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Improving Leaf Area Index Retrieval over Heterogeneous Surface

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ABSTRACT: We have been improving leaf area index retrieval over heterogeneous surface. The collection of ground measurements for validating remotely sensed crop leaf area index is labor and time intensive. This method presents an automatic measuring system that was designed based on a wireless sensor network (WSN). The data were analyzed in three ways 1) Comparison with LAI-2000, 2) a daily and 5-day aggregated time series analysis, and 3) a comparison with a Moderate Resolution Imaging Spectro radiometer (MODIS). The preliminary results indicated that the measured LAI values from the LAI Net were correlated with the values derived from LAI-2000. When compared with MODIS LAI, we found that the spatial values of the ground LAI Net observations and the scaled-up ASTER (Advanced Space borne Thermal Emission and Reflection radiometer) LAI were identical or similar to the MODIS LAI values over time. With its low cost and low energy consumption, the proposed WSN observation system is a promising method for collecting ground crop LAI in flexible time and space for validating the remote sensing land products.

KEYWORDS: LAI, Land surface, growth ratio.

I. INTRODUCTION

The collection of ground measurements for validating remotely sensed Crop Leaf Area Index (LAI) is labor and time intensive. This paper presents an automatic measuring system that was designed based on the Wireless Sensor Network (WSN). The data were analyzed in three ways: 1) A Comparison with LAI 2000 2) A daily and 5 day aggregated time series analysis, 3) A comparison with a moderate resolution imaging spectro-radiometer (MODIS) LAI. In forest region, the vegetation is calculated by LAI NET system this can predict the accurate value of LAI. Two light sensors are used to determine the solar radiation in different angles. The Collected data is stored in the Micro Controller. To save the power, RTC is used. This will have an automatic backup power. To locate the fire occurring area inside the forest by using MODIS, Large area monitoring is covered by using GSM(upto 22miles).speed of data transmission is high. To detect unauthorised person entering the forest IR sensor. RF transmitter is given to the authorised person while entering the forest. When the transmitter RF ID matched with the receiver the alarm get deactivate. Thermal radiation and earth temperature is detected using ASTER.

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Interpretation and application of LAI

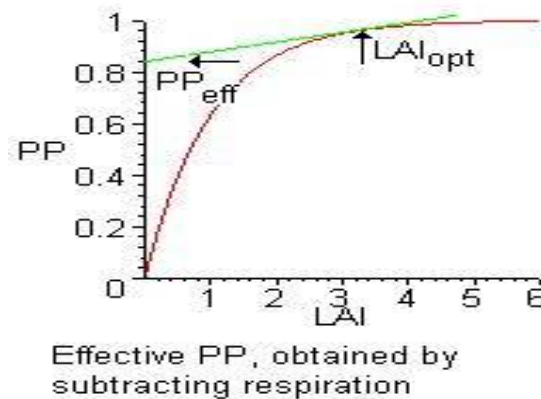


Figure 1 LAI is used to predict photosynthetic primary production, transpiration and as a reference tool for crop growth. As such, LAI plays an essential role in theoretical production ecology. An inverse exponential relation between LAI and light interception, which is linearly proportional to the primary production rate, has been established.

$$P = P_{\max} (1 - e^{-c \cdot LAI})$$

Where P_{\max} designates the maximum primary production and c designates a crop-specific growth coefficient.

II. EXISTING METHOD

There are two main categories of procedures to estimate LAI: 1) Direct method 2) Indirect methods. The former group consists of methods measuring leaf area in a direct way, while the latter group consists of methods where LAI is derived from more easily (in terms of time, workload, technology) measurable parameters. In this review article, basic inversion theories, demonstrated advantages and disadvantages of the more frequently used direct and indirect techniques to estimate LAI in forests will be discussed.

