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Variability reduction using variable rate drip irrigation (VRDI) in Vineyard

Dr. Itamar Nadav, Netafim, Maggal, Kibbutz Maggal, Maggal 3888000, Israel; itamar.nadav@netafim.com (presenting author)

Most of the vineyards worldwide are subjected to spatial variability, exhibits in areas with lower yield than the rest of the plot. In addition to the spatial variability in yield there is also variability in the quality of grapes and thus for the produced wine. In most cases the cause for variability is the available water for the vines in the different growth stages, vines on soils with low water holding capacity will grow to be smaller and produce less yield than vines on high water holding capacity soils. The new irrigation concept we developed the VRDI gives an answer to the variability found in vineyards. The VRDI system divides the vineyard into 30 by 30-meter irrigation zones where each zone can be irrigated separately according to NDVI maps and compensating irrigation method. The first VDRI system was installed in Israel in a 2006 Syrah red wine variety on a 1.2 ha plot size. On the year before the installation we collected data on the spatial variability in the vineyard such as: LAI, leaf water potential, yield quantity and quality and wine produced from different locations at the plot. The trend found was reduced yield, LAI and canopy size along the rows from south to north while at the same time increased water potential values and increased quality. At the first year of operating the VRDI system the trend found in previous year was vanished. The yield, LAI, canopy size, water potential and primary juice chemical analysis were very similar in comparison to previous years. The elimination of the spatial variability was due to different irrigation for each zone. The low NDVI value zones got more water than the high NDVI value zones and thus the canopy sizes and all other parameters where eventually similar.

Keywords:

variability, drip irrigation, NDVI

A Machine Vision System for Automatic Grading of Golden Delicious Apple Based on Color Homogeneity

Dr. Mehdi Jahangiri, Dept of AgroTechnology, College of Abouraihan, University of Tehran, Tehran, Iran; mehdijahangiri@ut.ac.ir (co-author)

Dr. Redmond Ramin Shamshiri, Adaptive AgroTech Research Group Int, 401 Brittany Rd, Seaside, CA 93955, United States of America; redmond@adaptiveagrotech.com (presenting author)

Defective spots on apple fruit, depending on the growth condition and storage have diverse irregular shapes and colors values. A conventional technique to determine these random spots, as suggested by previous studies, is to set the extent of pixels value of the defected area and use that as the threshold to assess the defects. However, the main issue with this technique is that it can be easily disturbed with the light source of the environment, imposing a significant increase in time for an efficient computer image processing. In addition, this technique becomes inaccurate when it comes to the detection of Blister spots and insect's bites. In this study, we proposed a different image

processing algorithm based on skin color homogeneity of the apples to extract their physical appearance and quality. The principle was to establish a correlation between degrees of normality in the distribution of the fruit color histograms and the homogeneity in their skins' color. We introduced a statistical parameter that is specific for golden delicious apple cultivar. Our results were validated on 86 randomly selected apple fruit samples with two human experts that graded them based on their skin color into three classes of (i) excellent appearance, (ii) fairly accepted and (iii) rejected. The accuracy of the result for each of the graded classes was 90%, 95%, and 88% respectively.

Keywords:

Apple, image processing, machine vision, grading, homogenous color

Development of UAV-based Yield Monitoring and Inventory Management System for Oil Palm Plantations

Dr. Redmond Ramin Shamshiri, Smart Farming Technology Research Center, Dept of Bio and Ag Eng, Faculty of Eng, Universiti Putra Malaysia, Serdang, Selangor, Malaysia; raminshamshiri@upm.edu.my (presenting author)

Ms. Bahareh Kalantar, Geographic Information System Lab, Department of Civil Engineering, Faculty of Engineering, UPM, 43400 Selangor Serdang, Malaysia; bahare_kgh@yahoo.com (co-author)

Prof. Dr. Desa Ahmad, Smart Farming Technology Research Center, Dept of Bio and Ag Eng, Faculty of Eng, Universiti Putra Malaysia, 43400 Selangor Serdang, Malaysia; desa@upm.edu.my (co-author)

Assist. Prof. Muhammad Razif Mahadi, Smart Farming Technology Research Center, Dept of Bio and Ag Eng, Faculty of Eng, Universiti Putra Malaysia, 43400 Selangor Serdang, Malaysia; razifman@upm.edu.my (co-author)

