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Remote Monitoring (RM) – System using ZigBee and WiFi wireless network for oil palm plantation

Pushparani Marappan[1]
[1]*UNITAR International University, Malaysia*

Abstract: *The increasingly competitive global agriculture market is undergoing challenges to create sustainable operational efficiency. To enhance work productivity by increasing workflow efficiency and maintaining operational effectiveness, remote monitoring could be one of the solutions for plantation industry. Wireless remote monitoring is a well-established technology that can be applied to the agriculture industry to improve efficiency and operational productivity. This research describes a methodology that incorporates hardware and software components that enable remote management of the plantation operation in real time. The research defines deployment of technology that includes wireless technology, video streaming, vehicle tracking and soil testing to compliment fertilizer application. Access control being one of the common and vital issues faced in today's plantation operation, remote monitoring system works as a tool to address the issues. The system captures videos at specified location and transmit it to the guardhouse using the wireless network, Information about the soil pH value could be received from different locations from the plantations in respective blocks that shall enable the management to plan and forecast the type of fertilizer to improve the soil condition. Load management method is used to track the yield in plantation and check on theft and mismanagement. Based on the gathered information customized reports shall be generated as per user requirement.*
Keywords: *load management, remote monitoring, soil testing, security surveillance*

I. Introduction

A major challenge faced by Malaysian oil palm plantations is under-optimized in crop productivity. The productivity is imperative since there is complication due to limitations such as labor shortage and declining planting acreage. Decision making is bogged down by several factors including the fact that data is spread across different geographical locations and in disparate forms. Traditionally the oil palm plantations have been run by estate managers with vast on-the-job experience. Today, the oil palm industry has grown to become a multi-billion-dollar industry in Malaysia, Indonesia, with top management located across the globe and managing plantations with their multi-skilled task force (Alwee, S. S, et.al., 2010). Most of the issues that are addressed by the existing plantation management system do not focus on issues such as load management, soil testing and surveillance at the prime location. The management have to make crucial and timely decisions, taking into consideration factors ranging from costing, environmental issues and policies governing the operations of the palm oil industry.

II. Objective

The objective of the RM – System is to provide remote monitoring system with night surveillance to monitor the plantation daily operation at strategic location in the plantation such as main roads, road junctions, stray entrance, loading area and collection area (ramps); access control using biometrics to monitor the storage area where things are stored like tools, fertilizer etc in-order to improve operational efficiency at the plantation. This system uses WiFi and ZigBee wireless network (Huang, J., et.al. 2010) as a platform to plant relevant components based on the type of information intended to be tapped. The management will be able to make immediate decision since information is provided remotely at anytime from anywhere where there is internet access.

III. Scope of Research

The scope of this research is to have wireless network with a combination of WiFi and ZigBee (Huang, J., et.al. 2010) to provide real time information about the plantation operation to the management to manage the plantation remotely effectively rather than going to the plantation to make decisions. The research provides security and surveillance using video streaming at strategic location like main roads, sub-roads, bridges, ramps (fruit loading bay), entrance & exit in a plantation. The load management with vision system to estimate the load that is carried out of the plantation to the oil mill so in case of any pilfering the system will send alert. Soil management performs soil testing in each block on a periodic basis, planting sensors in the plantation at various blocks that shall determine the pH level (Zhang, N., et.al. 2002) in the soil, to enable the management to plan the fertilizer for each block depending on the mineral contents in the soil. In addition, the system also provides access control using biometrics to monitor the storage area where tools and fertilizer are stored. Monitor the activities at the guardhouse and alert triggers to the relevant personal for immediate action and then follow the escalation list provided by the management. Weather conditions at the plantation at a given point of time.

IV. Literature Review

Malaysia currently accounts for 41 % of world palm oil production and 47% of world exports, and therefore also for 11% and 25% of the world's total production and exports of oils and fats (MPOC, 2009). As the second biggest producer and exporter of palm oil and palm oil products, Malaysia has an important role to play in fulfilling the growing global need for oils and fats in general (Lam, M. K., et.al, 2009). The refining of crude palm oil commenced in the early 70s in response to Government's call for increased industrialization. The emergence of refineries marked the introduction of a wide range of processed palm oil products. The wireless networks are composed of nodes with several constraints due to the nature of the wireless sensor network field, like very low power consumption or very low cost and reliability of the nodes. With sensor network it is possible to improve the measurement procedure since human intervention is reduced almost totally. When the developers focus on the centralized architecture there is communication clogging so we used the distributed architecture this approach avoids bottlenecks in the central node that enabled to process the signal locally (Portilla, J, 2006). In case of any node failure then the network will not be down. Currently three main wireless standards are used namely: WiFi, Bluetooth and ZigBee. The benefits of using the wireless technologies in agriculture resulted in a large number of research projects in this application domain. In the agriculture field, some factors such as dynamic and slow reaction of the environment changes, and large amount of environment related data to consider make it hard to monitor these variables by human. The crop field monitoring system (He, D., et al. 2007) the data that is obtained were identified by the internet protocol (IP) that was transferred to take turn and omitted IP disconnection. There was disruption in communication. Research conducted in integrated field monitoring system (Hashimoto, A., 2007) used sensing and information technique in tomato grove to acquire and analyze the growth information, the research was conducted in the controlled greenhouse environment. The possibilities that were explored to consider gaps in ubiquitous information systems analysis and design stages which could direct the right path for database arrangement (Huang, C. P. 2009), this was used for the in-build a u-campus to have communication shared by the teachers and students

