2019 2nd International Conference of Computer and Informatics Engineering (IC2IE)

Prediction Based Smart Farming

Sai Yasehwanth Chaganti, Prajwal Ainapur, Mayank Singh, Sangamesh
Department of ECE, NIIT Univertity
Rajasthan, India
yesh.chaganti@gmail.com

Shinta Oktaviana R
Dept. Computer and Informatics Engineering
Politeknik Negeri Jakarta
Indonesia
shinta.oktaviana@tik.pnj.ac.id

***Abstract*— The world population is expected to grow by over a third by 2050. Market demand for food will continue to grow. Automated drones and different robots in savvy cultivating applications offer the possibility to screen ranch arrive on a for each plant premise, which thus can diminish the measure of herbicides and pesticides that must be applied. There is a gap between current food productivity growth and needed growth. To boost the yield, farmers switched to extensive use of chemical fertilizers. Excessive fertilizer usage has its negative impact like decreased yield, wastage of fertilizer, damage to soil, and groundwater contamination. Currently, farmers mostly rely on guesswork, estimation, experience when deciding the crop that should grow, and the fertilizer that should be used. In this paper, we have proposed a solution that uses technologies like Machine Learning, Image Processing, and the Internet of things to improvise farm productivity and at the same time, decrease the fertilizer usage. This paper describes the outcomes of a prototype implemented in Rajasthan, India.**

Keywords*— *machine learning, drone imagery, satellite imagery, image processing

I. Introduction

Pervasive agriculture, sometimes also called Precision Agriculture, has witnessed incredible growth in interests from agro giants over the past decade, specifically in technologically developed countries like the USA, Japan, Canada, Germany, and others. The rest of the world, at the same time, has seen minimal implementation, but the change is coming. The most common definition used to describe Precision Farming is that form of Farming where the Right time, Right amount, and Right place, Right manner, form the core of this form of practice. Precision farming consists of three major components, namely, Information, Technology, and Management. Pervasive agriculture is a management-intensive and technology-intensive process that utilizes many scientific techniques to get better yield at the same time while using as little inputs as possible.

This paper focuses mainly on using Prediction analysis and Image processing techniques that could be utilized in the field of Precision Farming. The technology of autonomous driving systems has already seen lots of development with big tech giants, namely Tesla Inc., Google Inc., showing significant interests. Prediction-Analysis, Image processing, and its use in the autonomous driving system will be mainly focused among its many other applications in this paper. Pervasive agriculture achieves continuous growth in environmental, economic, market, and public pressures on arable agriculture, which is also known as a crop management concept. It is Information Intense and could not realize without the massive advancement in networking and computer processing power.

India has one of the highest net areas under cultivation, but its net output/hectare is far below its counterparts. The Government of India is striving very hard to bridge this gap. This project aims at working hand in hand with the soil health centers which have been set up by the government and provide ways to all the farmers to use minimum fertilizers, to maintain the soil health and also would provide them an opportunity to gain total revenue from the same piece of land. The concept behind pervasive agriculture is dividing the agricultural field into smaller cells to which a whole amount of information can be assigned. After evaluating and drawing up cultivation plans, a tailored management plan can be set up. Pervasive farming in Europe entails specific site farming. Present farming techniques mainly involve the uniform planting of a field with a particular crop, although the primary characteristics for crop planting of an agricultural field often vary up to a maximum extent. The remaining paper, organized as section II, introduces Related work; section III presents our proposed algorithm; section IV explains the Performance Evaluation. Conclusion and Future are stated in Section V.

II. Related Work

In [1], the author focuses on automating the process of extracting feature boundaries from satellite imagery. In their proposed model, they utilized a sequence of techniques to arrive at an automated solution for feature extraction. They utilized techniques such as image segmentation, crust extraction, medial axis extraction, and pruning to arrive at the results. The major drawback, as the researches highlighted, is that due to different color scales of the satellite image, noise, many a times' undesired features were detected and thus suggested to pre-process the image for proper feature extraction.

In [2], the author compared different feature extraction algorithms for optical flow tracking. The algorithms taken into were canny edge detector, Harris Corner detector, Good Features to Track (Shi- Tomasi), SIFT, SURF, and random seeding. With the help of the Gantry test, Vienne's test, Birmensdorf test, and Odometry test, the authors analyzed the different advantages each algorithm possessed and their area of application. Few parameters referred by the authors for these analyses include simplifying the implementation, the processing speed, and the ability to extract suitable features for frame-by-frame tracking using optical flow algorithm in all types of test conditions.