Assoc. Prof. Siti Khairunniza Bejo, Smart Farming Technology Research Center, Dept of Bio and Ag Eng, Faculty of Eng, Universiti Putra Malaysia, 43400 Serdang, Malaysia; skbejo@upm.edu.my (co-author)

Quantification of the amount of oil palm fresh fruit bunches (FFB) is an intensive labor task that is either ignored or is carried out manually by the use of hand counters. High spatial resolution images captured with UAV drones offer a reliable prospect to detect palm trees and estimate their fruit yield. The objective of this study was to develop a low-cost remote sensing platform by integrating a UAV imagery system and real-time robust machine vision algorithm for automated yield monitoring in oil palm plantations. Data collection was carried out by flying a multi-rotor Onagofly Nano Smart 1 Plus drone equipped with streaming RGB Camera and GPS Control over and inside an oil palm plantation in Melaka Pindah located on the South-West coast of Malaysia Peninsula. Selected images were matched in Agisoft PhotoScan using ground control points acquired with GPS for the registration process. Registered images were mosaicked to generate a panoramic image from which the study area was subset. Template matching and object-based image analysis technique were performed by calculating the cross-correlation between the ground truth shapes of the fruit bunched and the image. Several templates were identified in the original image and the template with the

highest R2 was selected. Results were exported into GIS software to automatically count the number of FFB in each image. The accuracy of the results for FFB was found to be 87% (582 detected versus 509 ground truth). Future steps of the project involve improvements of the sensing system and detection algorithm and automating the analysis procedure into a simplified mobile application for growers and non-technical users.

Keywords:

Quantification, Oil Palm, yield, Palm census, UAV imagery

Digital Crop Advisor ' A smart Bayer tool to transfer knowledge

Albert Schirring, Bayer CropScience AG, Crop Strategy and Portfolio Management, Alfred-Nobel-Straße 50, 40789 Monheim, Germany; albert.schirring@bayer.com (co-author)

Dr. Dirk Schaefer, Alfred Nobelstrasse 50, 40789 NRW Monheim am Rhein, Germany; Dirk.Schaefer@bayer.com (co-author)

Soni Munish, Bayer CropScience Limited, Bayer House, Hiranandani Estate, Thane, 400607, India; munish.soni@bayer.com (presenting author)

According to the FAO, the globe requires 50% more agricultural produce by 2050 to support the growing world population. , A large portion of the additional demands will be required for Asia and Africa. Fruit and vegetable production in these regions relies on the productivity of 500 – 700 mio small holder farmers. At current status, productivity at these farms is hampered by lack of access to quality inputs (seeds, nutrients and crop protection), low mechanisation, and limited investment in land improvement, poor infrastructure and transportation, lack of processing facilities, market information and exposure to volatile market prices. Actual yield gaps are more than 70%. In a fragmented market like India, farmers are grappling with lower productivity issues and are in desperate need of information which is accurate, real-time and consistent. It is physically impossible to reach out to all these farmers on a regular basis. In 2017 Bayer developed the Digital Crop Advisor connecting on real time basis with horticulture farmers using the smart phone as a platform to transfer know-how and expertise to improve sustainable production methods.

Digital can act as an “integrator” for farmers, can enable reach and provide desired agro advisory on real-time basis. Bayer has been engaged with farmers by providing innovative products and services by reaching out to these millions of farmers. In order to further complement this, Bayer initiated testing its ‘digital advisor’. This mobile based farming application provides information on weather forecast, mandi (market) prices, Bayer products, diseases, pests, customized cropping calendars with suitable agronomic practices and disease alerts. Features like digital fieldmap creation, track & trace (to check authenticity of Bayer products), retailer location and ROI calculators are included. The tool will be piloted on grapes, tomato and apple crops in selected geographies. It will be launched in English and other relevant regional languages.