DIRECT METHOD

Direct methods can be easily applied on deciduous species by collecting leaves during leaf fall in traps of certain area distributed below the canopy. The area of the collected leaves can be measured using a leaf area meter or an image scanner and image analysis software. The measured leaf area can then be divided by the area of the traps to obtain LAI. That way it is not necessary to measure the area of all leaves one by one, but weigh the collected leaves after drying (at 60–80 °C for 48 h). Direct methods in evergreen species are necessarily destructive. However, they are widely used in crops and pastures by harvesting the vegetation and measuring leaf area within a certain ground surface area. It is very difficult (and also unethical) to apply such destructive techniques in natural ecosystems, particularly in forests of evergreen treespecies. Due to the difficulties and the limitations of the direct methods for estimating LAI, they are mostly used as reference for indirect methods that are easier and faster to apply.

Indirect methods:

Indirect methods of estimating LAI *in situ* can be divided in two categories:

- (1) **Indirect contact** LAI measurements such as plumb lines and inclined point quadrature.

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(2) Indirect non-contact measurements



Fig.2.Fisheye photography

Due to the subjectivity and labor involved with the first method, indirect non-contact measurements are typically preferred. Non-contact LAI tools, such as hemispherical photography, Hemi-view Plant Canopy Analyser from Delta-T Devices, the CI-110 Plant Canopy Analyzer from CID Bio-Science, LAI-2200 Plant Canopy Analyzer from LI-COR Biosciences and the from Decagon Devices, measure LAI in a non-destructive way. Hemispherical photography methods estimate LAI and other canopy structure attributes from analyzing upward-looking fisheye photographs taken beneath the plant canopy. The LAI-2200 calculates LAI and other canopy structure attributes from solar radiation measurements made with a wide-angle optical sensor. Measurements made above and below the canopy are used to determine canopy light interception at five angles, from which LAI is computed using a model of radiative transfer in vegetative canopies. The LP-80 calculates LAI by means of measuring the difference between light levels above the canopy and at ground level, and factoring in the leaf angle distribution, solar zenith angle, and plant extinction coefficient. Such indirect methods, where LAI is calculated based upon observations of other variables (canopy geometry, light interception, leaf length and width, etc.) are generally faster, amenable to automation, and thereby allow for a larger number of spatial samples to be obtained. For reasons of convenience when compared to the direct (destructive) methods, these tools are becoming more and more important.

Indirect non-contact LAI measurement methods

Optical methods are indirect non-contact methods and are more commonly implemented. They are based on the measurement of light transmission through Canopies. These methods apply the Beer– Lambert law taking into account the fact that the total amount of radiation intercepted by a canopy layer depends on incident irradiance. It involves ground-based measurement of total, direct, and/or diffuse radiation transmittance to the forest floor, and it makes use of line quantum sensors or radiometers, laser point quadrats and capacitance sensors. These instruments have already proven their value in the LAI estimation of coniferous as well as broad-leaved stands. The disadvantage of the direct method is that it is destructive, time consuming and expensive, especially if the study area is very large. The disadvantage of the indirect method is that in some cases it can underestimate the value of LAI in very dense canopies, as it does not account for leaves that lie on each other, and essentially act as one leaf according to the theoretical LAI models

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III. METHODOLOGY

LAINET:

LAINET is an automatic device that obtains multi-angle transmittance of the vegetation canopy during the day following sun's movement based on WSN technology and then calculates the crop LAI from multi-angle transmittance using a vegetation gap probability model. This WSN consists of three different nodes:

- 1) Circle node with 3 light sensors.
- 2) Linear node with 9 light sensors.
- 3) Sink nodes with GPRS network

The first node type is a circle node with three light sensors that are deployed above the canopy

.The second node type is a linear node with nine light sensors placed under the canopy and that receive the permeated radiation. Sink nodes are used to collect and transmit the data to a remote data server through general packet radio service network.

ADVANTAGES OF LAINET:

- 1) It can reduce the time required for one to access the experimental site, therefore can minimize the plant disturbances by the experimenter which is not possible with current traditional instruments.
- 2) Multiple measurement nodes are automatically synchronised which ensures that the measured data of each node are obtained simultaneously and avoids the data Uncertainty caused by the differences in measurement time.
- 3) The field data are remotely transmitted to the data centre via public wireless network and are automatically saved on the data base server.
- 4) It reduces data acquisition costs, including labour and instrumental costs.

