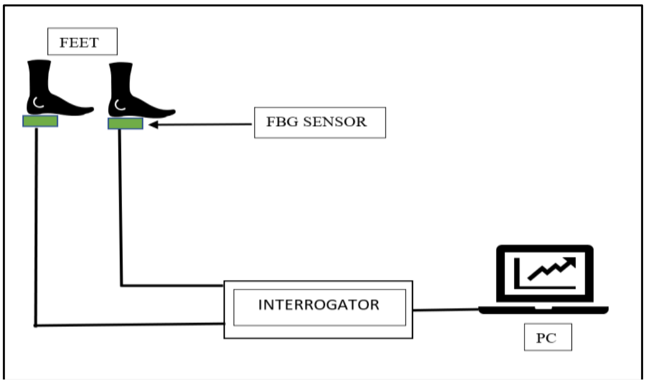

Fig. 1. Experimental Setup for observed the alignment of human body

The x30 interrogator core employs high speed hardware peak detection, optimized for rapid data acquisition of the FBG sensors. Interrogator is further connected with an output source Personal Computer (PC). Another parameter of FBG sensor is defined in Table 1.

Table 1. Properties of FBG Sensor [8]

Specifications	Range
Performance Properties Strain Sensitivity	~ 1.2 pm/με
Gage Length	10 mm
Operating Temperature Range	-40 to 60°C (80°C Max)
Strain Limits	± 5,000 με
Maximum Drift	< 50 με
Standard Wavelength	1512 to 1588 nm
Extended Wavelength	1460 to 1620 nm

As this paper is deal with strain observation and we are using FBG strain sensor so to calculating the strain using FBG Sensor, following mathematical approach has been adopted: To calculate the strain equation 1 was used with the help of FBG sensor parameter (mechanically induced µm/m) [8]:

$$\varepsilon = (\Delta\lambda/\lambda_0)\ 1\text{x}10^6 / F_G - \varepsilon_{TO} \qquad (1)$$

where $\Delta\lambda$ is wavelength shift, λ_0 is nominal wavelength, F_G is Gage factor, ε_{TO} thermally induced apparent strain.

To calculate the Thermal Output equation 2 was used (thermally induced apparent strain, µm/m) [8]:

$$\varepsilon_{TO} = \Delta T\ [C_1 / F_G + CTE_S - C_2] \qquad (2)$$

where ΔT is temperature change, C_1 and C_2 Gage constant 1 and 2, CTE_S is CTE of test specimen.

3. Results and discussion

From the experiment the change in wavelength against strain on each foot is measured using the strain FBG Sensors (FBG_A1 and FBG_B1) having wavelength fixed at 1576 nm and 1572 nm respectively. The wavelength shift in each sensor was jotted-down when the person was walking with the sensors. This experiment is deal with three people, wherein, first person is facing issue in spine (Spine Dislocation), second person has a medical history of back pain and third person who is fit and no complaints regarding physical pain.

