Development of Software for Measurement and Analysis of Solar Radiation

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Abstract

This software was under development using LabVIEW to be using with StellarNet spectrometers system with USB communication to computer. LabVIEW have capabilities in hardware interfacing, graphical user interfacing and mathematical calculation including array manipulation and processing. This software read data from StellarNet spectrometer in real-time and then processed for analysis. Several measurement of solar radiation and analysis have been done. Solar radiation involved mainly infra-red, visible light and ultra-violet. With solar radiation spectrum data, information of weather and suitability of plant can be gathered and analyzed. Furthermore, optimization of utilization and safety precaution of solar radiation can be planned. Using this software, more research and development in utilization and safety of solar radiation can be explored.

Key words –

Solar radiation, hardware interfacing, user interface, mathematical calculation, StellarNet spectrometer, LabVIEW

Pembangunan Perisian Pengukuran dan Penganalisa Sinaran Matahari.

Perisian yang sedang dibangunkan ini menggunakan LabVIEW digunakan bersama dengan Sistem Spektrometer StellarNet dengan komunikasi komputer USB. LabVIEW berkebolehan dalam antaramuka perkakasan, antaramuka grafik pennguna dan pengiraan matematik termasuk manipulasi dan pemprosesan jujukan. Perisian ini membaca data dari spektrometer StellarNet dalam masa nyata dan memproses untuk penganalisaan. Beberapa pengukuran sinaran matahari dan penganalisaan telah dibuat. Sinaran matahari yang terlibat terutamanya adalah lampau merah, cahaya boleh lihat dan lampau ungu. Dengan data-data spectrum sinaran matahari, maklumat cuaca dan kesesuaian tanaman boleh dikumpulkan dan dianalisa. Selanjutnya, pengoptimaan penggunaan dan langkah-langkah keselamatan sinaran matahari boleh dirancang. Menggunakan perisian ini, lebih banyak penyelidikan dan pembangunan dalam penggunaan dan keselamatan sinaran matahari boleh diteroka.

INTRODUCTION

Solar as non-ionization radiation is unlimited source of energy for earth forever. Our eye can sense intensity of visible light & our skin can sense heat of solar radiation. In fact, solar radiation consist of infra-red, visible light and ultra-violet as main wavelength. Solar radiation is promising utilization and application in the future, however certainly with safety risk in non- ionization radiation in the form of ultra violet and high intensity of visible light. Solar Irradiance arrives at earth's surface have peak value of 100mW/cm^2 and nominal value of 80mW/cm^2.

A spectrometer is a device to measure light intensity at different wavelengths. The light is diffracted into a spectrum which is detected by a sensor and interpreted into results we can use. The output of a spectrometer is usually a graph of light intensity versus wavelength.

It is a device that breaks up light into different colours by spreading out, or dispersing different wavelengths. Light enters the spectrometer through a 50 micron wide slit. That is very narrow; 5/100ths of a milimetre.

The light passes through an optical geometry of focusing mirrors and a reflection grating. The spectrum falls on a linear CCD array with hundreds of tiny sensors in a row so that each sensor (often called a pixel) in the array corresponds to one wavelength. The number of photons hitting each pixel is

converted to a voltage which is converted into a y-axis value on the graph. The x-axis is scaled to the pixel number which indicates wavelength.

Figure 1 shows the concept of spectrometer.