In [3], the author explains the utilization of Bio-Remotely Sensed imagery for civilian applications, both industrial and academic, has been available since 1972 with the launch of the Landsat 1 satellite and published the first paper discussing the spectral properties of plants in 1913. While the analysis of remotely sensed imagery can be applied to various industries, usually by measuring the amount of reflected radiance, this technology enables the extraction of information from the object of interest itself. For vegetation, we can better understand the plant's stress, moisture content, and stage of the growing cycle, health, spatial variability from the soil or irrigation systems, leaf density, crop height, and other factors of overall crop health.

In [4], the author described that it is essential to note regardless of Carter conclusions (1993), it is written, "around x nm" because the angle of solar irradiance, the atmospheric, climatic, and pollutant levels in the air, as well as the slope of the ground, time of the day, and season; all became Variable factors in the interpretation of these values. Remote sensing is very sensitive to all environmental factors and is a technically complex field where conclusions are drawn from the information, but the precise understanding of each interpretation is not always fully known.

In [5], the author describes the advent of UAVs for geospatial dataset production is a revolution within the discipline of GIS and Remote Sensing. Unmanned Aerial vehicles can collect data at specific spatial and temporal resolutions for a range of studies. With the flexibility to carry different types of sensors, UAVs can be used to collect data for specified projects [5]. The prevalence of UAVs for GIS and Remote Sensing will increase in the coming years because of their innovative nature.

In [6], the author in the paper portrays precision farming as a fundamentally new domain for computational intelligence and constitutes a genuinely interdisciplinary aspect. Agriculture is thus rapidly turning into a knowledge-intensive industry concluding the paper, and they have posted various challenges in the data mining for agriculture.

In [7], the author explains how to extract patterns from a spatial database using the k-means algorithm, which refers to patterns that are not stored explicitly in a spatial database. Because mining spatial associations need to evaluate multiple spatial relationships in a large number of spatial objects, the process can be costly. The k-means algorithm works randomly by selecting as many objects ask, where each object represents groups. For the remaining objects, the value of proximity to objects in the object in the existing group calculated. After that, the average value of each object in each cluster calculated. In this paper, k-means is used to analyze when the time is right for the agricultural period based on rainfall and ambient temperature so that farmers get maximum crops.

In [8], the author describes agriculture concerning the environment. The focus of research carried out is how to increase crop yields with limited land, limited water sources, and limited use of fertilizer. This research builds a model that can be applied to a machine learning approach.

In [9], the author in the model explained approximately 59 and 93% of yield variability at the time of calibration and validation, respectively. The model performance is good at non-zero N rates, with most of the simulation errors being < 10%. Model-estimated EONR varied from 70 to 250 kg ha−1. Economic analyses indicated that applying N fertilizer at year-, hybrid-and MZ-specific EONR had the potential to increase net return.

In [10], arable farming systems in the Netherlands combine high yields with high inputs of fertilizers and biocides. Management operations are highly dynamic (e.g., multiple fertilizer applications in a growing season), and environmental constraints are continuously tightening. In this setting, the efficient use of inputs is crucial. Precision agriculture aims at increasing efficiency by incorporating spatial and temporal variability into farm management operations. In [11], the author elaborates on Shotter’s idea of knowledge-from-within, we argue that knowledge-cultures are social achievements that equip those who embody them with a relational–responsive kind of understanding of events and surroundings built on multiple knowledge-forms.

In [12], the author describes that farmers throughout the world are continuously looking for ways to maximize their returns. Remote Sensing, Geographic Information Systems (GIS), and Global Positioning Systems (GPS) may provide technologies needed for farmers to increase the economic and environmental benefits of precision farming. However, most farmers do not have the skilled knowledge to utilize these technologies effectively. In [13], the author describes the potential benefits of ‘doing things more precisely' in agriculture include terms such as environmental, economic, audit trail, vehicle guidance, crop management, and others. Whereas some benefits have proved to be difficult, others are contributing positively to today's agriculture. In such an environment, continuing research is required.