Keywords:

Digital Farm Advisor, Digital Farming, Horticulture, Customized Agronomic Solutions

MOVIDA: a decision support tool to help the winegrower mitigate yield loss

Albert Schirring, Bayer CropScience AG, Crop Strategy and Portfolio Management, Alfred-Nobel-Straße 50, 40789 Monheim, Germany; albert.schirring@bayer.com (co-author)

Mr. Koji Fukuhara, Bayer SAS, 16, Rue Jean-Marie Leclair, 69009 Lyon, France; koji.fukuhara@bayer.com (co-author)

Dominique Steiger, Bayer AG, Division Crop Science, Alfred-Nobel-Strae 50, 40789 Monheim, Germany; dominique.steiger@bayer.com (presenting author)

Grapes are one of the major crops in Europe with 3.2 mha. Spain, France, Italy, Portugal, Romania, Greece and Germany, represent 94% of the European production. 92% of the grape growing area in Europe is dedicated to wine production. Diseases such as Downy mildew (Plasmopara viticola) and Powdery mildew (Erysiphe necator) can reduce both yield and quality of the wine produced. Therefore, an adequate protection is required. To do so, Bayer developed MOVIDA, a Decision Support Tool (DST) which aims at supporting the winegrowers to optimize their practices and enhance their profitability. Based on field-specific agronomic data and historical and forecast weather conditions, it helps the user determine downy mildew and powdery mildew contamination risks and better manage his spray program. This DST is already commercialized in France and in calibration in other countries such as Spain, Italy and Portugal, using agro-climatic data calibrated over the years with trials set up by Bayer to provide information on grapes life cycle such as growth stage, epidemiology of Powdery and Downy mildews and effects of active ingredients on them. Developed since 2008, this DST is currently reshaped to provide a more flexible and user-friendly interface which would allow numerous new applications such as automatic recognition of diseases, variable dose application or new diseases models. This new MOVIDA tool will allow an optimum positioning of biological products for a sustainable grapes protection and will support change for an environmental friendly precision viticulture.

Keywords:

Grapes, Plasmopara viticola, Erysiphe necator, Decision Support Tool, Sustainability

Evaluating whether multispectral vegetation indices can estimate leaf area index of pecan orchards

Assist. Prof. Yahia Othman, Department of Horticulture and crop Science, The University of Jordan, Amman, Jordan; ya.othman@ju.edu.jo (presenting author)

Prof. Rolston St. Hilaire , Plant and Environmental Sciences, New Mexico State University, Las Cruces New Mexico, United States of America; rsthilai@ad.nmsu.edu (co-author)

Plant physiologists use leaf area index (LAI) as an essential tool to predict vegetation cover, growth and yield. The objective of this two-year study was to determine whether multispectral reflectance indices derived from Landsat 7 Enhanced Thematic Mapper (ETM+) can estimate LAI of pecan orchards. The study was conducted on two mature (20-30 years old) pecan orchards, one growing on a sandy loam soil and the other on a clay loam soil. Ground reference LAI measurements were synchronized with overpasses of Landsat ETM+ satellite acquisition times. For both orchards, single band surface reflectance, band ratio and vegetation indices were determined and their correlations with LAI were assessed. At sandy loam site, ground reference LAI ranged from 1.11 to 2.06. At the clay loam site, LAI was between 1.01 and 1.60 across the growing seasons. Our results revealed that surface reflectance from single bands did not significantly correlate with LAI at both sites. Additionally, the relationship between LAI and most studied vegetation indices was inconsistent or/and not significant across both orchards (sandy and clay sites). However, three vegetation indices showed significant correlation (P-value < 0.05) with LAI in both pecan orchards. In the orchard grown on the sandy soil, the correlation coefficient (r) for normalized difference infrared Index-band 5 (NDII5) was 0.84, enhanced vegetation index (EVI) and green normalized difference vegetation index (GNDVI) was 0.83. The correlations for the orchard grown on the clay soil were, NDII5 = 0.75, EVI = 0.65 and GNDVI = 0.63. Overall, we conclude that multispectral data derived from Landsat ETM+ hold promise for estimation of the LAI of pecans grown on clay and sandy soils.

