A mobile application that uses fiber optics to test the polarimetry of various substances

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INTRODUCTION

The accuracy in measuring the concentration of substances in solutions is crucial in numerous scientific and industrial fields. Traditional methods such as spectroscopy, chromatography, and reflectometry can be costly, complex, and time-consuming. In this context, the study of optical properties, such as light polarization, offers a promising alternative. Substances like sugar can rotate the plane of light polarization, a phenomenon known as optical activity, which can be correlated with its concentration in a solution.

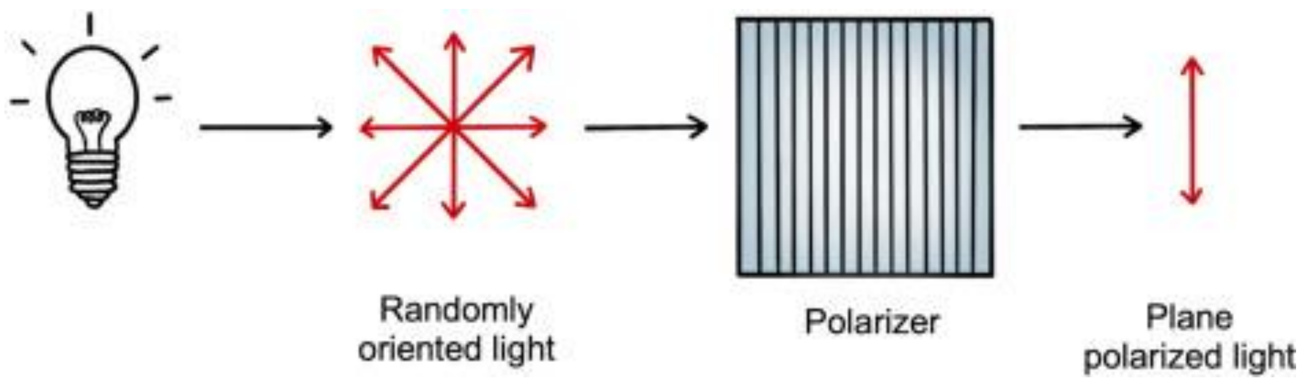

Fig. 1 Functioning of a polarizer

GOALS

- Evaluate the effectiveness of light polarization as a tool to measure the concentration of sugar in aqueous solutions.
- Develop a mobile application that automates the measurement process and facilitates data visualization.
- Implement an algorithm to predict the concentration of sugar in different solutions based on previous measurement data.
- Analyze the differences in polarization between standard sugar, refined sugar, and brown sugar.

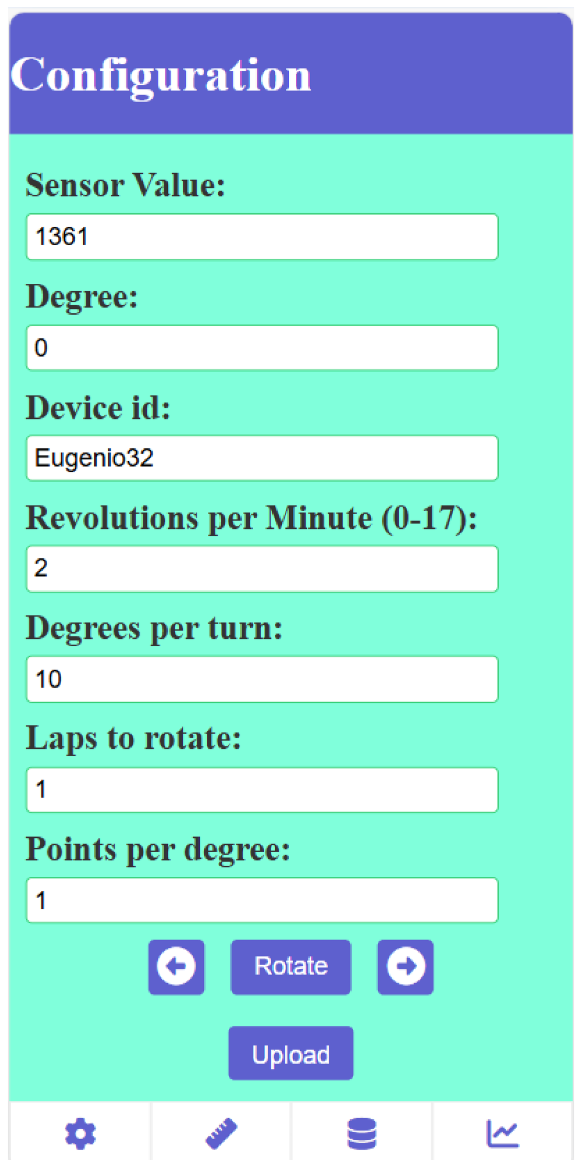

Fig. 2 Configuration Module with standard setup.