In [14], the author describes Precision agriculture to crop management methods that recognize and manage within-paddock spatial and temporal variations in the soil–plant–atmosphere system. This paper reveals the principles, practice, and perceived benefits of precision agriculture. The objective of precision agriculture is to improve the control of input variables such as fertilizer, seed, chemicals, or water concerning the desired outcomes of increased profitability, reduced environmental risk, or better product quality.

In [15], the author proposed a model for automated the activities of farming by using the internet of things. The main input of the system is data from the soil moisture sensor. Then the measured result will automatically drive the irrigation machine and determine the amount of water supplied.

III. System Model and formulation

Our System consists of three important technologies; Satellite Imagery based Machine learning, Image Processing, and the Internet of Things. Our proposed model is different from the existing systems as it involves multiple technologies and modularity of our design. Fig.1 describes our proposed solution to the field of agriculture.

In machine learning, inputs values are N, P, K, PH, and temperature of the soil, and Outputs obtained are Top three crops depending on the input values of the soil, and this is done using K-NN and ARIMA models. We have added Bio-Fertilizers used for the crops as Extra Input values to improve farm productivity. Machine Learning is used to predict the crop in which, when grown, would utilize minimal inputs while also providing maximum profits to the farmer. There are three different modules used in the Internet of things, namely Fig. 2 as a soil moisture sensor,

Fig. 3 as a Wi-Fi launchpad, and Fig. 4 as a PH sensor. Soil Moisture sensor measures the moisture content of soil and PH sensor probe, which measures the PH content of the soil.

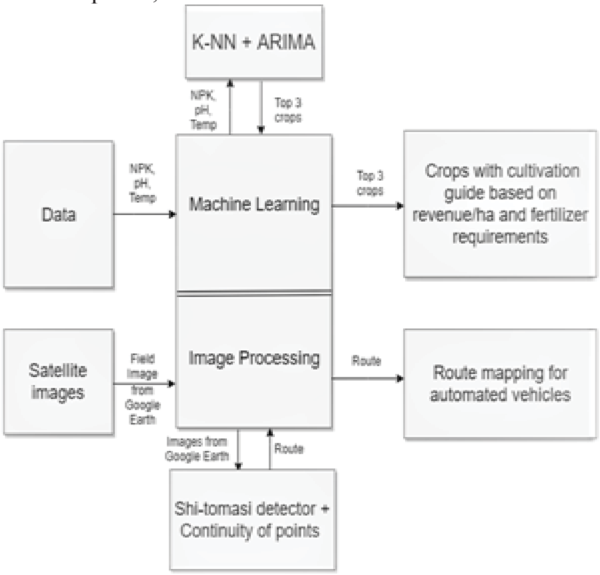

Fig. 1. Flow chart of the scenario system

The data from these sensors are thus retrieved, and CC3200 Wi-Fi LaunchPad kit is used to host the web server and send the sensor data on to web server. Depending on the PH, Moisture content of the soil, we can manually predict the crops which can be grown in their soil. In this Satellite Imagery is used for creating the Route mapping for the Automated vehicles. It is better than Drone Imagery due to some advantages. The term Satellite imagery refers to various types of digitally transmitted images taken by artificial satellites revolving around the earth. In Image Processing, The Images received from the Satellite Imagery detected by using Shi-Tomasi Detector plus continuity of points for image segmentation, which in turn creates a Route for Automated vehicles.

It would be accessed in one of the two ways. The first one would be the automatic way, wherein the farmer selects their location and based on the previous soil tests that conducted at or near that place, and the suitable crop would be suggested. The second way is to manually enter the required parameters such as N, P, and K values along with Temperature and pH of the soil, and this would generate a suitable list of crops for the entered values. The machine learning algorithm is also utilized to predict the expected revenue per hectare that could be generated under ideal conditions. Thus, as a result, the farmer gets insights about his expected revenue at the end of harvest thus helping them make an efficient decision over which crop to sow with minimal inputs and maximum income