Keywords:

Landsat ETM+, remote sensing, chlorophyll, band ratio, NDVI

Estimating chlorophyll content of grafted cucumber seedlings using hyperspectral images

Prof. Dr. Yong Hyeon Kim, Dept. of Bioindustrial Machinery Eng., College of Agriculture & Life Sciences, Chonbuk National University, 561-756 Jeonju, Korea (Republic of); yhkim@jbnu.ac.kr (presenting author)

Mr. Sunghyuk Jang, 567 Baekje-daero, deokjin-gu, Dept. of Bioindustrial Machinery Engineerin, Chonbuk National University, 54896 Jeonju, Korea (Republic of); sung@jbnu.ac.kr (co-author)

Grafting is one of popular techniques to produce high-quality seedlings in nurseries. However, quality of grafted seedlings was greatly affected by the physical environment during healing stage. Hyperspectral imagery was used to estimate chlorophyll content of grafted cucumber seedlings healed under artificial lighting sources. In this study, cucumber (Cucumis sativus L. cv. Joeun Baekdadaki) and figleaf gourd (Cucurbita ficifolia, cv. Heukjong) were used as scion and rootstock, respectively. Grafted seedlings were healed under red, blue, or white LED (light-emitting diodes) used as artificial lighting sources. Hyperspectral images of grafted seedlings were daily acquired for 10 days just after grafting by using a HYPERSPEC VNIR camera (Headwall Photonics, USA) over the 380-1000 nm wavelength range. Pre-procession of measured data was performed by using an ENVI

(V5.4, Harris Corporation, USA). Then spectral reflectance of grafted seedlings was determined by a MATLAB (R2012, MathWorks, USA). Chlorophyll content of grafted seedlings was measured by a portable chlorophyll meter (SPAD 502 PLUS, Spectrum Technologies, USA). The correlation coefficient spectrum and the stepwise multiple linear regression of SAS (V9.3, SAS Institute Inc., USA) were used for selecting significant wavelengths of 472, 486, 546, 571, 671, 713, and 727 nm. Correlation coefficient spectrum produced a coefficient of determination for the validation data set was 0.8 and a root mean square difference of 2.82%. It was concluded that hyperspectral reflectance imaging could be a good potential for estimating chlorophyll content of grafted cucumber seedling.

Keywords:

Chlorophyll content, grafting, hyperspectral imaging, spectral reflectance, artificial lighting sources

Spectral imaging for evaluation of spatial distributions of leaf photosynthetic light use efficiency

Dr. Keach Murakami, 1677-1, Yoshida, Yamaguchi-shi, Yamaguchi 7538515, Japan; keach.murakami@gmail.com (presenting author)

Prof. Yasuomi Ibaraki, 1677-1, Yoshida, Yamguchi-shi, Yamaguchi 7538515, Japan; ibaraki@yamaguchi-u.ac.jp (co-author)

Evaluating intra-plant spatial distributions of photosynthetic light use efficiency (LUE; photosynthetic rate per photosynthetic photon flux density (PPFD)) may help improving light environmental control in horticultural systems (e.g. interlighting in greenhouses). Photochemical reflectance index (PRI), a parameter calculated from leaf spectral reflectances at two wavebands, represents a positive correlation with LUE (Garbulsky et al. 2011) and thus may be applicable for LUE monitoring. However, most previous studies on PRI imaging have focused on the application to large-scale and/or long-term monitoring (e.g. satellite-based phenology). The aim of this study is to examine the applicability of PRI imaging for small-scale (i.e. leaves to whole-plant) and short-term (i.e. hourly to daily) LUE monitoring. Dark-adapted leaves of 2-week-old cucumber seedlings were subjected to the following PRI imaging. Time-lapse images of the leaves and a reflectance standard were captured using two CMOS cameras with band-pass filters and PRI values of binned pixels were calculated according to Gamon et al. (1997). Time-courses of PRI after the commencement of irradiation at several PPFDs were measured and compared with those of the photochemical yield of photosystem II (YII, also known as ΦPSII), which is highly correlated with LUE (e.g. Genty et al. 1989). Irrespective of the PPFDs, YII dropped sharply after the commencement of irradiation and then recovered gradually to the stable values. The PRI followed the decrease phases with time delays irrespective of the PPFDs while the recovery phases were only observed under low PPFD conditions. The differences between PRI values at dark- and light-adapted states represented a considerable correlation with the steady state YII. These results suggest that PRI imaging may be applicable for detecting a drop in LUE and estimating spatial distributions of steady-state LUEs in horticultural systems. Up-to-date results including estimated spatial distributions of leaf photosynthetic rates by spectral imaging will be shared.