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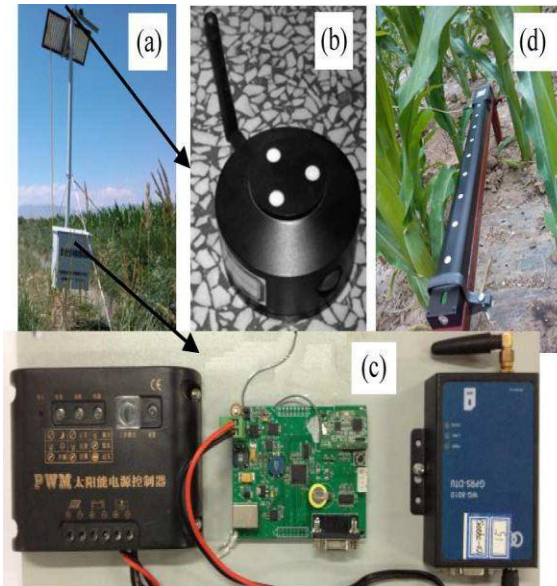


Figure 3 LAI Net nodes

Figure (a): The solar power system and the sink nodes above the canopy

Figure (b): The zoom of a node above the canopy

Figure(c): The zoom of a sink node (middle), the solar power control (left) and GPRS unit (right)

Figure (d): The linear nodes with 9 light sensors.

IV. TABULATION

Type	Hardware Cost			Labor (Work Days)			
	Single price	Number	Total	Deploying cost	Per measurement cycle	Maintain	Total
LAI2000	\$8000	2	\$16000	0	4-32	0	32-416
LAINet	\$250	90	\$ 22500	6	0	3	9

Table1: COST-EFFICIENCY OF TRADITIONAL

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INSTRUMENTS VERSUS LAINET

From the tabulation:

- The traditional measurements take approximately 4-32 days of labour to complete the weekly repeated measurements.
 - For growth time of 3 months and a sampling frequency of 7 days e.g., approximately 13 times the observation are required to obtain continuous observed data over such a long period of time.
- The approximate cost efficiency comparison between LAINET and traditional instruments is given in the tabulation.

V. TECHNOLOGIES

MICROCONTROLLER

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry standard 80C51 instruction set and pin-out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

Features:

- Compatible with MCS®-51 Products
- 8K Bytes of In-System Programmable (ISP) Flash Memory – Endurance: 10,000 Write/Erase Cycles
- 4.0V to 5.5V Operating Range
- Fully Static Operation: 0 Hz to 33 MHz

SIM900 GSM/GPRS Module

This GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily.

The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to send and receive SMS or make/receive voice calls. It can also be used in GPRS mode to connect to internet and do many applications for data logging and control. In GPRS mode you can also connect to any remote FTP server and upload files for data logging.

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Figure 4 - SIM900 pin diagram

- SIM900 is designed with a very powerful single-chip processor integrating AMR926EJ-S core
- An embedded Powerful TCP/IP protocol stack
- Based upon mature and field-proven platform, backed up by our support service, from definition to design and production.

QUICK START GUIDE

- **Insert SIM card:** Press the yellow pin to remove the tray from the SIM cardholder. After properly fixing the SIM card in the tray, insert the tray in the slot provided.
- **Connect Antenna:** Screw the RF antenna if not already connected.
- **Connect RS232 Cable to PC/MCU:**

(Cable provided for RS232 communication). Default baud rate is 9600 with 8-N-1, no hardware handshaking.

- Connect the power Supply** (12V 1A) to the power input of board. Polarity should be Center +ve and outer-ve DC jack.

- **Network Led** indicating various status of GSM module eg. Power on, network registration & GPRS connectivity.
- After the Modem registers the network, led will blink in step of 3 seconds. At this stage you can start using Modem for your application.
- AT commands can be sent to control GSM Modem.