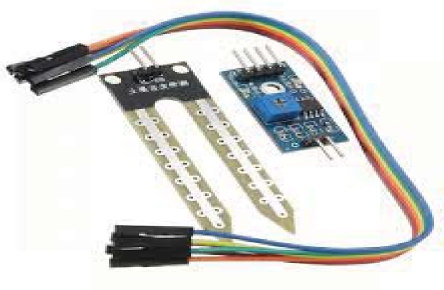

Fig. 2. Soil moisture sensor

Fig. 2. CC3200 Wi-Fi launchpad kit

Fig. 3. PH sensor probe

A. ARIMA Model

ARIMA model is an excellent class of estimating a model that utilizes past information to make future predictions in Machine Learning. ARIMA stood for the auto-regressive integrated moving average and indicated by these three order parameters: (p, d, q). An autoregressive (AR (p)) component is commonly known for past values in the regression equation for the series Y. The d term represents the degree of differencing in the integrated (I (d)) component. Differencing an arrangement involves only subtracting it is present and past values d times. The auto-regressive parameter p specifies the number of slacks used in the model. A moving average (MA (q)) component represents the error of the model as a combination of previous error terms. The order q determines the number of terms includes in the model network system.

B. K-NN

K-Nearest Neighbors is a supervised algorithm for classification and regression. The input consists of the k most proximate training examples in the feature space, and the output is a class member of the object. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most prevalent among its k most proximate neighbors (k is a positive integer, typically minuscule). If k = 1, then the object is assigned to the class of that single most proximate neighbor.

C. Methodology

The following steps were followed for crop and fertilizer predictions.

- Historic soil data (N, P, K, pH, Temperature) of the region (where the farm is located) is given as input to the ARIMA model where forecasting of the above parameters done. Here Historic Soil data is collected from Soil Health Card issued by the Department of Agriculture, Government of India.
- The output from the ARIMA model then passed through KNN-Classifier for crops where the region's forecasted values are classified against the typical nutrient values required by different crops for optimum growth, as shown in Table I.

- Similarly, for the fertilizer prediction, the output from the ARIMA model is given to KNN-Classifier for fertilizer, where the forecasted values are classified against the nutrient level provided by different combinations of organic fertilizers. Table II is a sample data for KNN-Classifier in for the nutrient level.
- The output of classifiers are displayed on the web application along with the cultivation guide and predicted fertilizer for that crop.

TABLE I. DATABASE OF THE IDEAL NUTRIENT LEVEL OF CROPS

CROPS	Variable of Input				
	N	*P*	*K*	*pH*	*Temp*
Garlic	142	24	105	6.5	15
Onion	155	60	132	6.5	23
Orange	135	16	110	6.75	24
Peas	125	20	105	6.5	22
Potato	170	22	220	5.25	20
Rice	217	68	256	5.5	31
Tomato	136	24	192	6.25	23
Sugarcane	225	62.5	112.5	6.5	35

TABLE II. DATABASE FOR BIOFERTILIZERS OF CROPS

Biofertilizers (Azotobacter)	Variable of Input		
	N	*P*	*K*
Pisolithus sp.	125	97	63
Sclerocystis sp.	125	97	57
Acaulospora sp.	125	97	70
Pisolithus sp.	125	95	63
Sclerocystis sp.	125	95	57
Acaulospora sp.	125	95	70
Pisolithus sp.	125	107	63
Sclerocystis sp.	125	107	57
Acaulospora sp.	125	107	70

D. *Route Mapping for Farm Vehicles*

Route mapping for farm vehicles is on the rise, with advances in farm automated vehicles now being developed. There are many ways in this could be achieved, such as Drone Imagery, Local Navigation System, etc. These techniques might be feasible in some parts of the world only due to regional restrictions by the government and field locations. Satellite Imagery slots in to be the solution as it is not only available worldwide but also utilizes less of manual interference for operation. The images for the prototype testing were taken from Google Earth. The procedure is as mentioned below.

- Binary Image Extraction
- Post Extraction and Continuity of Points

The primary task from binary image extraction is to extract/isolate the field from the satellite image. The task is done using morphological image processing techniques, as is observed to produce better object extraction against other available methods during the prototype development. The morph opening is applied, followed by a morph closing technique to generate a near proper binary image of required pixels. To even further increase the efficiency, this is morphed over a rectangular kernel.