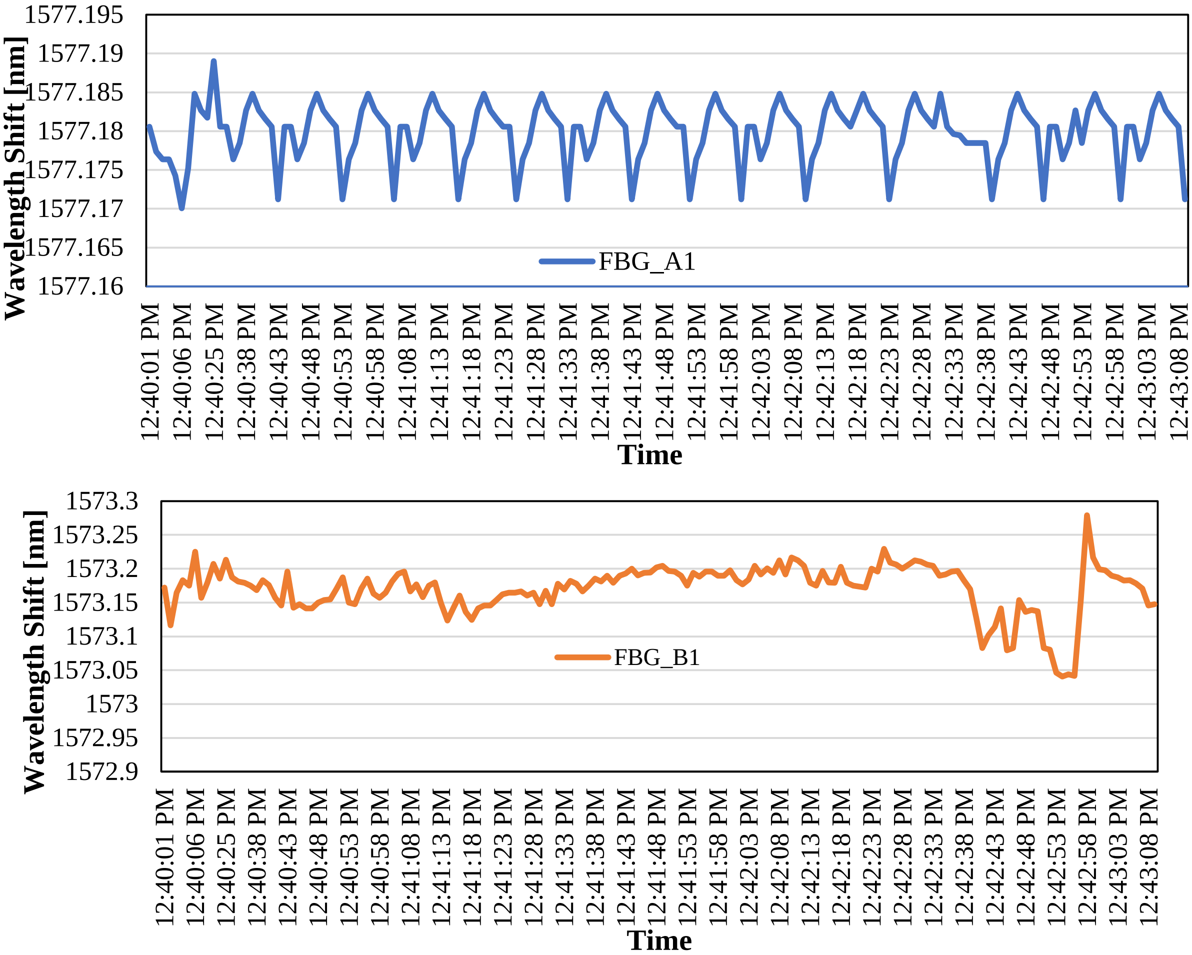

Fig. 2. Observation of Wavelength shift in FBG_A1 and FBG_B1 while few seconds walk of Person 1

From Fig. 2 it was observed that when person 1 started walking at 12:40:01PM and stopped walking at 12:43:04, i.e., total time comes out to be 183 seconds then it was observed that there was a constant toggling shift in wavelength in both sensors. Maximum shift in FBG_A1 while walking, was 1.189 nm at 12:40:25 PM whereas, in FBG_B1, it was 1.279 nm at 12:42:58 PM.

