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ANALYSIS OF MOISTURE CONTENT OF THE SAMPLE UNDER STUDY USING NIRS

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Abstract

Objective: The Objective of this research was to detect moisture content of the samples undertaken for study which on later can be tested with the human subjects to detect the fluid inside sinus cavities. This article refreshes the fundamental properties of NIRS and detects moisture content of vegetables with the help of prototype developed.

Methods: Near Infrared, NIR-LED is a high temperature GaAlAa IR emitter, OD-850WHT specified by an Optodiode corporation. The sensor operates at a wavelength of 850nm and the features of NIRS make it applicable for IR detection. Prototype hardware developed to detect the moisture content of the vegetables like potato and tomato and the outputs obtained through serial chart gives a visual display. Outputs recorded with the help of sigview software and the spectral responses performed to differentiate dry and wet vegetables.

Results: The visual display obtained from the serial chart clearly identifies the dry, wet potato and tomato. The spectral response shows high spectral components for juicy tomato as the fluid/ moisture content is more when compared to potato. The signal diffused inside the gall bladder also recorded in both empty as well as with water and sugar solution. The variations in the readings were observed for empty, 1ml, 3ml and full water and sugar solution. It is identified that the delay is more when the gallbladder is completely filled with sugar solution than with the water as the signal diffuses in less amount with the sugar solution.

Conclusion: Signal penetration is more with an empty gall bladder than with completely filled fluid. The viscosity of the solution further rejects the transmission of the optical signal inside the object. Thus the sample filled with water alone makes more diffusion of the optical signal within the object than with the sugar solution which is highly viscous. This encourages us to implement the same hardware to identify normal and sinusitis patients in future.

Keywords:

NIRS, Sensors, IR detection, penetration, moisture, serial chart, spectral response

Introduction:

Recent researches pave a new way in the field of optics to utilize an optical sensor for biomedical challenges. Near Infrared (NIR) [1] sensor, introduced by Herschel recently gained its attention in various fields. It uses light in the NIR spectrum ranging from 750 to 1400nm. It has attractive features like poor absorption by water and hemoglobin, which allows deep penetration inside tissues. It also works like an optical window [2] with great penetration and reflection from deeper tissues.

These features make it applicable in detecting the fluid/moisture [3] content inside an object. Scattering reduces [4] by increasing the wavelength, and the reflection varies with the light incidence on the surface of the object. NIRS offers high spatial [5] and temporal resolution. NIRS can easily differentiate air-filled and fluid/tissue-filled spaces [6] with the help of their signal penetration patterns. The signal gets reflected more quickly from the air-filled space than the fluid-filled space.

The fluid accumulation absorbs more light than transmitting it. This feature plays a key role in this work to detect the fluid level inside an object. Thus this work serves as a preliminary evaluation in diagnosing the moisture [7] content of the object by analyzing the vegetables/fruits [8] and with the gall bladder. As the water content is 94% in tomato and 79% in potato, it is considered as a sample for study.

NIR LED sensor is used to detect the moisture content within an object, and compared with the results obtained using gall bladder. It detects the fluid level with the help of a serial chart, and spectral responses also obtained to compare the results. NIRS can also be used to diagnose sinusitis by observing the reflected signal from the cavities. Further research carried out to make a diagnosis of sinusitis with the help of this cost effective, bedside monitoring device. The NIRS, currently used to detect sinusitis [9] in frontal [10][11] and maxillary [12] cavities. Thus the prototype reduces the radiological effects [13] of the various imaging modalities, and serves beneficiary to the entire society.

Materials and Methods

NIRS System uses a setup for detecting the fluid content inside an object. Prototype hardware developed to monitor the moisture/fluid inside vegetables, and also tested with the gallbladder. The hardware consists of an NIR LED probe and an interfacing card to the system. Near Infrared, NIR-LED is a high temperature GaAlAa IR emitter, OD-850WHT specified by an Optodiode corporation. The sensor operates at a wavelength of 850nm and the features of NIRS make it applicable for IR detection. NIR LED operates with a source and a detector properly shielded. LEDs selected by their cost effectiveness and high penetration capability. The block diagram of the proposed system is shown in the fig. 1. The sampled output (8-bit FFT value) obtained from MSP-430, and connected to LCD and communication port. The output obtained using LCD can be visualized using a serial port in the system with the help of a hyper terminal.

The prototype setup is shown in fig.2, used for observing the signal from any object and provided with an NIR LED sensor. The sensor detects the reflected signal.

The detected signal captured for a period of 20sec. It is non-invasive and completely free from radiation. This feature helps in observing signals from anybody. The captured signal interfaced through a USB port to the PC, and the signal is plotted using the serial chart, application software.