The process of post-extraction and continuity of points contains several steps:

- *Step 1*: Shi-Tomasi technique based 'Good Features to Track' function is used to isolate the corners of the obtained binary image.
- *Step 2:* Set of equidistant points are plotted along the line joining the corners and forming a pseudo quadrilateral with equidistant points as the corners.
- *Step 3:* The labeling order is decided based on the number of points on each side. i.e., if the number of points along a set of opposite sides is more. The labeling is done along this corner first, and the same order is continued. Due to the muddy terrain, it is difficult for the farm vehicles to turn around with ease. Moreover, the proposed solution would generate a route keeping in mind that the least turns are utilized for the vehicle to traverse around the field.
- *Step 4:* The points are joined based on the label starting from 1 till the end. Thus, forming the route required by the farm vehicle to traverse around with the least number of turns.

IV. PERFORMANCE AND ANALYSIS

There are two results from the proposed system, the first one is classifier for crops and predicted fertilizer using ARIMA and K-NN, and the second one is the image processing for the map of farming land. Fig. 4 is the result of the classifier in crops and Fig. 5 is the result of the prediction of the best bio-fertilizer. These outputs are shown in web applications.

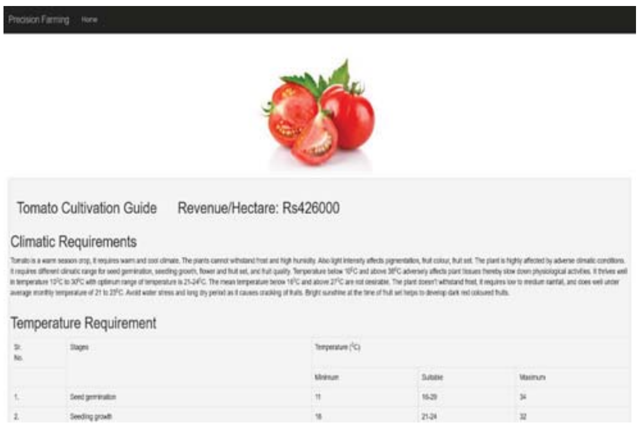

Fig. 4. Result for prediction of the better crop to grow for the submitted details

Fig. 5. Result for prediction of the bio-fertilizer combination

Fig. 6 is a satellite image of a farm field in Chennai. Above is the input data for image processing to get the point base of a farm field. The satellite image extracted into binary images by taking the main features only. Fig. 7 is the sample of binary image form Fig. 6. This image is the result of step 1 in image processing. Fig. 8 shows the output of Shi-Tomasi and continuity of point's algorithm on the binary extracted image. The Continuity of Points Algorithm defines the shortest path traced by points, for example, Comparing the Horizontal and vertical traversing of points. Fig. 9 shows the Farm selection on the map and can enter the values of N, P, K, PH, and Temperature Manually /Automatic from the techniques mentioned above.

Fig. 6. Before extraction of a farm in Chennai

Fig. 7. After extraction of a farm in Chennai

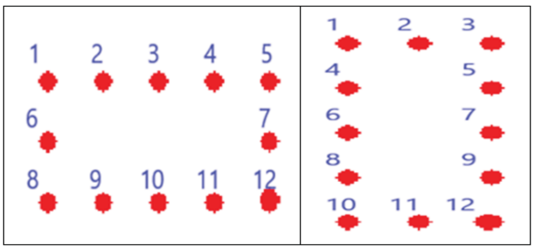

Fig. 8. Horizon and vertical labeling of the base of the points on orientation

The primary web page designed for our Project Prototype and the Satellite image downloaded on the web page is from Google maps API. For Example, The Satellite Image shown in the figure is the location of NIIT University, Neemrana, Rajasthan, India. On the web page, we have two options Contact and Analyze options where users can use them for any troubleshooting purposes after entering the values of the Nutrients of the Soil.