Keywords:

PRI, Chlorophyll fluorescence, Proximal remote sensing

Proximal detection using robotics for vineyard monitoring: A concept

Dr. Carlos Poblete-Echeverría , Department of Viticulture and Oenology, Faculty of AgriSciences, Stellenbosch University, Stellenbosch, South Africa; cpe@sun.ac.za (presenting author)

Albert Strever, Department of Viticulture and Oenology, Faculty of AgriSciences, Stellenbosch University, Stellenbosch, South Africa; aestr@sun.ac.za (co-author)

Mr. Berno Greyling, Institute for Wine Biotechnology, Stellenbosch University, Stellenbosch, South Africa; btg@sun.ac.za (co-author)

Dr. Melane Vivier, Institute for Wine Biotechnology, Department of Viticulture and Oenology, Stellenbosch University, Stellenbosch, South Africa; mav@sun.ac.za (co-author)

The South African viticultural industries are susceptible to the impacts of the climate change and in particular stresses related to water scarcity. One approach to provide alternative solutions to the industry towards sustainability and productivity of the industry despite the constraints is to invest in technological solutions for better vineyard management. The monitoring of vineyards using modern technologies such as robots and sensors offers potentially exciting solutions to support advanced management decisions and/or adapted production strategies. In this context, The Viticulture platform of the Institute for Grape and Wine Science (IGWS) of Stellenbosch University (SU) implemented a flagship project with the aim to promote sustainable viticulture practices by using advanced technology to improve the monitoring process in field conditions. A remote-controlled prototype robot was developed and are being tested in vineyards in combination with an array of sensors (laser LIDAR scanner, non-contact electromagnetic induction device (EM38), thermal cameras, and high definition cameras) of defined stresses to gather information through the seasonal progression and/in conditions. The information collected by the robot-sensor interface is used to implement models and procedures for yield prediction, canopy characterization, and water management, amongst others. This paper describes the main characteristics of the project, technological tools, and sensors used for monitoring as well as the main results of experimental tests obtained thus far. Further functions and developments are being implemented in collaboration with strategic partners by considering challenges and opportunities within global viticulture, but with a particular focus on the South African scenario.

Keywords:

Modelling; precision viticulture; Image analysis; climate change

Long-term assessment of variable rate N-fertilization in a Vitis vinifera L. cv. Barbera vineyard

Assoc. Prof. Matteo Gatti, Via E. Parmense, 84, 29122 Piacenza, Italy; matteo.gatti@unicatt.it (presenting author)

Alessandra Garavani, Via E. Parmense, 84, 29122 Piacenza, Italy; alessandra.garavani@unicatt.it (co-author)

Cecilia Squeri, Via E. Parmense, 84, 29122 Piacenza, Italy; cecilia.squeri@gmail.com (co-author)

Dr. Tommaso Frioni, Via E. Parmense, 84, 29122 Piacenza, Italy; tommaso.frioni@unicatt.it (co-author)

Dr. Paolo Dosso, Via A. Costa, 17, 20037 Paderno Dugnano(MI), Italy; p.dosso@terradat.it (co-author)

Prof. Stefano Poni, Via E. Parmense, 84, 29122 Piacenza, Italy; stefano.poni@unicatt.it (co-author)

Variable rate technologies allow site-specific management of parcels characterized by different levels of vigor and/or yield. N-fertilization based on actual plant needs is one of the most promising applications of precision farming aiming at improving efficiency, optimizing yield-to-quality relationship as well as limiting environmental impact. Despite this strategy appears suitable for developing new viticultural models, few experiences validating this hypothesis are available in the literature. Based on a pre-trial remotely sensed vigor map (NDVI-derived, 5m resolution) a four-year study was performed in a Vitis vinifera L. cv Barbera vineyard sited in the Colli Piacentini wine district. Vigor level (L = low, M = medium and H = high) and fertilization strategy (Standard, variable rate application -VRA and unfertilized Control) were the main factors in a randomized block design. For each vigor level the study compared no N-supply (0 kg/ha), standard supply (60 kg/ha) and VRA supply delivering 0, 60 and 120 kg/ha to H, M and L, respectively. Post-trial effects were assessed by remote and proximal sensing considering a 5m multispectral image and a Very High Resolution characterization of the canopy growth, respectively. Vine growth, yield, leaf nutritional status and fruit composition were assessed. Results show that variability among vigor levels was significantly reduced over year 3 and 4, whereas effects related to fertilization strategy were often non-significant. The Canopy Index calculated by proximal sensing proved that VRA was able to reduce variability among vigor levels (CV = 1.42%) vs. standard fertilization at 60 kg/ha (8.20%). Leaf area did not vary among strategies whilst N-fertilization affected yield and vine balance. Despite VRA increased yield as compared to Standard, technological and phenolic maturity was similar in both fertilization strategies. The VRA reduced N waste in H while vines from L blocks showed a low sensitivity to increased N-supply.