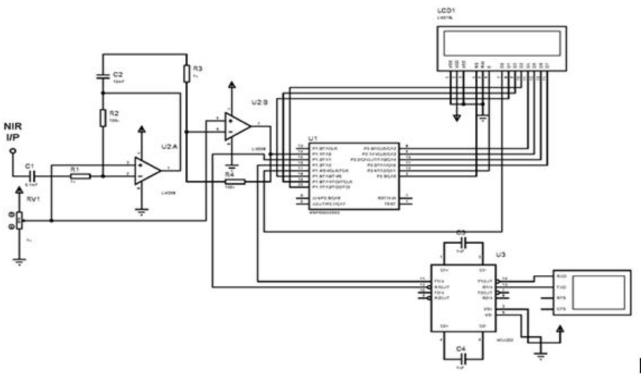

Fig. 1 Block diagram of the prototype.

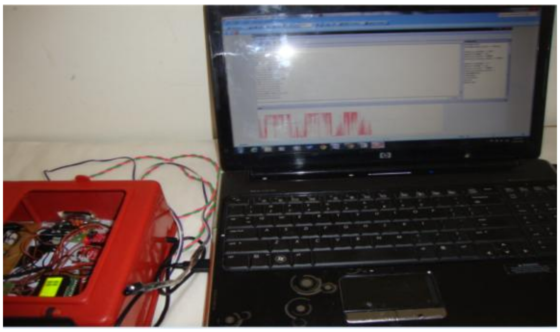

Fig. 2 Prototype of the Hardware interfaced with system.

The output from the microcontroller drawn as input to LCD shown for visual analyses of the output generated for the sample under study.

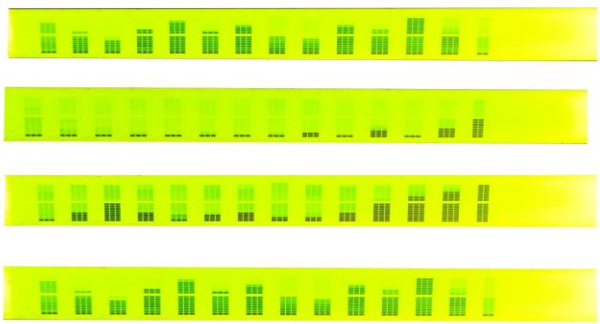

Fig. 3 LCD outputs.

If the object is dry and without fluid, then the signal level will be less and varies sequentially at the same level. The signal increases with the increase in moisture content. Signal level increases for wet potato and increases rapidly for tomato.

The signal detected from the object is processed further to monitor fluid level inside them. The received signal varies with the moisture content, and the output signal fed to the microcontroller.

The values from the communication port viewed using two types of software: Energia and Serial chart.

Energia (fig. 4) is an open source prototype, which uses a serial port monitor to retrieve the digital values of the sample under study. Once the device gets interfaced, dump the program if required or check the com port to retrieve the readings. The received values give a concluded report about the level of water content of the sample under study. However, it is very hard to see the digital values each time to know the moisture content of the object. So a graphical analysis is required to assess easily, which is made possible using a serial chart.

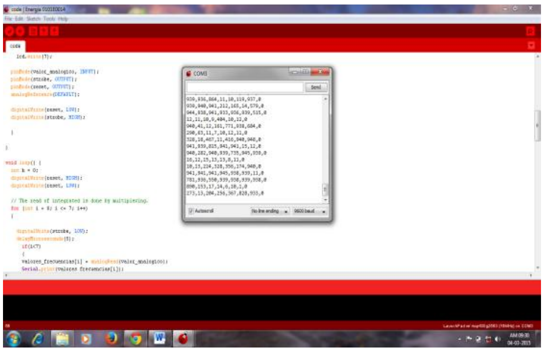

Fig. 4 Energia output of the sample

The serial chart not only helps us to analyze the sample, but it also pertains to study the optical properties in an intense manner using graphical analysis. Each field monitored to determine the best way for final description of the data

Sigview, a time analysis application for real signals is used to capture the signal and spectral response obtained to validate the output from the serial chart. Spectral response also shows the moisture level of the object.

Results and discussion

The fluid content inside the cavity can be easily detected using this prototype hardware. Moisture detection tested in preliminary with the vegetables. As diagnosing with human subjects requires a lot of ethical issues to be met, we tested the water content using dry and wet potato and tomato. Samples, cleanly washed in water before starting with the experiment. Later potato is dried in sunlight for nine hours so as to remove the moisture content and cut into 10 slices to test with the hardware. The signals were captured using sigview software with a sound card. NIR rays radiated inside the samples get reflected to the surface after diffusing inside the potato. The detected signal also recorded for 20sec using the serial chart. Fig. 5 shows the serial chart of the dry potato. Similarly sliced potato taken before for testing immersed in water for 10 hours and taken for recording the signal. The Serial chart provides the output of dry and wet potato in the data plane whose variation available in a graphical plot. Fig.6 shows the serial chart of the wet potato. In this, the value in the data plane shows a very high value initially, and later it reduces a very low value, again to a very high value and then to a very low value, and this continues. We have plotted the required field for intense analyses in chart window. The graph initially rises to a very high level and tries to reduce but again returns to the original high level. Thus the moisture content of the wet potato is more, and the signal gets reflected quickly without diffusing inside the object. But this is not the case with the dry potato where the signal gets reflected back from the object after diffusing inside the surface. Thus the graphical plot shows similar variation throughout. The same experiment conducted with a ripe tomato. The values and chart shows, that the fluid content of tomato is high. The graph remains almost at the maximum level indicating the signal gets reflected back at the earliest without diffusing much inside the object shown in fig. 7.

