LOW COST HYPERSPECTRAL DEVICE SUITABLE FOR MONITORING SENSOR NETWORKS

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1. Introduction

The development of spectrometers oriented to in-situ measurements is increasingly gaining importance due to remarkable advances achieved on spectroradiometric systems technology. Hyperspectrometers, once limited to laboratory, can be used nowadays to carry out field analysis due to its miniaturization and power supply reduction.

These features allow potential applications such as a monitoring sensor network based on optical sensors, to date conditioned by its economical cost and technical limitations.

2. Low-cost hyperspectral device

Microspectrometers as monolithic modules are commercially available and offer the possibility of carrying out the goal of this project: the development of a custom designed hyperspectral device to be used on sensor networks. Boehringer Ingelheim microParts GmbH manufactures this type of microspectrometers, which combines LIGA and CMOS technologies. LIGA is a technique of micro-molding and replication of high-aspect-ratio structures, that offers the possibility of having an optical quality surface. Due to the monolithical design, it is stable in both mechanic and environmental aspects. CMOS photodiodes are an alternative to CCD sensors, with lower consumption, extended spectral range, improved SNR, very small size (54 x 32 x 9.5 mm) and lower cost.

We have developed a control system for this spectrometer aimed at environmental monitoring applications. A Microchip dsPIC microcontroller has been chosen due to its high calculus power on very small dimensions. A reduced size, high autonomy and low cost make it suitable for a wide deployment of devices.

One of the key components is the hyperspectral sensor. It collects the light spectrum by coupling the light through a silica fibre into the centre layer of a three-layer waveguide, which contains a moulded grating (Figure 1). This analog data is conditioned, converted to digital data and gathered by another main component, the dsPIC microcontroller.

The microcontroller fulfils the role of governing the whole system, synchronizing and sending control signals to the sensors, the A/D converters, and the rest of the network. Sampled data can be subjected to signal processing inside the dsPIC with the aim of obtaining a better characterization of the monitored environment. The results of the analysis can be stored on the system, sent to the user, or sent to another node of the network.

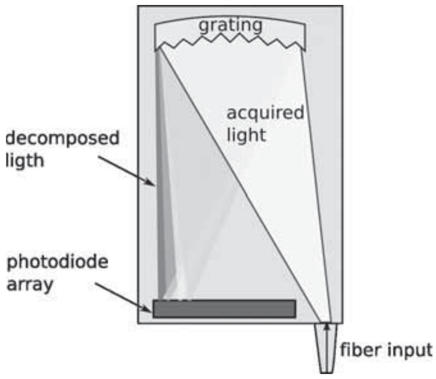

Figure 1. Hyperspectrometer interior view. The grating decomposes the collected light (from 200 nm to 1000 nm) into 256 bands. Each band excites a different photodiode, transforming the light intensity into an electric signal.

2. Testing and Results

In order to show the features of the system, a set of algal culture samples (Rhodomonas sp.) have been characterized. The experiment consisted on sampling several concentrations with a single sensor, and storing the data into a PC. Software to govern and stablish the communication with the sensor has been entirely developed using open source utilities. Thus, it can be easily updated and fitted to other applications. The results can be seen on Figure 2, where the absorption due to chlorophyll can be qualitatively detected. Digital signal processing [1-2] (e.g. derivative analysis) can be performed to obtain extra characteristics of the acquired spectra (Figure 3). The resolution and spectral range of the designed device is appropriate for water characterization applications [3].

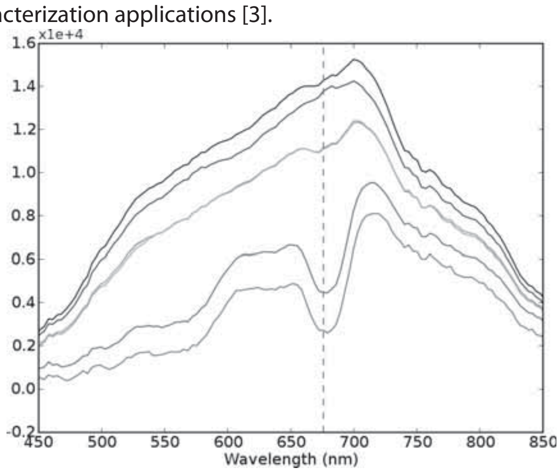

Figure 2. Spectra at different concentration rates of an algal culture sampled with the prototype device. Note the chlorophyll effect at ~680 nm.

