Ain Shams University
Faculty of Engineering
Engineering Physics and Mathematics Department

Signal Processing for Microscale Optical Spectrometers

A Thesis
Submitted in partial fulfillment of the requirements of a Master of Science degree in Engineering Mathematics

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Statement

This thesis is submitted as partial fulfillment of M.Sc. degree in Engineering Mathematics, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or qualification at any other scientific entity.

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Curriculum Vitae

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Islam Samir
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THESIS SUMMARY

This thesis aims to use the MEMS spectrometers and enhance the resolution of these spectrometers, but the resolution of these spectrometers is limited, as higher spectral resolution requires increasing the maximum optical path difference, which depends on the maximum displacement of the scanning mirror. The maximum displacement in miniaturized spectrometers is limited and; consequently the resolution. Our objectives in this thesis are divided into two directions. Firstly, is to propose and implement a transformation algorithm to get a proper spectrum using the compact architecture of the cascaded Fabry-Perot FTIR spectrometer. This is to make use of the merit of having smaller size and simple manufacturing process. The second direction is to investigate the use of signal processing algorithms of AR model to enhance the resolution of the FTIR spectrometers without increasing the size of the FT-IR spectrometer and apply this extrapolation model to enhance the resolution of practical measurements.

The thesis is organized into five chapters as listed below:

Chapter 1: Brief introduction of the objective, contributions and thesis outlines are introduced.

Chapter 2: MEMS FT-IR spectrometer is studied, and Literature review on resolution enhancement techniques and also literature survey on different types of integral equations and the different analytical and numerical methods for solving these equations are presented.

Chapter 3: The architecture of the cascaded FPI is described, and then a mathematical algorithm is derived to find the spectrum from the interferogram. The accuracy of the algorithm is examined by calculating the error between the original spectrum and the reconstructed spectrum. The practicality of the algorithm is tested by adding noise to the spectrum. The reconstruction resolution is extracted. Then a numerical solution based on the trapezoidal method is implemented and compared to the proposed algorithm.

Chapter 4: The super resolution technique of the Auto-regressive (AR) is used to enhance the resolution of the MEMS FTIR spectrometer based on the Michelson interferometer. A theoretical investigation on the capabilities and limitation of the AR algorithm is conducted. Finally, the model is applied to enhance the resolution of practical measurements.

Chapter 5: The thesis work is concluded, and future work suggestions are proposed.

Key words:

Fabry-Perot interferometer, Micro-electro-mechanical systems (MEMS) technology, Autoregressive (AR) model, Fourier transforms spectroscopy, Cascaded Fabry-Perot interferometer, Resolution enhancement.

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