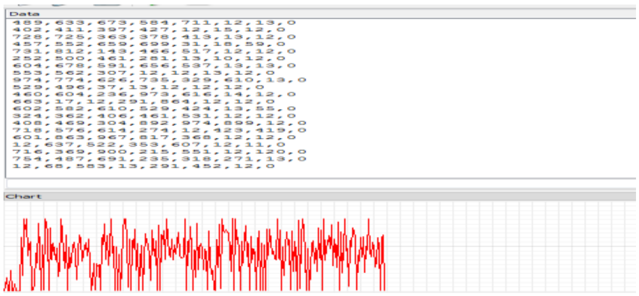

Fig. 5 Serial chart of dry potato.

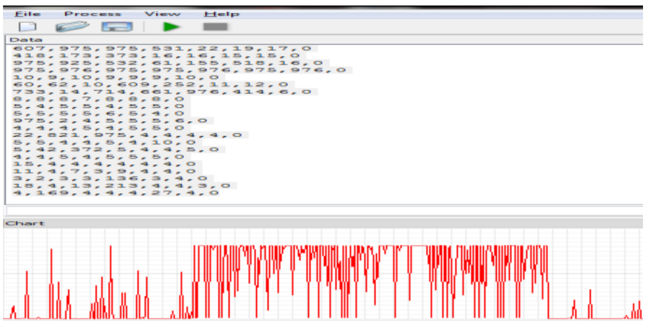

Fig. 6 Serial chart of wet potato.

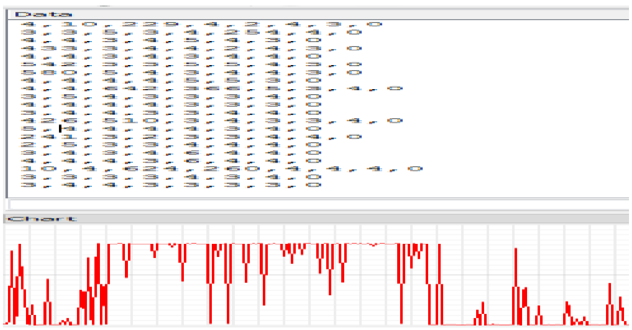

Fig. 7 Serial chart output of tomato.

Peak signal also captured using sigview software to perform spectral analysis. Fig. 8,9,10 shows the spectral response of the dry, wet potato and tomato. In Fig.10, the output shows strong magnitude spectral components for tomato when compared to wet and dry potato.

High spectral components specify that the tomato is fully filled with fluid. Thus in future, the prototype can be used to test the fluid inside the cavities in an easy manner.

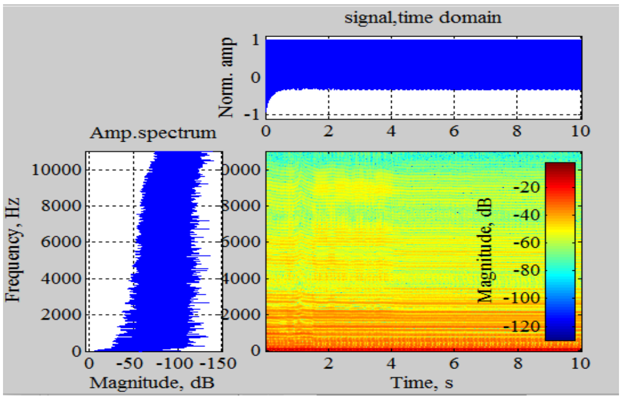

Fig.8 Spectral response of dry potato.

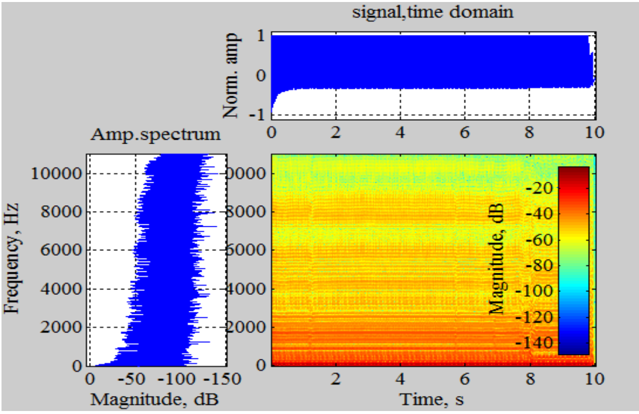

Fig..9: Spectral response of wet potato.

