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# Improving the performance of FBG sensing system

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# IMPROVING THE PERFORMANCE OF FBG SENSING SYSTEM

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## CERTIFICATION

I, Xingyuan Xu, declare that this thesis, submitted in partial fulfillment of the requirements for the award of Master of Engineering Research, in the School of Electrical, Computer & Telecommunications Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not be submitted for qualifications at any other academic institution.

Xingyuan Xu

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# TABLE OF CONTENT

LIST OF FITURE……VI

ABSTRACT……IX

ACKNOWLEDGEMENT……XI

LIST OF PUBLICATION ……XII

**CHAPTER 1 INTRODUCTION ..... 1**

1.1 General Introduction ..... 2

1.1.1 Fiber Bragg grating ..... 2

1.1.2 FBG applications in sensing field ..... 2

1.1.3 Aims of the thesis work ..... 3

1.2 Literature Review ..... 3

1.2.1 Introduction ..... 3

1.2.2 Fundamental of FBG ..... 3

1.2.2.1 Grating fabrication ..... 4

1.2.2.2 Properties of FBG ..... 5

1.2.2.3 Types of fiber Bragg grating ..... 7

1.2.3 Fiber Bragg grating sensor ..... 12

1.2.3.1 Bragg grating point sensor ..... 12

1.2.3.2 Chirped Bragg grating sensor ..... 13

1.2.3.3 Bragg grating laser sensor ..... 15

1.2.3.4 Applications of FBG sensors ..... 15

1.2.4 Demodulation technique of optical sensing system..... 17

1.2.4.1 Reference filter demodulation .....17

1.2.4.2 Ratiometric demodulation .....18

1.2.4.3 Interferometric demodulation .....20

1.2.4.4 Fabry-Perot filter demodulation .....21

1.2.5 Multiplexing techniques..... 21

1.2.5.1 Wavelength division-multiplexed (WDM) systems.....22

1.2.5.2 Time-division-multiplexed (TDM) systems .....23

1.2.5.3 Intensity and wavelength division multiplexing.....24

1.2.5.4 The Combination of TDM and WDM.....25

1.3 Existing Issues..... 26

1.4 Contributions of The Thesis Work..... 28

1.5 Organization of thesis..... 29

1.6 Conclusions..... 30

**CHAPTER 2 FBG SENSING SYSTEM FOR DYNAMIC STRAIN MEASUREMENT……....31**

2.1 Introduction..... 31

2.2 FBG Wavelength Determination Using FP Tunable Filter: A Review……...32

2.3 A Novel Demodulation Technique Based On FP Tunable Filter..... 36

2.3.1 Selection of reference Bragg wavelength..... 38

2.3.2 Selection of reference operation point ..... 38

2.3.3 Multipoint measurement using multiplexed FBG sensors ..... 41

2.4 System Implementation and Experimental Results ..... 43

2.4.1 System setup ..... 43

2.4.2 Vibration measurement by single FBG sensor ..... 44

2.4.3 Multipoint vibration measurement using multiplexed FBG sensors ..... 47

2.4.3.1 Response of system output to step driving voltage.....48

2.4.3.2 Signal separation and adjustment for addressing accurate vibration information .....50

2.4.3.2 Processing result of the measured vibration signals .....52

2.5 Conclusions ..... 54

**CHAPTER 3 SIGNAL PROCESSING METHODS FOR IMPROVING MEASUREMENT PRECISION OF FBG SENSING SYSTEM .....56**

3.1 Introduction ..... 56

3.2 System Model ..... 57

3.2.1 Principle of FBG sensing system using tunable laser source ..... 57

3.2.2 Signal model for simulations ..... 59

3.3 Improving the Measurement Precision Using Classical Digital Filters ..... 59

3.4 Improving the Measurement Precision Using Adaptive Filters ..... 63

3.4.1 Principles of operation ..... 63

3.4.2 Implementation of adaptive filter ..... 67

3.4.3 Simulations ..... 67

3.5 Noise Cancellation Using Back Propagation Neural Network ..... 70

3.5.1 Principles of operation ..... 70

3.5.2 Implementation of BP neural network ..... 73

3.5.3 Simulations ..... 73

3.6 Conclusions ..... 77

**CHAPTER 4 IMPROVING THE PERFORMANCE OF IWDM-BASED FBGS SENSING SYTEMS……...78**

4.1 Introduction ..... 78

4.2 System Model ..... 79

4.3 Improving the Performance of IWDM-Based FBG Sensing Systems Using Gradient Optimization Algorithm……...81

4.3.1 Principles of operation ..... 81

4.3.2 Simulations ..... 83

4.3.3 Discussion ..... 85

4.4 Improving the Performance of IWDM-Based FBG Sensing System Using Tabu Search Algorithm……...86

4.4.1 Principles of tabu search ..... 86

4.4.2 Implementation of TS for optimizing MVS technique ..... 89

4.4.3 Simulations ..... 90

4.5 Improving the Performance of IWDM-based FBG Sensing System using tabu–gradient Optimization algorithm.....93

4.5.1 Principles of operation ..... 93

4.5.2 Simulations ..... 95

4.6 Conclusions ..... 97

**CHAPTER 5 CONCLUSIONS AND FUTURE WORK…….98**

5.1 Conclusions ..... 98

5.2 Suggestions for Future Research Work ..... 99

**REFERENCES……..101**

**APPENDIX-Program Codes ..... 107**

# LIST OF FIGURES

Figure 1.1 Properties of the uniform Bragg Grating……..5

Figure 1.2 Filter arranged in a Michelson type configuration……8

Figure 1.3 (a) Chirped grating with an aperiodic pitch……..9

(b) A cascade of several grating with increasing period

Figure 1.4 Linear chirped Bragg grating……9

Figure1.5 Blazed fiber Bragg grating……...10

Figure 1.6 Reference filter demodulation (Zhang, 2004)…….18

Figure 1.7 Ratio metric Demodulation (Zhang, 2004)…….19

Figure 1.8 Interferometric demodulation system for FBG sensor……....20

Figure 1.9 Tunable FP filter demodulation……..…….21

Figure 1.10 Wavelength-division Multiplexing……...22

Figure 1.11 WDM/TDM addressing topologies for FBG arrays. (Kersey, 1997)……26

