Fiber pad for pressure mapping

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Abstract. Optical fiber sandwiched pad designed as a pressure mapping sensor has been configured and characterized. Optical fiber sensor was aligned to form a web-like configuration (x-y matrix). Several fibers were positioned to form lines parallel to y-axis while others are in parallel to x-axis. When a mass with a particular surface contour was loaded on the fiber pad, we have shown the dependence of the magnitude of light attenuation on the mass surface contour. Combining these light attenuation results we have successfully constructed a three dimensional contours showing the pressure distribution given by the mass to the fiber pad.

1. Introduction

Optical fiber is a transparent solid conduit used to propagate light from one point to any other point in any path forms. Optical fibers used for optical communication are mainly made of silicate glass. Fibers of this type have low loss but less elastic. In contrast, optical fibers made of polymer are characterized by their high optical loss but show a good elasticity. Because of this reason, these two groups of fiber find their own application area. If delivering light to long distance and hazardous area is our main interest, optical fiber made of glass is the best choice [1-3]. Optical fiber used for ultra-low loss optical communication as well as for most chemical and bio-chemical sensing falls into this group. Optical fiber made of polymer usually called polymer optical fiber (POF) is chosen if elasticity is our main consideration [4-5]. Most mechanical fiber sensors are configured using POF.

Fiber sensor configured to form a kind of fabric has many applications. In medical application, fiber Bragg grating (FBG) has been used to measure plantar strain distribution in human foot [6, 7]. Result of this research can describe the pressure distribution created by foot on the pad at different area of foot such as fore foot, mid foot and hind foot. Similar work intended to measure pressure distribution of foot has also been done. For this purpose, hetero core fiber sensors are embedded in the insole [7]. In this work, fiber sensors are embedded under the heel, thenar, anti-thenar, and big toe. In my paper, fiber sensors were distributed throughout the pad surface. Using this configuration, distribution of force given to the pad can be easily made.

2. Experiment

As shown is Figure 1, several strands of polymer optical fibers are sandwiched in rubber pad. Several strands are aligned parallel to y-axis while several others are parallel to x-axis. Light is launched from one end and series of photo-detectors are positioned at other end. Three small pins are positioned at every point at which optical fiber from y-direction and x-direction meets each other. When a load is positioned in a certain area, all fibers underneath the load will be bent result in light attenuation. By measuring light intensity detected by each fiber from both axis x-axis and y-axis and then adding them to form I_{x-y}, a matrix indicates intensity distribution can be obtained.

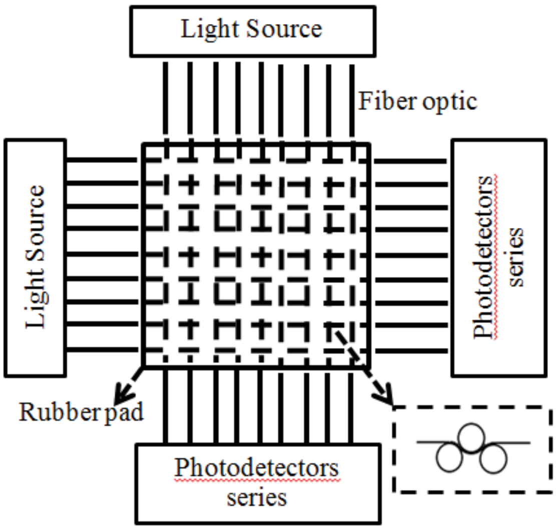

Figure 1. Basic experiment setup

3. Results and Discussion

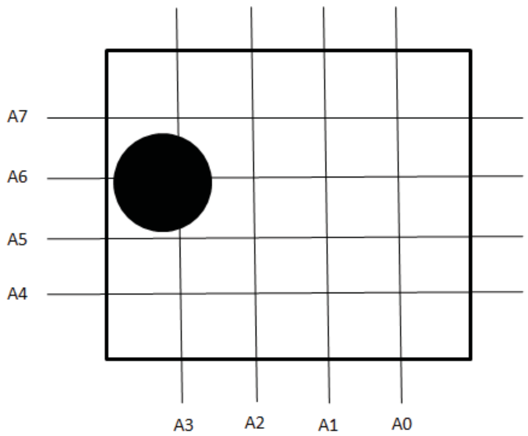

Figure 2. Load position on the fiber pad

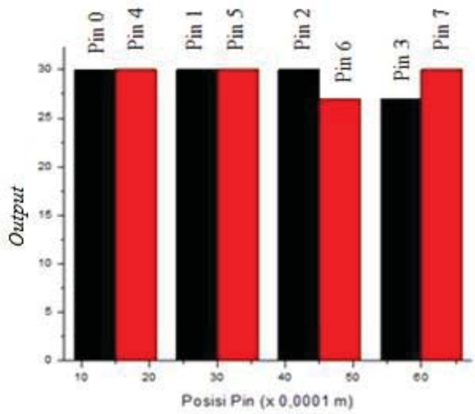

Figure 3 Output power of light detected by photodetector

Figure 2 shows the position of a load placed on the fiber pad. As shown, there are two fibers affected by this load, they are A6 and A3. Because of this load, the upper pin as shown in figure 1 puss the fiber down to some extent that depends on the load mass. Consequently, these two fibers were locally bent and light intensities passing through them decrease (figure 3). Bending loss mechanism was presented by the authors in other paper [4, 8].

		A3	A2	A1	A0
	Loss	3	0	0	0
A7	0	0	0	0	0
A6	3	6	0	0	0
A5	0	0	0	0	0
A4	0	0	0	0	0

Figure 4. Matrix representing pressure distribution experienced by fiber pad

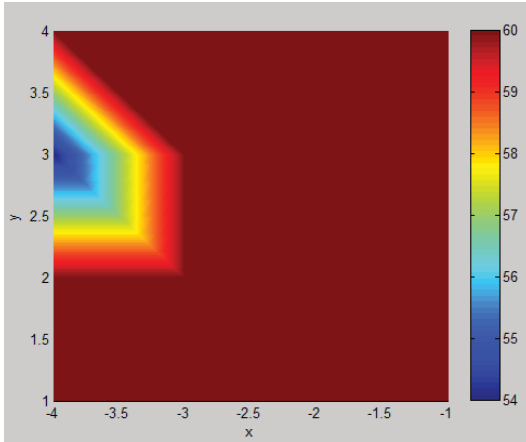

Figure 5. Typical contour plot of pressure mapping showing load position on the fiber pad.

Figure 4 is a matrix constructed based on figure 2 with output power detected by each photodetector taken from figure 3. As shown, A3 and A6 fibers have non-zero output power explaining that they are burdened. Although light attenuation occurs at both fiber does not inform the point source position of load, by adding the output powers of fiber optics between those flowing in y-direction (I_{yi}) to those flowing in x-direction (I_{xi}) we can figure out the position of load (pressure mapping). The intensity of light at each fiber intersection (I_{xi-yi}) can be calculated using equation

$$I_{xi-yi} = I_{xi} + I_{yi} \qquad for\ I_{xi}\ and\ I_{yi}\ \neq 0 \tag{1}$$

Summation requirement as given in equation (1) is needed to ensure that all area other than the position at which the load is placed have the same color (figure 5).

4. Conclusions

In this paper, we have demonstrated the work of a basic design of a fiber pad used for pressure mapping. The sensor works based on an optical loss due to fiber bending. Basic configuration of fiber sensor consist of two groups of fiber optic strands, one was stranded in x-direction and one in y-direction. We have used matrix to process the light intensity data (in the form of output voltage) recorded from those two groups and finally present the results in the form of contour color plot.

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