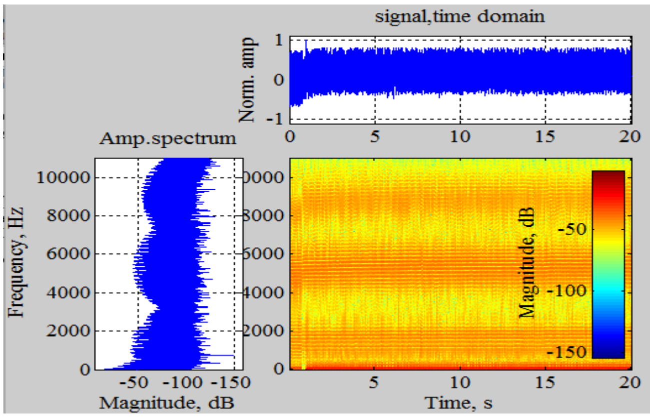

Fig. 10: Spectral response of tomato.

The moisture content identifed also using gallbladder. The gallbladder is extensively used in research to standardize the medical results. The sensor detects the signal from the gall bladder. The signals from the gallbladder recorded with bile, empty and filled with water gradually till it becomes full.

Signals detected through the communication port and viewed using the serial chart. For convenience, the values were tabulated (No.1) to understand the concept easily.

Table 1: Serial chart output of gall bladder

Empty	1 ml water	1 ml sugar soln.	3 ml water	3 ml sugar solution	Full water	Full sugar solution
978	508	623	980	12	977	964
969	976	9	12	8	9	6
957	254	11	10	11	7	3
934	976	6	11	10	9	7
936	556	8	828	9	7	9
318	978	11	979	892	976	12
953	659	267	978	9	161	14
967	942	733	979	58	9	13
954	341	966	529	10	9	9
857	465	979	602	10	5	9
932	693	799	14	16	9	954
955	164	978	14	7	9	9
965	687	829	638	10	11	11
987	521	695	978	10	12	11

From the values, it is clear that the empty gall bladder records around the same value indicating perfect reflection from the object. As it is empty, the signal diffuses well inside the gallbladder and reflected showing almost the same reading. At first, readings obtained with 1ml, 3ml and full water, and later the gallbladder is filled with sugar solution of equal quantity and recorded. As the fluid increases, the signal gets reflected back very quickly without passing through the entire bladder. The signal reflects even more earlier from the sugar solution as the solution is highly viscous. It is very clear from the values that the signal remains at the peak value and reduces to a very low value for longer intervel and then returns to a peak value in case of water, which increases further with the sugar solution. Fig. 11 shows that the gallbladder completely filled with sugar solution reaches maximum wavelength quite earlier than after a longer duration than with full quantity of water. The delay is due to the viscosity of the sugar solution which restricts the penetration of the signal inside the object. Thus the signal gets reflected back after a long duration. Thus this can be interpreted with the normal person, slightly affected sinus glands and thick mucosa formed inside the gland.

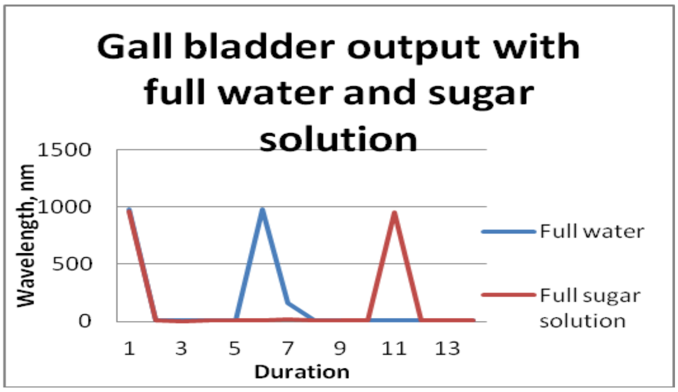

Fig.11 Gall bladder output with full water and sugar solution.

Conclusion

This study illustrates that the Near Infrared LED Sensor can be used to detect the moisture content of an object. Signal penetration is more with an empty gall bladder than with the fluids filled inside. Highly viscous solution further rejects the transmission of the optical signal inside the object. Thus the sample filled with water makes more diffusion of the optical signal within the object than with the sugar solution which is highly viscous. Similarly air filled and fluid-filled cavities of sinusitis patients can be compared. In future, this setup can be utilized to test the patients with normal, lightly affected and with severe infections. Thus it is an initiative to detect moisture content inside the sinus glands in an easy manner

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