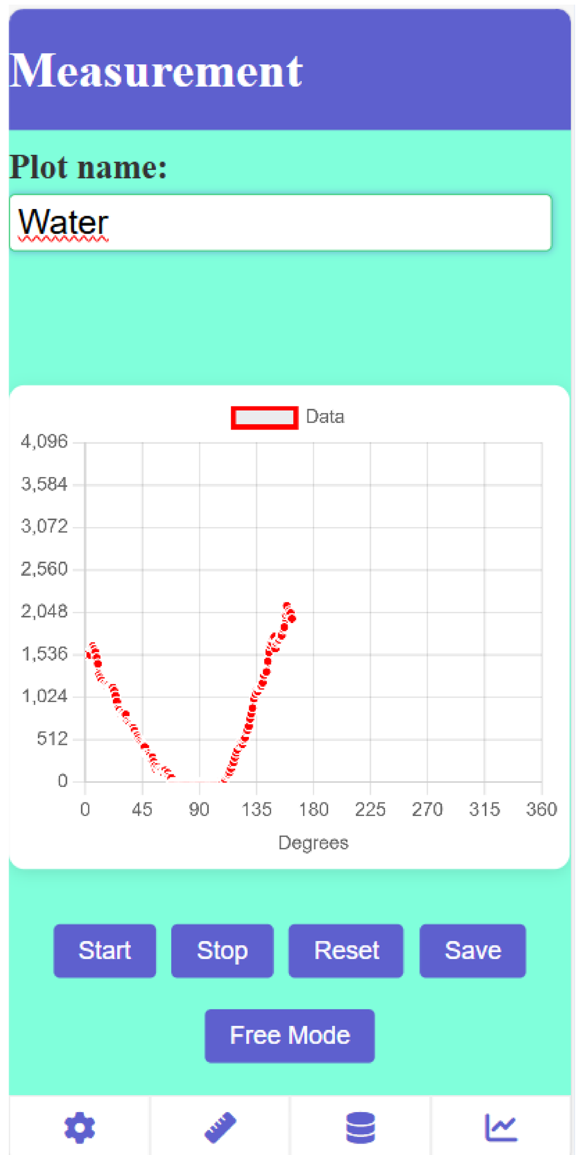

Fig. 3 Measurement Module getting real time data.

METHODS

The experiment utilized a 633 nm laser, two polarizers, a container for the solutions, a stepper motor controlled by an ESP32, a light condenser, a photodiode, and data analysis software, along with samples of water, standard sugar, refined sugar, and brown sugar.

The process began with the laser emitting a beam of light that passed through the first polarizer. This beam then traveled through the container filled with solutions of varying sugar concentrations (40%, 50%, 60%, 70%), starting with distilled water as the reference. Next, the beam passed through the second polarizer, which rotated degree by degree, controlled by the stepper motor and ESP32. Finally, the beam reached the light condenser and the photodiode, which recorded the light intensity for each degree of rotation of the analyzer.

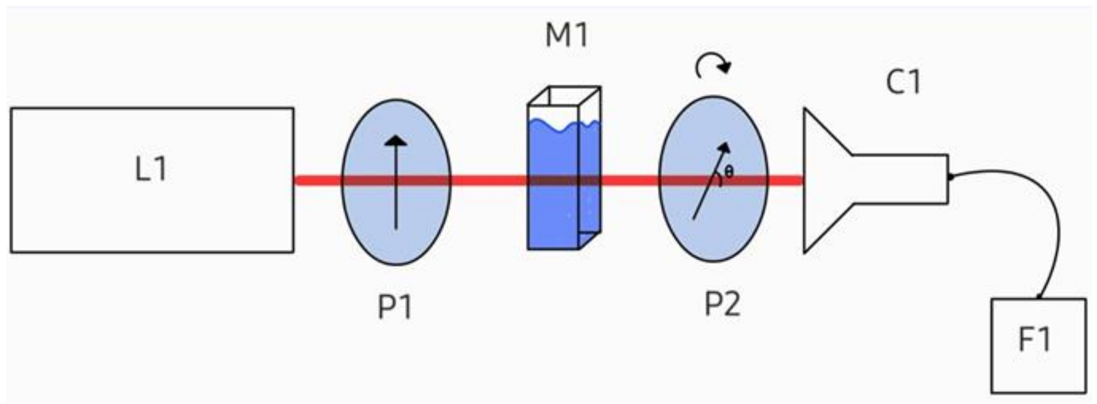

Fig. 4 Experimental Setup. L1: 633 nm Laser, P1: Polarizer, M1: Sample Container, P2: Polarizer/Analyzer, C1: Light Collector, F1: Photodiode

The ESP32 sends the data to a server using IoT and Cloud technology, ultimately reaching the mobile device, where the measurements can be visualized in real time.

