Chapter 6

Conclusion and Future Work

6.1 Conclusion

In this thesis, an intensity modulation technique has been used for FODSs in conjunction with a multimode fiber as the probe. This thesis studied and demonstrated various types of FODSs to cater future applications, which require better resolution, longer range, better linearity, simple construction and low cost unit. Thus, the main objective of our work is to improve the performance of FODSs and to explore new applications for the FODS.

In chapter 3, the performance of various FODS with a flat target is investigated theoretically and experimentally using different types of laser source, sensor probes, and targets. To improve the performance of the FODS, various new sensor probe's designs are introduced. For instance the FODS configured with two receiving fibers has achieved an almost double linearity range when compared to a conventional sensor with only one receiving fiber. In the FODS with asymmetrical fibers bundled, the effect of different core radial ratios (CRRs) on the dynamic range and sensitivity of the sensor has been investigated. From results of theoretical and experimental, it can be found that the location of the maximum output is shifted toward the right along the axis of displacement as the value of k increases. Besides, the linear range for both front and back slopes increases with the value of *k*. To improve the sensitivity, a FODS with two inclined asymmetrical fiber is proposed. We found that the higher inclination angle can produces higher sensitivity. The FODS use of probe with the highest number of receiving fibers also can provide the highest sensitivity and the higher linearity range can be achieved by increasing the diameter of the receiving fiber. The experimental results also show that the sensor is more sensitive with higher reflectivity object as a target. As such, all of theoretical and experimental results are capable of offering quantitative guidance for the design and implementation of a practical FODS.

In Chapter 4, various configurations of FODSs are presented using a concave mirror as a target, these FODSs can improved the sensitivity and measurement range in the same manner. The measurement range as far as 26mm can be achieved by using a 12mm focal length concave mirror. The maximum sensitivity of 0.299mV/mm had been obtained at the 3rd slope of the FODS. The theoretical and experimental performances of the FODS are also presented for three axes displacement measurement which cannot achieve in the FODS with conventional configurations. Another FODS is then proposed using a multimode fiber coupler as sensor probe for comparison purpose. The simulation result shows that the performance is better with a lower coupler ratio of 50:50, smaller core diameter or lower refractive index of the surrounding medium.

In Chapter 5, many applications of FODS have been described such as the detection of metal surface roughness, liquid refractive index and glucose concentrations, liquid level, as well as vibration measurement. In the estimation of the roughness of metal surface, the roughness of the three types of metals is investigated by fixing the object within the linear range of the front slope and measuring the output voltage as a function of lateral displacement. The application of the FODSs in liquid refractive index measurement is investigated theoretically and experimentally. In the theoretically, a sensor probe with a pair type of bundle fiber inclined is analyzed to increase the sensitivity. Through the theoretical analysis, a highest sensitivity of 0.8235 is achieved by probe inclined with angle 20° which is almost 13 times higher than that in 0 inclinations which is referred as conventional FODS. In the detection of concentration of glucose in distilled water, the experimental results show that the peak voltage or light intensity and its position are increases linearly with the glucose concentration. An extra-low cost, ultra-high sensitivity, and wide compatibility fiber optic LLS is also proposed and demonstrated in this section. In this design, three various experiments are conducted to prove the proposed sensor has very wide compatibility with other type of FODSs. A flexible selection of sensitivity and measurement range is achieved by proposed sensor from free choose of FODSs. For the measurement of amplitude and frequency of vibration, the displacement curve exhibits the maximum output voltage of 1.65mV at a distance of 1.2mm between the reflective surface of the speaker and the fiber optic probe. The sensor is capable of measuring vibration amplitude ranging from 0.22 mm to 0.44 mm within a frequency range of 200 to 350 Hz.

6.2 The future work

For future work, the FODS based on flat target system can be improved by compensation technique to reduce the effect of variation in the reflectivity of the target. The study should also focuses particularly on the reducing sensor system cost without decreasing the system performance, especially on the selection of laser source. In the selection of laser source, if the cost is not a issue the attention should paid more to the wavelength which fall into the low absorption band of the POF rang, the higher output power stability, small divergence angle and beam size in order to evoke more leaky rays. In the work of FODS system based on concave mirror, the theoretical analysis and experimental implementation should be further developed so that the sensor probes are compatible with any types of bundle fibers, not only for pair bundle fibers and coupler. A performance improvement is expected from this work.

A compact device with the ability for sensing the curve metal surface roughness is very important for industry applications. To reduce the size and cost of the sensor, the probe can be fabricated from a cheap single-mode plastic optic fiber and the measurement of curved surface roughness can be implemented by using the existing data acquisition method, such as, the neural network technique. An intensity modulation fiber optic LRIS with the ability for non-contact measurement should be improved so that it can avoid the limitation of total Fresnel law and can also senses an acid solvent. Thus, a compensation technique and novel design can be developed for the future LRIS.

In the detection the concentration of glucose, a fiber optic sensor which can do an accurate and logical measurement and with good selectivity, low detection limit, easy usage, good reproducibility and stability is highly desired. In the sensing of liquid level, a compensation technique can be used to reduce the change in the effective shape of the tip when it immersed in a liquid, this technique can be achieved from the design of sensor probe and data processing method. The future work in the sensing of vibration is suggested by using various configurations of sensor probe and fast Fourier transform to compensate for the voltage or power fluctuation due to target reflectivity as well as to offset for the gain in the measurement chain.