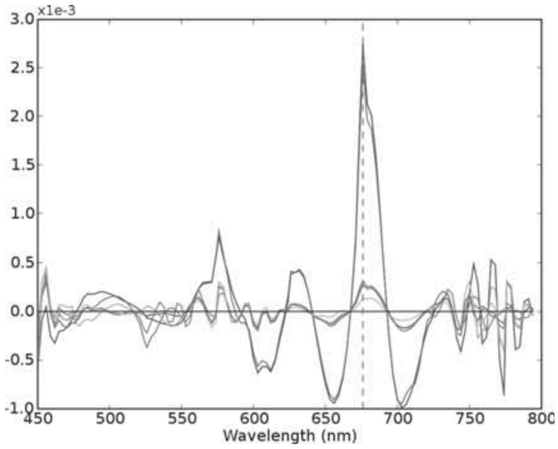

Figure 3. Computed derivative normalized spectra using a mean smoothing filter following F.Tsai and W. Philpot (1998).

3. Conclusions

The developed hyperspectral system is capable of detecting different concentrations of an algal culture. The reduced size and low consumption make it suitable as embedded system to be integrated into more complex systems. Furthermore, its low cost allows the deployment of several devices, resulting on an inexpensive sensor network.

4. Acknowledgments

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5. References

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[3] Torrecilla, E., Aymerich, I. F., Pons, S. and Piera, J. 2007. Effect of spectral resolution in hyperspectral data analysis, IEEE International Geoscience and Remote Sensing Symposium, 23-27 July 2007, submitted for publication.

USING AN EMBEDDED CONTROLLER TO PRE-PROCESS LARGE AMOUNT OF RAW DATA ON A SUBSURFACE INSTRUMENMT FRAME TO ALLOW A REAL TIME TELEMETRY

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At present the Proudman Oceanographic Laboratory has a pilot coastal observatory situated in Liverpool Bay. The aim of the observatory is to understand, through effective continuous measurement and modelling, a coastal sea's response to natural and anthropogenic forcing.

The coastal observatory in part consists of two instrumentation frames which lie on the sea bed at two separate sites. These frames measure various physical characteristics of the sea. Recently it has been shown that it is feasible to transmit data from these subsurface frames back to the POL labs via an acoustic/satellite telemetry system. Unfortunately there is a draw back to the system; the real-time raw data that is output by the various instruments is too large to be transmitted. Only part of the data from one of the instruments is currently transmitted in real time.

This paper shows how a low cost, low power, off-the-shelf embedded controller (the persistor CF2) can be used to pre-process large amounts of raw data. This enables useful data to be telemetered back to POL in near real-time to be displayed on the Coastal Observatory website. Two instruments were used to demonstrate the system, a 600kHz RDI ADCP and a Seabird 16+. Using data output from these instruments the following parameters were calculated and output along with a reduced data set from the instrument, specific wave height, peak period and average wave direction.

DATA ACQUISITION SYSTEM WITH GPRS COMMUNICATIONS

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1. Introduction

This paper presents the implementation of a low cost environmental data acquisition system with the capability of sending the measured data using a high speed link based on the GPRS technology [1]. The equipment is based in low power Digital Signal Processor; this allows develop digital algorithms to preprocces the signal. The system is powered from batteries and solar panels what enable its use at isolated locations. The equipment can be controlled locally using a RS232 channel or remotely using a GPRS link, so it has no built in user interface. The equipment is enclosing in an ABS plastic case with IP65 grade, to work in strong weather environmental.

2. Hardware architecture

The figure 1 shows the overall architecture of the system. The core of the system is a digital signal processor that controls all the peripherals and implements the measurement algorithms and the communication protocols. The processor runs at 150 MHz, and the memory block, which stores the program code and the data, is made of an 8Mb SDRAM and a 4Mb flash memory.

The system includes a class 8 GPRS modem to allow its remote control. It also includes an A/D audio converter and A/D converters for the environmental sensors. A TCP/IP/PPP protocols' stack has been implemented to enable the GPRS communication using TCP and UDP sockets [2][3]. All the software has been implemented using DSP-BIOS [4].

Since the system is intended to work at isolated locations using a solar panel, a low power fixed point TMS320C5501 processor is used in order to optimise power consumption. In a normal operation mode, with low complexity algorithms working in real time and being annexed to the GPRS network, the system consumes 70 mA from the 12 V power supply. When sending data over the GPRS network peaks up to 200 mA are observed.

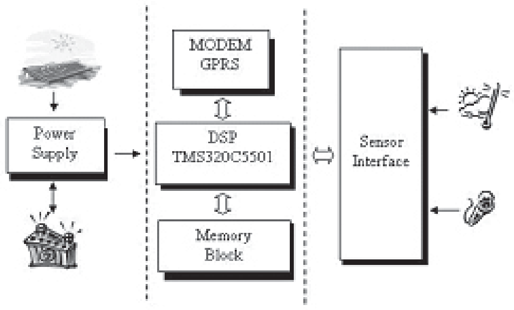

Figure 1. Block Diagram.