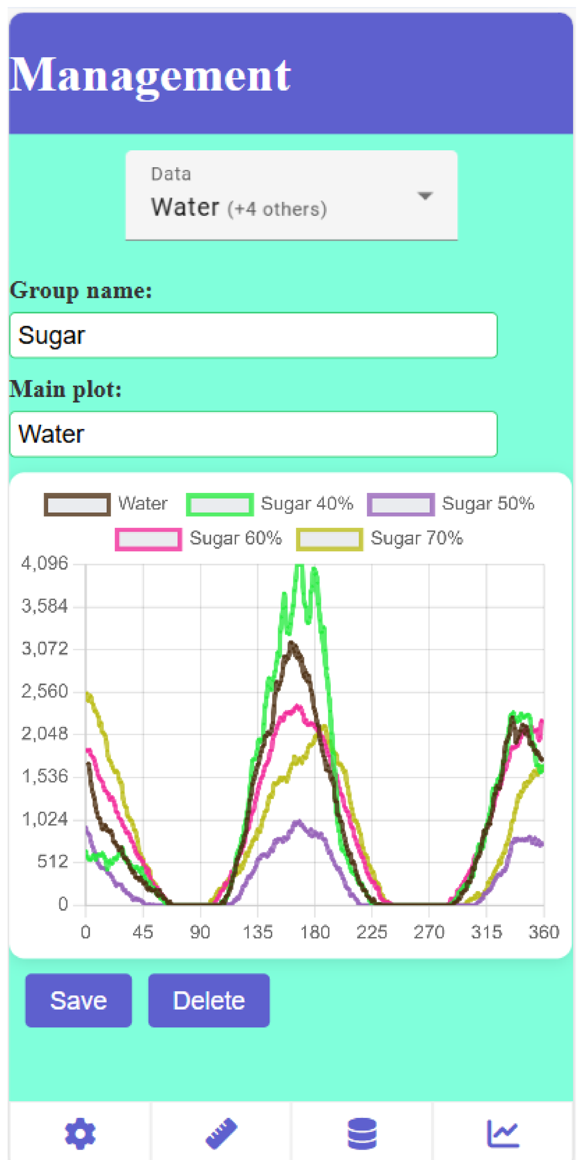

Fig. 5 Management Module grouping standard sugar plots.

Fig. 6 Visualization Module with fitted plots

RESULTS

- **Standard Sugar:** Directly proportional correlation between the sugar concentration and the phase shift relative to the reference (distilled water). The average values obtained were slightly lower than those predicted by theory.
- **Brown Sugar**: Greater variability among data of the same concentration, with a slight positive correlation but no conclusive results.
- **Refined Sugar:** High repeatability among data of the same concentration, with a positive correlation similar to that of standard sugar.

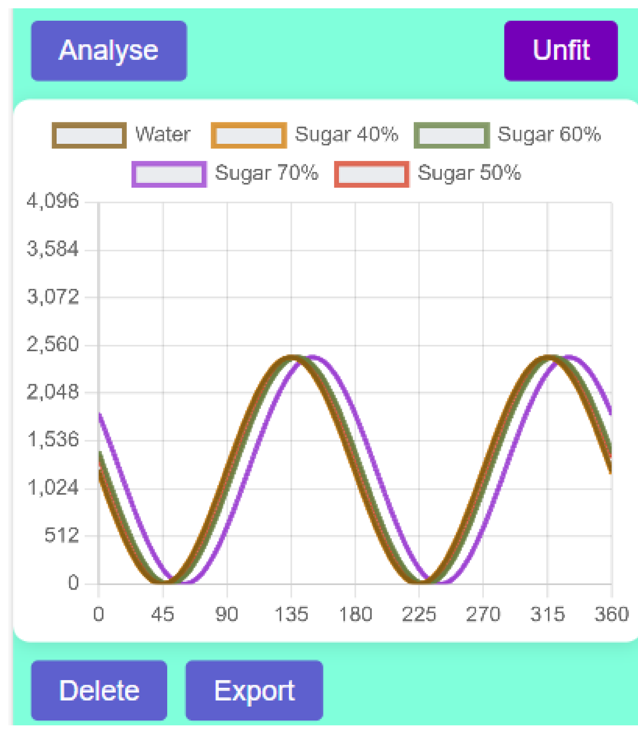

Fig. 7 Visualization Module with normalized plots

Name	Function	α	Class
Water	-1216.498sin(2x+0.000) +1216.498	0	-
Sugar 40%	-1216.498sin(2x+0.023) +1216.498	1.307	40%
Sugar 60%	-1216.498sin(2x-0.165) +1216.498	9.442	60%
Sugar 70%	-1216.498sin(2x-0.522) +1216.498	29.884	70%
Sugar 50%	-1216.498sin(2x-0.125) +1216.498	7.148	50%

Fig. 8 Standard Sugar Results Table

CONCLUSIONS

- A software was developed that accurately measured over 60 time series, allowing for automatic adjustment of the experimental design and efficient data analysis.
- A tool was successfully created to predict the concentration of sugar in aqueous solutions with an accuracy of 75% over the 4 different concentrations.
- Repeatability between measurements of the same sample was achieved, with a standard deviation of 1.36 degrees.
- A relationship was observed between data repeatability and the purity percentage of the sugar, with less reliable results in solutions of less pure sugar, such as brown sugar.

REFERENCES

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2. Orlandi, R. D. M., Verruma-Bernardi, M. R., Sartorio, S. D., & Borges, M. T. M. R. (2017). Journal of Agricultural Science, 9(2), 115-126. doi:10.5539/jas.v9n2p115.