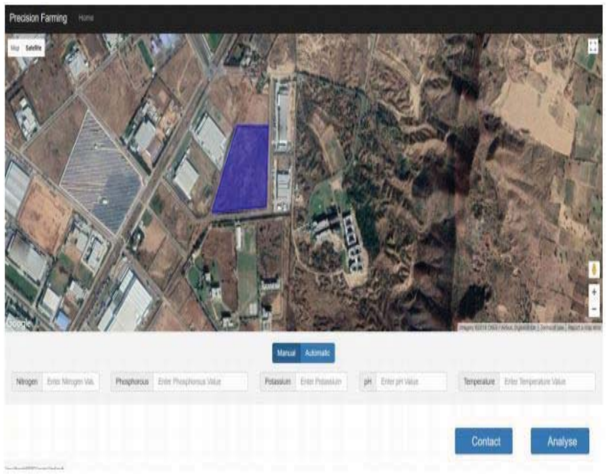

Fig. 9. The selected land for smart farming

V. Conclusion and Future Work

In the above work, the Predictive investigation service is utilized to recommend the main three most appropriate yields dependent on the nourishment levels of the Soil, temperature, and furthermore, the average income that this specific harvest could create. There are two different ways by which this could be utilized. One would be the programmed way wherein the rancher chooses their area and dependent on the past test that was directed at or close to that place; an appropriate yield recommended. The second route is to physically enter the subtleties of the dirt quality and afterward get an appropriate yield for the entered in worth. Bio-Fertilizers, for example, Azotobacter, Pencilium are recommended dependent on the entered qualities. An entry for the ranchers where they could send in their inquiry to an agro master and furthermore get in touch with them for further subtleties.

A mechanical base for future improvement for robotized vehicles, for example, rambles and mechanized tractors, has been arranged, and in future, Agricultural Drones with sensors and picture preparing ideas would give ranchers inventive approaches to build the yield and abbreviate the harvest harm. In creating nations, for example, India and Brazil, a large portion of the medium-scale and little scale ranchers still use customary strategies to develop crops which on occasion, influences the dirt wellbeing, for example, the developing a similar yield again and again and utilization of over the top manures. The ranchers would massively profit with these canny innovations, which could enable them to boost their incomes without enormous speculations. This thought is relied upon to be brought into the market and executed presumably over a membership-based B2C model.

References

[1] Pooja et. Al, "Application of MQTT protocol for real-time weather monitoring and precision farming", 2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT).

[2] Rob Dolci et. Al, “IoT Solutions for Precision Farming and Food Manufacturing: Artificial Intelligence Applications in Digital Food”, 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC)

[3] David J. Mulla, “Twenty five years of remote sensing in precision agriculture”, from https://experts.umn.edu/en/publications/twenty-five-years-of-remote-sensing-in-precision-agriculture-key.

[4] Roldan,“Robots-in-agriculture-state-of-art-and-practical-experiences”

[5] Anderson and Gaston, "Lightweight unmanned aerial vehicles will revolutionize spatial ecology" https://esajournals.onlinelibrary.wiley.com/doi/10.1890/120150

[6] Bauckhage and Kersting, “Data mining and pattern recognition in agriculture”, KI – Ku nstliche Intelligence 27(4):313-324’, · October 2013 from http://ceur-ws.org/Vol-1458/LWA2015_Proceedings.pdf

[7] Jetendra Joshi et. Al, "Machine Learning-Based Cloud Integrated Farming", 2017 International Conference on Machine Learning and Soft Computing.

[8] Dimitriadis and Goumopoulos, “Applying Machine Learning to Extract New Knowledge in Precision Agriculture Applications”, IEEE Computer Society Washington, DC, USA.

[9] Andrea Colantoni et. Al, "Smart Machines, Remote Sensing, Precision Farming, Processes, Mechatronic, Materials, and Policies for Safety and Health Aspects", https://doi.org/10.3390/agriculture8040047.

[10] B.J. Van Alphen, "Precision Nitrogen Fertilization: A case study for Dutch arable farming", Laboratory of Soil Science and Geology, Netherlands.

[11] Judith Tsouvalis, Susanne Seymour, Charles Watkins, "Precision Farming, Yield mapping, and Expert-Farmer Interface".

[12] Santhosh K Seelan, Soizik Laguatte, Grant M Cassady, George A Seielstad, “Remote Sensing applications for Precision agriculture”.

[13] S.E Cook, R.G.V. Bramley, “Precision agriculture-Opportunities, benefits and pitfalls of site-specific crop management in Australia”, Australian Journal of experimental agriculture, 1998.

[14] Philipp Lottes et. Al, “UAV-based crop and weed classification for smart farming”, 2017 IEEE International Conference on Robotics and Automation (ICRA).

[15] R, Ganesh Ram et. Al, " Smart Farming System Using Sensors for Agricultural Task Automation", 2015 IEEE Technological Innovation in ICT for Agriculture and Rural Development (TIAR)