V. Plantation Monitoring System

The RM-System provides remote monitoring using ZigBee and WiFi wireless network for data transmission as a backbone. Based on the persistence of problems as explained in the problem statement the system caters to 3 main areas

- *security and surveillance* – monitoring on prime location and major roads including the entrance and exit of the plantation using IP cameras, WiFi routers, sensors, lights gates and a simple control system at the guard house.
- *load management* – capturing images of a loaded lorry leaving the plantation and reaching the oil in order to detect theft.
- *soil testing* – that enables the management to plan the type of fertilizer to be sprayed on a specific block based on the pH value of the soil. This system consists of three main functionalities or features in order to monitor the remote plantation effectively. The features include security and surveillance, load comparison and soil management.

i) **Security and surveillance:** The IP cameras would use either solar power to transmit the video or use the normal IP cameras, depending on the monitoring locations now a day's there are many IP cameras that has an in-built application and it can be added into the portal for video streaming. The rest of the components that are specified in the system could be integrated on to the existing system like the biometrics etc. The computer located at the guard house can be upgraded based on the advancement to accommodate the latest updates and technology.

ii) **Load management:** The normal plantation yields load (FFB) on a day to day basis and the load are transported to the oil mill every day. There is a lot of malpractice during the transportation of yield; as shown in the Fig. 1 the system is initially setup with an image of the loaded lorry will be taken and sent to the data centre, when the same lorry reaches oil mill an image of the lorry is capture and sent to the data centre. Upon receiving both the images of the lorry there is a comparison drawn between the two images using the vision system and optical character reader (OCR) in case of any discrepancies the system will alert the person in-charge about the indifference in duration for the lorry taken and the load difference. This system will enable to track down details such as the driver driving the load out and also record the pattern of load being transported by individual drivers including the time duration for transporting the load. The load management system is supported by the weighing bridge as a typical scenario; every time the lorry leaves the plantation the weighing bridge is used to weigh the load carried by each lorry along with the picture that is grabbed during the exit, when the same lorry reach the oil mill similar check is performed.

The transmitted data at the data center will then compare the two images captured and in case of any discrepancies the vision system shall be called upon to verify the shape of the load that was carried out using the visual system incorporating the existing parameter such as follows;

- Self-weight
- Weight when the lorry is loaded with FFB up to the rim of the body
- Estimated weight if the load is at three various stage.
- The type of fruits that is carried out whether the FFB is grade A, B or C the weight would vary.
- During the harvesting / loading and transporting whether there was rain.
- Are the FFB wet in any of the above said operation.

All the above discussed information will be taken in as parameters during the calculation stage in order to double check where there was any theft for loss of fruit during the transportation.

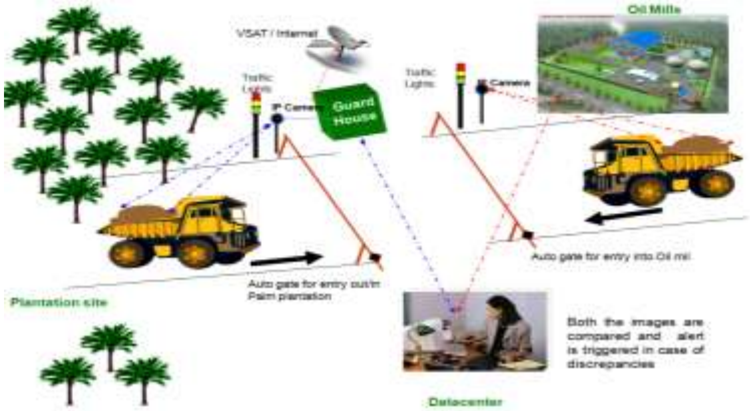

Figure 1: Load comparison to predict the load carried by the lorry

The load management was implemented in block A as shown in Table 1, conducted five rounds of testing and the result are as tabulated. The test result should that the load weighting accuracy was achieved and the standard deviation was 1.17 and the tolerance level was between 0.11. The system was used and the results were satisfactory by the users.