For sending SMS in text Mode:

- AT+CMGF=1 press enter
- AT+CMGS="mobile number" press enter

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- Once The AT commands is given ' >' prompt will be displayed on the screen. Type the message to send via SMS. After this, press

"ctrl+Z" to send the SMS.

- If the SMS sending is successful, "ok" will be displayed along with the message number.

For reading SMS in the text mode:

- AT+CMGF=1 Press enter
- AT+CMGR= no.
- Number (no.) is the message index number stored in the SIM card. For new SMS, URC will be received on the screen as +CMTI: SM

'no'. Use this number in the AT+CMGR number to read the message.

GUIDE TO VOICE CALLING

- **Initiating outgoing call:**
- ATD+ mobile number; <enter key>
- **For disconnecting the active call:**
- ATH <enter key>
- **For receiving incoming call:**
- ATA <enter key>

Note: The modem automatically sets to the baud rate of the first command sent by the host system after it is powered up. So there is no need for setting the baud rate using commands. Before you start using the modem, please make sure that the SIM card you inserted support the needed features and there is enough balance in SIM

RF TRANSCEIVER

The QFMT5 and QFMR5 data link modules are miniature UHF radio modules, which enable the implementation of a simple telemetry link up to 300 meters, and at data rates of up to 128Kbit/s The QFMT5 and QFMR5 modules will suit one-to one and multi-node wireless links in applications including building and car security, remote industrial process monitoring and computer networking. Because of its small size and low power requirements, these modules are ideal for use in portable battery powered wireless applications.

LIGHT SENSOR:

A Light Sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called "light", and which ranges in frequency from "Infrared" to "Visible" up to "Ultraviolet" light spectrum. Photoelectric devices can be grouped into two main categories, those which generate electricity when illuminated, such as *Photo-voltaics* or *Photo-emissives* etc, and those which

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change their electrical properties in some way such as *Photo-resistors* or *Photo-conductors*.

Photo-junction Devices – These photo-devices are mainly true semiconductor devices such as the photodiode or phototransistor which use light to control the flow of electrons and holes across their PN-junction. Photo-junction devices are specifically designed for detector application and light penetration with their spectral response tuned the wavelength of incident light.



Figure 5- light sensor

VI. HARDWARE AND SOFTWARE

IMPLEMENTATION

- MICROCONTROLLER 40 PIN IC 89S52
- RF TRANCEIVER
- PIR SENSOR
- LDR
- LCD DISPLAY
- GSM
- MPLAB IDE COMPILER
- EMBEDDED C LANGUAGE

VII. IMPLEMENTATION

Microcontroller has been interfaced with upper and lower Light sensors, PIR sensors RF transceiver, GSM module and the result have been calculated using Beer-Lambert Law. This law is simpler because the exponential extinction of light as it passes through the canopy is assumed to be adequately described by the extinction coefficient, k . The light below the canopy, Q_i , is related to the light above the canopy, Q_0 , and LAI, by the relationship $Q_i = Q_0 e^{-kLAI}$ and solving for LAI gives $LAI = -\ln(Q_i / Q_0) / k$. Besides the gap fraction (Q_i / Q_0), only the extinction coefficient, k , for the canopy need be known or estimated for application of this method. For a canopy with a spherical distribution of leaf

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inclination angles, k is well approximated by 0.50. Extinction coefficients reported for 13 needle and broad-leaved tree species ranged from 0.28 to 0.65 and averaged 0.47.

VIII. CONCLUSION

In this present work, system has been designed and interfaced using a microcontroller with upper and lower Light sensors, PIR sensors RF transceiver, GSM module and test that for result by using Beer-Lambert Law. The light below the canopy, Q_i , is related to the light above the canopy, Q_0 , and LAI, by the relationship $Q_i = Q_0 e^{-KLAI}$ and solving for LAI gives $LAI = -\ln(Q_i / Q_0) / k$.

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