(a) Serial system with lower festivity gratings

(b)Parallel network

(c) Branching network

Figure 2.1 Typical FP filter based sensing system……...33

Figure 2.2 Working principle of FP tunable filter……34

Figure 2.3 Output voltages change versus $\Delta\lambda_B$ when $\lambda_S$ is set to a reference

point $\lambda_C$ …… ……37

Figure 2.4 spectral curves of multiplexed FBG sensors……...42

Figure 2.5 The flow chart of the measurement scheme for multiplexed sensors…….43

Figure 2.6 Schematic diagram of FBG vibration detection system…….44

Figure 2.7 The output voltages of FP tunable filter during the scanning process for two FBG sensors……45

Figure 2.8 Output voltage obtained at different reference driving voltage……..46

(a) 1.20 volt (b) 1.22 volt (c) 1.24 volt (d) 1.26 volt

Figure 2.9 Output voltages of FP tunable filter for two FBG sensors……..48

Figure 2.10 The step response of FP tunable filte……49

(a) Driving voltage (b) Desired output voltage (c) Actual output voltage

Figure 2.11 The process of setting the FP tunable filter to the reference point……49

Figure 2.12 Output of the FP tunable filter including fast time varying vibration and low frequency DC offset……..50

Figure 2.13 Filtered output signal……51

(a) DC component and (b) AC component

Figure 2.14 A section of driving voltages signal using curve-fitting method……54

Figure 3.1 System diagram (Jin, 1998)……58

Figure 3.2 Spectrum of the combined signal……60

Figure 3.3 Frequency spectrum of the combined signal……..……61

Figure 3.5 Frequency spectrum of the combined signal $n\Delta L$ =7 cm……62

Figure 3.6 Block diagram of adaptive filter…….64

Figure 3.7 Structure of adaptive filter (Haykin, 1986)……64

Figure 3.8 Input signal (a) and desire signal (b) for adaptive filtering……68

Figure 3.9 Filtered signal by LMS additive filter……69

Figure 3.10 Learning Curves for five algorithms…….……69

(a)NLMS-OCF, (b) APA, (c) NDR-LMS, (d)NLMS and (e) LMS

Figure 3.11 Structure of BP neural networks……...…70

Figure 3.12 A pair of data used to train the network……74

Figure 3.13 Input and output from the well-trained network……..….75

Figure 3.14 Measurement errors versus optical path difference $n\Delta L$ of the noise signal ……76

Figure 3.15 Measurement errors versus optical path difference $n\Delta L$ of the noise signal……...76

Figure 4.1 System diagram……...79

Figure 4.2 Measured and original spectrums for two FBG sensors…….83

Figure 4.3 learning curve of $J_1 + J_2$……...84

Figure 4.4 Flowchart of a standard Tabu Search…….87

Figure 4.6 The reason that TS may miss a close global minimum Bragg wavelength……..93

Figure 4.7: Flowchart of tabu-gradient search…….95

Figure 4.8 Bragg wavelength detection error for FBG1 (upper diagram) and FBG2 (lower diagram) using TG algorithm……..96

# ABSTRACT

The Fiber Bragg Grating (FBG) is a periodic perturbation of the refractive index inside the fiber formed by exposure of the fiber core to an intense optical interference pattern. The most important property of FBG is that it will reflect the incident light with particularly predetermined wavelengths, while passing all the other wavelengths of light at the same time. As the wavelength of the reflected light varies with the strain, temperature and other environmental factors, detection of the wavelength will yield information about these quantities. Recently, FBG has attracted much research and development effort due to their potential enormous potential of strain and temperature sensing in smart structures and polymeric materials, thereby several FBG sensing systems have been developed.

This research aims to develop new approaches to improve the performance of FBG sensing system. Firstly, we have demonstrated a novel demodulation system based on wavelength-multiplexed FBG sensors and the Fabry-Perot (FP) tunable filter for measurement of vibration/dynamic strain. By using such a system, the restricted scanning frequency of FP tunable filter is overcome. Furthermore, signal processing methods are proposed to achieve more reliable and accurate measurement. In the experiment, program controlled multipoint dynamic strain detection is successfully implemented by this system. The second task involved in this research work is to develop signal processing methods for improving the measurement precision of FBG sensing system. In practical applications, various types of noise will occur that significantly limit the accuracy of wavelength detection. Therefore, proper signal processing method is required, especially for long-term applications. In this thesis, classical digital filter, adaptive digital filter and neural network were investigated to solve this problem.

The last issue of this thesis is to improve the performance of the FBG sensing system

which using intensity and wavelength-division multiplexing (IWDM) technique. IWDM technique has the advantages of low complexity and enabling the system to contain twice the number of FBGs as the conventional WDM technique. However, this technique requires long processing times to get high detection accuracy. In this chapter, three optimization algorithms: gradient algorithm, tabu search algorithm and tabu-gradient algorithm are developed to improve the performance of IWDM based FBG sensing system.

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# LIST OF PUBLICATION

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