Keywords:

Precision Viticulture, Remote Sensing, Vigor, Vine Balance, Mineral Nutrition

Studying spatial and temporal variability of a Barbera vineyard with traditional and precision approaches

Assoc. Prof. Matteo Gatti, Via E. Parmense, 84, 29122 Piacenza, Italy; matteo.gatti@unicatt.it (presenting author)

Cecilia Squeri, Via E. Parmense, 84, 29122 Piacenza, Italy; cecilia.squeri@gmail.com (co-author)

Ekaterina Kleshcheva, Via E. Parmense, 84, 29122 Piacenza, Italy; kater906@gmail.com (co-author)

Alessandra Garavani, Via E. Parmense, 84, 29122 Piacenza, Italy; alessandra.garavani@unicatt.it (co-author)

Dr. Massimo Vincini, Via E. Parmense, 84, 29122 Piacenza, Italy; massimo.vincini@unicatt.it (co-author)

Prof. Stefano Poni, Via E. Parmense, 84, 29122 Piacenza, Italy; stefano.poni@unicatt.it (co-author)

Land is variable and vine performances reflect such variability. Precision viticulture, based on remote sensing and variable rate technologies, is a valuable tool for its description and management. Because vineyard monitoring can be accomplished through different platforms, a wide array of solutions is now available combining different spatial and spectral resolutions, revisit time and cost. Challenge is selecting the most sensitive and cost-effective solution for facing specific technical issues. The research aims at comparing the sensitivity of four different platforms in detecting within-field vigor variability of a Barbera vineyard established in the Colli Piacentini wine district (NW of Italy).

A panel of 8 vines was selected for each of three vigor classes (L = low, M = medium and H = high) as previously identified by a 5m resolution vigor map referred to July 2014. In 2016, physiological, agronomical and enological parameters were measured. Remote (satellite and drone acquisitions at 10m, 6m and 5cm resolution) and proximal images (approximately one reading per vine) acquired in July 2016 were processed by calculating vigor indices and validated according to field data. Seasonal trend of Sentinel-2 derived NDVI values was described for each vigor class. Data were processed through linear regression and analysis of variance.

Results show L and H vines always demonstrated different growth, yield and ripening patterns. This variability was successfully detected by satellite imagery and close correlations between Sentinel-2 and SPOT-derived NDVI values with vegetative, yield and grape composition parameters were found. Conversely, performance of UAV-derived multispectral indices was not satisfying as well. Canopy Index provided by proximal sensor MECS-VINE® was highly sensitive to vigor variation at a single plant scale.

Open source Sentinel-2 allowed separating H and L areas over season suggesting potential suitability for vineyard monitoring and management under the experimental conditions. More consistent results require long-term confirmation.

Keywords:

Satellite Imagery, UAV, Remote Sensing, Proximal Sensing, Ground-truthing, Viticulture

Is machine learning efficient for mango crop yield estimation when used under heterogeneous conditions?

Mr. Julien Sarron, CIRAD, UPR HortSys, Campus International de Baillarguet, 34398 Montpellier, France; julien.sarron@cirad.fr (presenting author)

Dr. C.A. Bassirou Sané, Centre pour le Développement de, l'Horticulture, ISRA, Dakar, Senegal; cheikh84amet.bass@gmail.com (co-author)

Dr. Philippe Borianne, CIRAD, UMR AMAP, TA A51PS2, 34398 Montpellier, France; philippe.borianne@cirad.fr (co-author)

Dr. Eric Malézieux, CIRAD, UPR HortSys, Campus International de Baillarguet, 34398 Montpellier, France; eric.malezieux@cirad.fr (co-author)

Dr. Paterne Diatta, Centre pour le Développement de , l'Horticulture, ISRA, Dakar, Senegal; djilesso@yahoo.fr (co-author)