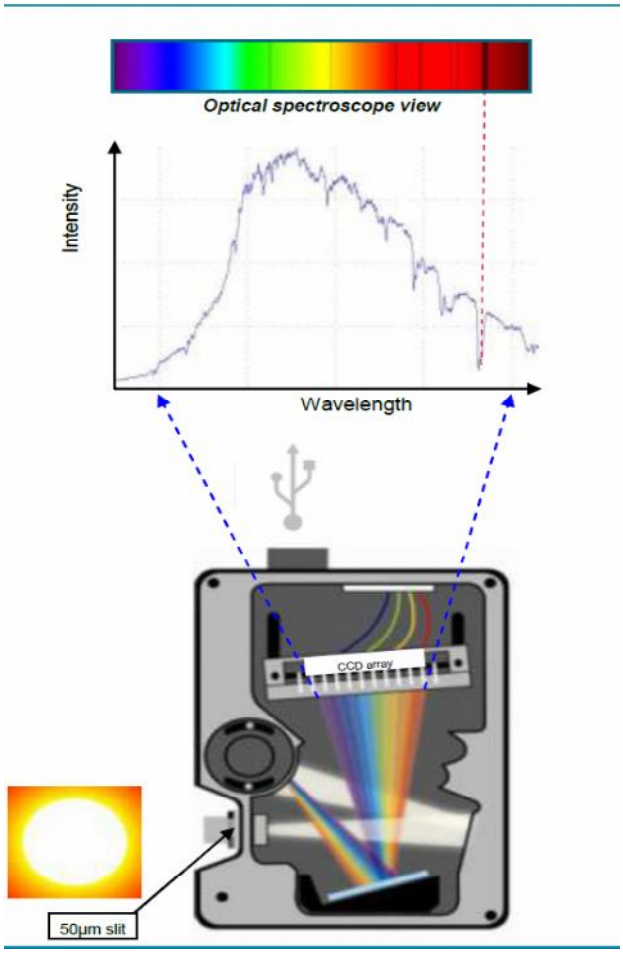

Figure 1: Concept of spectrometer

LabVIEW is product of National Instrument using in Windows operating system. Originally LabVIEW was use in scientific laboratory for instruments interfacing, sometimes to replace conventional instruments such as oscilloscopes and meters. Nowadays, LabVIEW have lot of improvements in laboratory experimental, product development, process control and various application.

LabVIEW have capabilities in hardware interfacing, graphical user interfacing and mathematical calculation including array manipulation and processing.

SOFTWARE DEVELOPMENT

This software was under development using LabVIEW to be using with StellarNet USB spectrometers system. StellarNet USB spectrometer was supplied with SpectraWiz operating software that can measure spectral data for real-time spectroscopy. This LabVIEW software was used to access real-time data from SpectraWiz dynamic link library as hardware interfacing.

This software consist of several main modules:

i. Read data from Spectrometer
ii. Save data to Hard Disk
iii. Read data from Hard Disk
iv. Separate data with certain wavelength
v. Processing data for specific requirement
vi. Plot graph for specific requirement

Read data from Spectrometer module can read data from spectrometer using SpectraWiz dynamic link library as hardware interfacing. Due to hardware limitation, data can be collected for wavelength from 229.00 nm to 1,100.50 nm.Figure 2 shows LabVIEW driver to read data from StellarNet USB spectrometer.

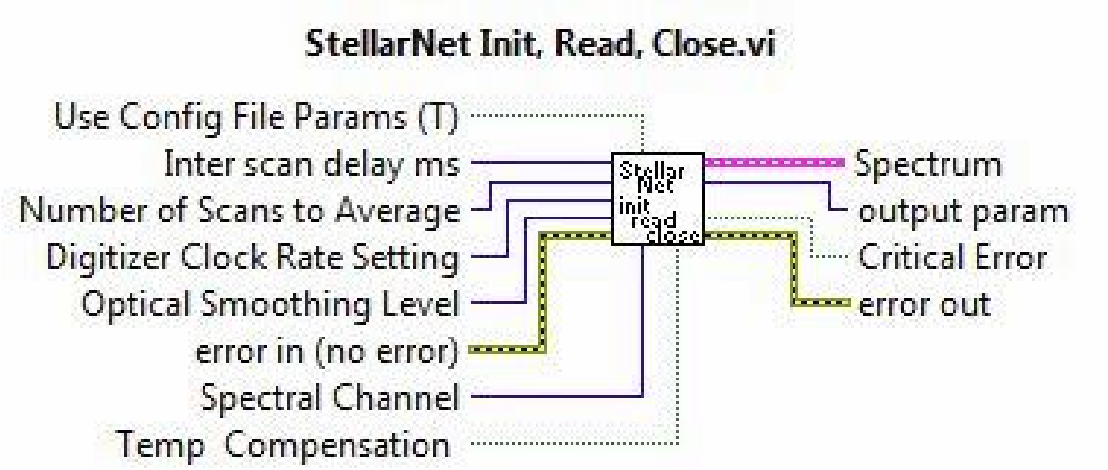

Figure 2: LabVIEW driver to read data from StellarNet USB spectrometer

Save data to Hard Disk module saved data for wavelength for certain time for off-line processing later. Data are saved in form of text file. Usually data saved in form of 2 dimension array consist of count and wavelength. Figure 3 shows example part of data saved in hard disk as count and wavelength in pair.