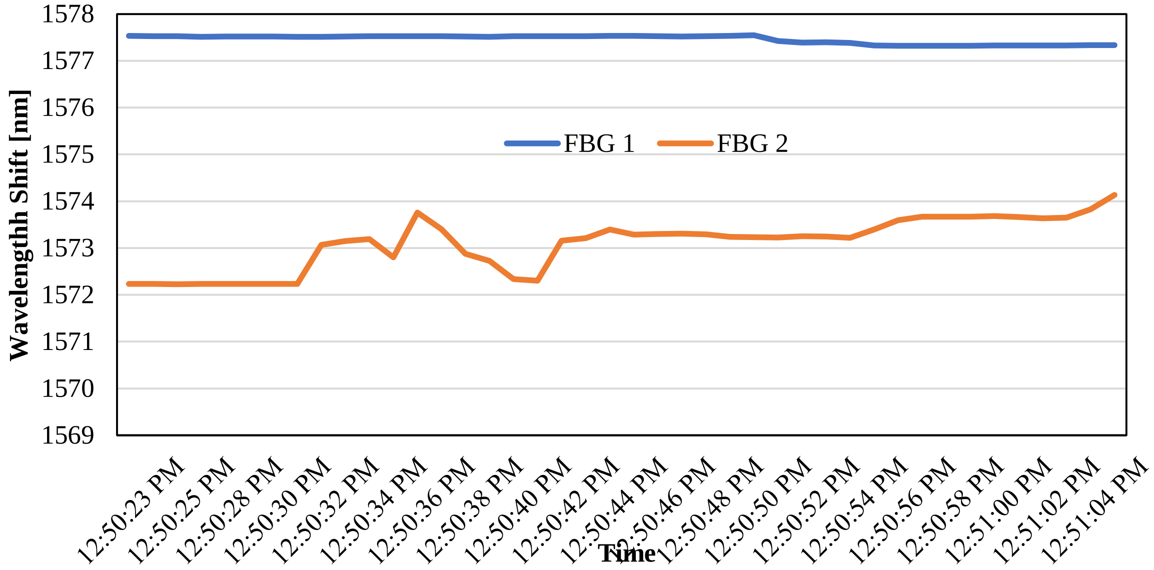

Fig. 3. Observation of Wavelength shift in FBG 1 and FBG 2 while few seconds walk of Person 2

It can be inferred from Fig. 3 that when person 2 started walking at 12:50:23 PM and stopped walking at 12:51:04 PM, so total experimentation time was 41 Seconds. From Fig. 3 it was observed that there are less wavelength toggling but wavelength shift of 1.133 nm has been found in FBG 2 and 1 nm in FBG 1 sensor. From it was observed that second person may deals with some body alignment issues.

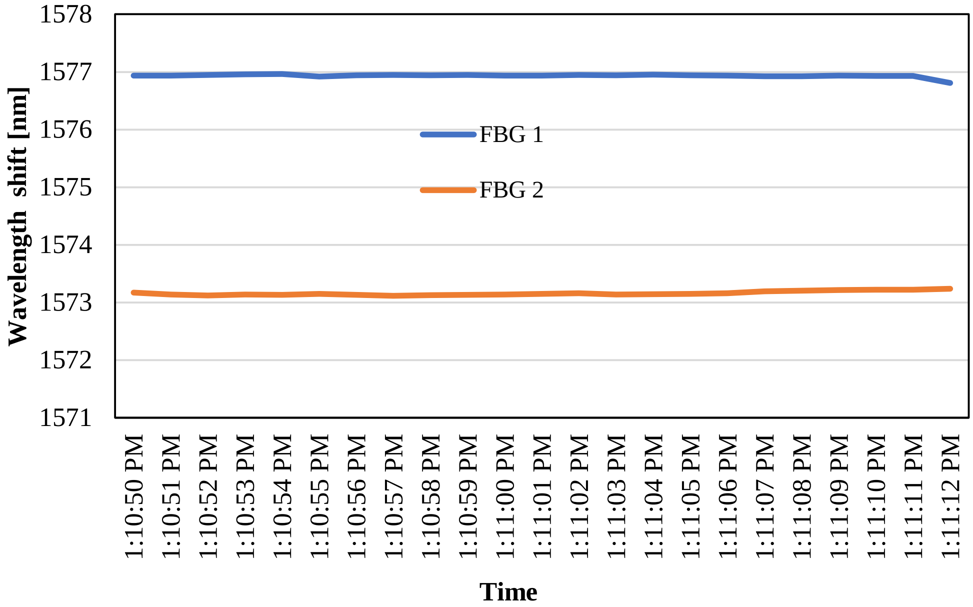

Fig. 4. Observation of Wavelength shift in FBG1 and FBG 2 while few seconds walk of third person

The same FBG sensor was mounted on third person where no toggling in wavelength found. From Fig. 4 it is observed that when third person started walking at 01:10:50 PM and stopped walking: 01:11:12 PM with total time of 22 Seconds. From the results it was reported that body alginment is measured with toggling in walength chart. As its is also reported that wavelength is shifted from its initial value and this is happend due to the FBG srain sensor, where strain was detected by sensor from human weight.

4. Conclusion

In this paper FBG based strain sensor was used to monitor the body alignment of human. In this experiment three different people was investigated. The person 1 which has Spine Dislocation, person 2 facing back pain and person 3 fit and fine. In the starting of experiment two FBG sensor was mounted on both feet and observed the wavelength toggling for few seconds. After the investigation it has been observed that the first-person walk is not normal because in result frequently toggling was found which mean the body alignment is not in good posture. When the second person was investigated then there is body load is heavily distributed to his right foot. The third person who fit and fine has not found any toggling in wavelength graph.

The research outcome shows that with the use of proposed FBG Optical Sensor of high strength monitoring of the Human Body Alignment is possible, as it gives precise readings about total load distribution of the Human Body. So, in future these sensors can be install in shoes so that with the help of few second walk we can easily check the body posture or body alignment.

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