Table 1: Load measurement using the RM – System

Accuracy of load management							
Data samples from block A	Round 1	Round 2	Round 3	Round 4	Round 5	Mean	Std Dev
Number of lorries measured	25	23	22	24	25	23.8	1.17
Number of lorries matched	20	19	20	23	22	20.8	1.47
Number of lorries unmatched	5	4	2	1	3	3	1.41
Tolerance level	0.5	0.6	0.7	0.4	0.45	0.53	0.11

iii) **Soil testing:** The sensor characteristics best suited for this type of application would be periodic data transfer, the sensor wakes up at a set time and checks for the beacon, exchanges data, and goes to sleep. Based on the data collected fertilizer spraying can be planned and customised for specific block. These sensors shall be connected using the ZigBee network which in turn connected to ZigBee router to transmit information to the guardhouse, the reason for using this network is the data packets are small and the sensor battery lifespan is very good.

The use of ZigBee is very useful because in cause of any failure the data would be transmitted using an alternative route still keeping the network active and up. As shown in Fig. 2 data is transmitted using the router to the guardhouse and later used for reports; plan fertilizer to correct the soil at a specified location. After the blocks are determined study or survey is made on the type of soil type in each block and those areas in the block that are prone to soil leaching. The soil get washed away during rain and there are certain mineral contents that reduce due to this effect. The installation of each sensor is decided based on a particular parameter soil leaching due to which the mineral contents keep varying. Based on the data of present soil condition at specific block at given point of time, plan for fertilizer for the coming up term this kind of information used to plan ahead on purchase of right quantities to facilitate current condition at specific block.

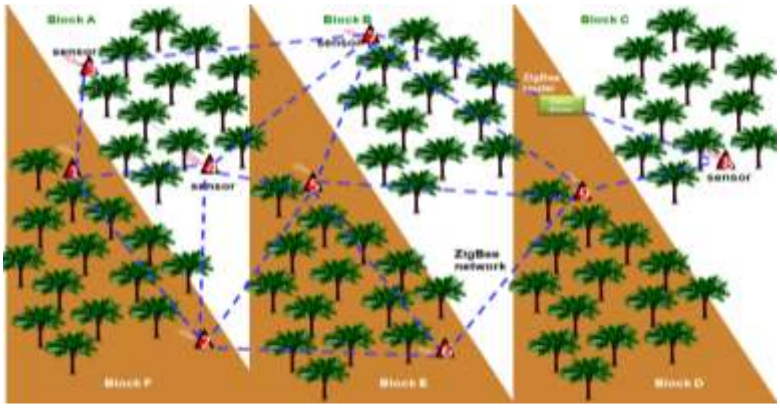

Figure 2: Sensors planted at various blocks to transmit signals using ZigBee Network

The sampling was done at block A, planted around 30 sensors within 3 area of surrounding, reading sampling as shown in Table 2.was recorded using before fertiliser spraying. Then based on the initial reading the soil analyst recommended the fertilizer and after the 1st round of fertilizer spraying and second round of fertiliser spraying the reading were determined. The table shows that the pH value of the soil can be achieved to a certain level to improve the soil condition that could be a significant fact in FFB production. The users upon using the results gave in remarks that if this was factored with the predictive weather condition then the result could be optimised.

Table 2: pH value reading

Block A 3 acres 30 sensors depth 0-15 cm		initial reading	after 1st round	after 2 round
	Month	1	3	6
	Sensors	pH Value		
	1	4.48	5.46	5.58
	2	4.30	5.29	5.29
	3	5.00	5.80	5.99
	4	5.20	5.98	6.09
	5	4.00	4.91	4.80
	6	4.30	5.17	5.18
	7	3.70	4.58	4.69
	8	4.12	4.91	5.03
	9	3.90	4.77	4.89
	10	4.30	4.99	5.23
	Mean	**4.33**	**5.19**	**5.28**
	Std Dev	**0.44**	**0.43**	**0.45**

VI. Conclusion

Based on the results achieved by implementing the system and tested by the plantation users, the remote monitoring was achieved with the three components that is video streaming, load management and soil assessment. The IP cameras were installed in strategic location to monitor the operation in the plantation. The load management enabled to counter check on the load that was transported from the estate to the mill, if there were discrepancies then it was triggered and highlighted. The soil pH value was determined to ensure that it is good for the palm to grow. The initial pH value was determined and fertilizer spraying was planned for the consecutive rounds to improve the soil condition and this was achieved using this system. This research can also be applied for other domains then modification are mode to the application it by redesigning from scratch all the system. An ideal solution would be to have a reference design that is flexible and adaptable to new situations with minimum reforming effort. The network and technology used by other plantation industry to enable remote monitoring possible and effective. However upon using the system the plantation operators concerns was that, the system is suitable for the current available technology but since most of the components are installed on the open environment the reliability of the components may vary on the weather condition. Although the system can be upgraded with the latest technology and application that will emerge in the market but there a definite limitation in terms of electricity and infrastructure availability. Installation of the system will be time consuming since the area coverage is huge and needs a lot of communication during the installation part. The “people management” is challenging aspect where vandalism would be an issue to address since the components lost will result in un-accomplishment of the systems efficiency. The RM-System could be improved with more modules such as financials and payroll also incorporated; mobile biometrics that can be incorporated on to the system.

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