UNIVERSIDAD DE LOS ANDES

SENIOR PROJECT REPORT

Infrared Spectrophotometry using thermal cameras for microfluidic systems

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For the Title of Bachelor in
Electronic Engineering

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Summary

Objectives:

General Objective:

- Calibrate and implement a device capable of taking temperature measurements through time using video-like characteristics and infrared cameras for microfluidic systems.

Specific Objectives:

- Analyze and characterize the thermal cameras for microfluidic systems in the new environment.
- Design a data acquisition system that allows for proper data manipulation of the temperature measurements.
- Implement a calibration system that allows the user to observe correct measurements in the proposed microfluidic systems.

Expected Results:

The expected results should consist of a device capable of interfacing with a program that allows for the recollection of data. The device is to use the AMG8833 thermal sensor for the temperature data acquisition along with a RaspBerry Pi 3 as its processor as a reference for improvement. This reference is based on Brayan Ariza's Senior Proyect: Thermal Camera for Microfluidic Systems, which shows the information in an LED screen making the design an embedded system. The major improvement should be the ability to record and interact with the temperature data through video like mechanics, which allow to view the temperature matrix throughout the sensing process. The process is to include a standardized model for calibration, which is to allow for the correct replication of the device.

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Introduction

The proposed work consists on the implementation of a device that facilitates the observation of thermal reactions in a microfluidic system with infrared sensors. Often spectrophotometers are used to obtain information about the absorbance of a fluid by using the intensity of the light that passes though it; this process is done by using the visible spectrum. This is done in the fields of physics, molecular biology, chemistry and biochemistry, where microfluidic systems tend to be used [1]. Microfluidic systems use lithographic techniques to manipulate small quantities of fluids, this can allow to observe chemical reactions in a controlled environment [2]. This project's purpose focuses on the calibration and replication of the thermal sensors to accurately observe the reactions that can be seen in such systems.

Justification

A temperature sensor that gathers information in microfluidic systems is very important as it shows the behavior of the fluids in a simulated environment. As previously discussed, some uses of microfluidic systems include molecular biology, which often happens at tens of micrometers, so understanding the chemical reactions without interfering with the reaction itself is a very important advance [2]. However, the replication and proper calibration of the device to obtain accurate information, is just as important, as it will not only allow proper sensing, but it will allow replication of the calibrated device. Data manipulation is also important, as with it one can find exactly at which time the reaction happened, and in the easiest format for further data analysis.

Theoretical-Framework

Spectrophotometry:

A method used to measure the transmission or reflection of visible light to find out the absorbance of a fluid [1]. This is done using Beer-Lambert's Law, $A = \mathcal{E}lc$, where A is the absorbance of the fluid [%], $\mathcal{E}$ is the molar extinction coefficient, l is the length of the path light travels to the sample [cm] and c the concentration of the fluid [mol] [3].

The infrared spectrum

A type of electromagnetic waves not visible to human eyes, that can be expressed as heat. These waves have frequencies between 300 GHz and 430THz, which makes their wavelengths between 700 nanometers and about 1mm [4].

Microfluidic systems

Systems that implement fluid manipulation in channels with diameters of tens of micrometers. Often used to simulate environments from fields such as chemistry, physics, biology and molecular biology [2].

Previous Works

This project is based on Brayan Ariza's Senior Proyect, which delivered a functional prototype capable of sensing temperature through infrared sensors and showing it in a 30x30 thermal map by using 2D interpolation. The device also allows for limited data processing in the form of an Excel file and allows to change the thermal map shown to include or not include the interpolation method. The methods often used for thermal sensing in fluids have included processes like the Seebeck effect, which is the process through which a material with different temperatures at two different junctions creates a difference of voltage and measuring material resistance through temperature changes [5].

The device is based on spectrophotometry applied to microfluidic systems, which often lacks the capacity to sense temperature while doing the visible spectrum sweep. However, spectrophotometers that apply infrared sweeps for larger scales of samples can be found in the market, such as those from LabCompare [6]. Therefore, there is a need to observe thermal reactions at a microscopic level.

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Methodology

This project's methodology starts with the analysis and understanding of the previous project. This will include the sensors used and the software development as well as the code used for the device's processing. After understanding how the device and all its components work, the new software development will be implemented. This will include the new video characteristics and the format settings for data manipulation. Electronic improvements will also be considered during this phase. The project's current major electronic components are the AMG8833 thermal camera and the RaspBerry Pi 3, for which better performance alternatives can be looked for.

Then the calibration and characterization processes will take place. In the previous project a calibration process was performed, however it was not standardized to accurately replicate the device. Thus, this will be the focus of this project. After which, an analysis and evaluation of the calibration will be presented as well as its overall performance for microfluidic systems.

Schedule

Proyecto de Grado

Juan Velasquez - Espectrofotometria infrarroja usando camaras termicas para sistemas microfluidicos

Duración del plan

PERIODOS 1 2 3 4 5 6 7 8 9 10 11 12 13 14

ACTIVIDAD	INICIO DEL PLAN	DURACIÓN DEL PLAN	PORCENTAJE COMPLETADO
Familiarización y analisis del sistema	1	2	0%
Evaluacion de software a implementar	2	2	0%
Implementacion del software	3	3	0%
Evaluacion del software	4	3	0%
Analisis de experimentos para calibracion	5	2	0%
Calibracion del dispositivo	6	3	0%
Evaluacion de la calibracion del dispositivo	7	4	0%
Pruebas despues de calibracion	9	2	0%
Modificaciones finales	10	2	0%
Pruebas finales	11	2	0%
Caracterizacion del dispositivo	12	2	0%
Consideraciones finales y concluciones	14	1	0%

References

[1] https://www.biocompare.com/Lab-Equipment/6531-Spectrophotometry/
[2] https://www.sciencedirect.com/topics/materials-science/microfluidics
[3] https://www.britannica.com/science/Beers-law
[4] https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Spectrpy/InfraRed/infrared.htm
[5] https://www.britannica.com/science/Seebeck-effect
[6] https://www.labcompare.com/Spectroscopy/116-Infrared-Spectrophotometer-IR-FTIR-Spectrometer/