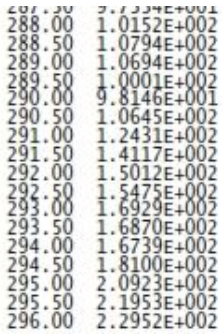

Figure 3: Example part of data saved in hard disk.

Read data from Hard Disk module read data from text file that saved early.

Separate data module will separate data for certain wavelength for more detail or in-deep processing. Data are separated as table 1.

Table 1: Type of radiation and their wavelength as well as index.

Radiation	**Wavelength (nm)**	**Array Index**
UVC (far UV – Germicidal)	100 - 280	0-102
UVB (middle UV – Erythermal)	280-315	102-171
UVA (near UV – Black Light)	315-400	171-302
V (violet)	380-450	302-442
B (blue)	450-495	442-532
G (green)	495-570	532-682
Y (yellow)	570-590	682-722
O (orange)	590-620	722-782
R (red)	620-750	782-1042
IR (Infrared)	750-1100.50	1042-1743

Processing data module can processing data for certain wavelength for specific requirement

Plot graph module can plot graph in various way for specific requirement, such as trend of Watt/m^2 for specific wavelength.

Those developed software heavily use array manipulation & processing as well as minimal mathematic calculation. Depending on the application and requirement, other module can be added with minimal modification and upgrading.

RESULT AND DISCUSSION

Figure 4 shows one of example of graph Irradiance in Watt/m^2 vs Time for measurement on 26th August 2015. Trend of UV, V, R and IR are shown. Weather during that day have haze and on around 04:00 PM, was cloudy.

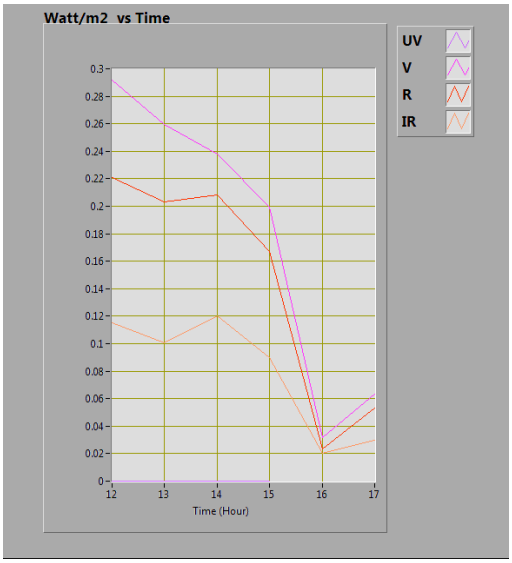

Figure 4: Example of graph Irradiance in Watt/m^2 vs Time for measurement on 26th August 2015.

Other wavelength can be selected depending on the interest of studies. Actually, this software can plot the trend of UVC, UVB, UVA, V, B, G, Y, O, R and IR. This software can process individually if needed. Irradiation trend can be measured for specific wavelength.

Other secondary calculation as energy can be calculated for specific wavelength. Irradiation for specific wavelength trend in daily, monthly and yearly basis can be obtained and evaluated.

As solar spectrum have various wavelength, surely consist of various benefit and application not fully understand yet and so it's under-utilized. In the field of safety and heath, UV maybe it's interested. For energy research using photovoltaic (PV), visible light to be interested. On infra-red, maybe interested for research in energy using solar thermal. For food processing, maybe infra-red are useful. In field of agriculture, it's more complex due to existing lot of various type of plants.

FUTURE RESEARCH

As mention before, this software are easy to upgrade for to be used in various application such as energy, safety and heath, agriculture, household utilization and so on. This software will be upgraded to be used in more specific application as well as research and development.

For household as example, with right timing and right method, solar radiation can be optimization such as for drying cloths, warm up bed-room, bath-room and even for cooking.

CONCLUSIONS

This developed software are capable of read data from spectrometer in real-time, and save data to hard disk. The important is this software can processing separate wavelength. It's also easy to upgrade for specific application on interest.

As solar spectrum have various wavelength, surely consist of various benefit and application not fully understand yet and so it's under-utilized. More research, development and application of solar radiation for benefit of human being.

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