Dr. Frédéric Normand, CIRAD, UPR HortSys, Campus International de Baillarguet, 34398 Montpellier, France; frederic.normand@cirad.fr (co-author)

Dr. Faye Emile, CIRAD, UPR HortSys, Campus International de Baillarguet, 34398 Montpellier, France; emile.faye@cirad.fr (co-author)

In the last decade, image analysis through machine learning algorithms proved to be an effective tool for plant organs detection and counting. Numerous studies provide fruit tree yield estimates based on machine learning with high levels of efficiency. However, most studies were conducted under homogeneous conditions of fruit appearance and light. The aim of this study was to develop a highly efficient machine learning method for ripe mango fruit detection from color images and apply it in heterogeneous conditions for in situ fruit yield estimation in Senegal. The algorithm consisted in a k-nearest neighbors (KNN) classification based on color and texture indices (3 indices selected among 20 using a ranking feature method) followed by a post-treatment based on shape indices. The F1 score, which considers precision and recall performances, was 0.72 for a homogeneous set of about 3000 visible fruits over 62 images of Kent mango trees with similar visual appearance under steady light conditions. The algorithm was then calibrated and used on a second set of 600 images of 300 trees representing the in situ heterogeneity in tree structure (height, canopy volume) and variety (Kent, Keitt and Boucodiékhal) found in Niayes region of Senegal. The F1 score was then 0.45. Even if the algorithm performed less under these conditions, a significant linear relationship was evidenced between the number of detected fruits and the actual number of fruits (manually counted for a sample of 52 trees) for each of the 3 varieties (Kent: $R^2 = 0.92$; Keitt: $R^2 = 0.93$ and Boucodiékhal: $R^2 = 0.90$). These models were used to estimate the actual fruit yields of the 300 trees, thereby leading to an average number of fruit per tree of 164.5. Those results will serve to identify factors that drive mango yield variability at the tree scale in Niayes region.

Keywords: (Last update 30 October 2017 21h27)

image analysis, automated fruit counting, k-nearest neighbors, algorithm efficiency, Senegal

Modelling Seedling Development using PAR and Thermal Effectiveness

Prof. Dr. Zhen Wu, nanjing agricultural university, nanjing, jiangsu, 210095, China; wzh@njau.edu.cn (co-author)

Ms. Tianmei Zhou, nanjing agricultural university, nanjing, jiangsu, 210095, China; 370724508@qq.com (co-author)

Ms. Yachen Wang, nanjing agricultural university, nanjing, jiangsu, 210095, China; 1351107462@qq.com (co-author)

Prof. Dr. Xiaojun Su, Jiangsu Academy of Agricultural Sciences, Nanjing, 210095, China; 1084348127@qq.com (co-author)

fangling jiang, Nanjing Agricultural University, No.1 Weigang, Xuanwu district, Nanjing, China; jfl@njau.edu.cn (presenting author)

Seedling quality is a prerequisite for successful field performance and therefore influence crop yields. Temperature and illumination are two major factors affecting seedling quality during nursery propagation. Suboptimal temperature and light of nurseries generally result in leggy or weak seedlings and great economic loss. However, production of healthy seedlings is challenging due to the lack of knowledge in systemic management of nursery environments, particularly in temperature and light. In this study, we have established simulation models to predict how temperature and illumination coordinately influence the growth of tomato and cabbage seedlings. Correlation between seedling quality characteristics (root-shoot ratio, G value, three kinds of healthy indexes) and accumulated product of relative thermal effectiveness (RTE) and photosynthetically active radiation(PAR) (TEP) were explored to establish the models that were validated with different independent test data. Our results suggested that the curve of healthy index 1 [HI1 = (stem diameter/height) × dry mass of seedling] and TEP fitted well with high coefficient of determination (R2) in both tomato and cabbage; indicating that the model is highly reliable and can be used for predicting vigor of tomato and cabbage seedlings grown under different temperature and light conditions, in addition, these models can provide us with an instructive tool that is useful for both temperature and light management during the nursery phase of production.

Keywords:

Tomato, Cabbage, Simulation Model, Healthy Index, G value

ASSESSMENT OF IRRIGATION PERFORMANCE WITH THE USE OF AN UNMANNED AERIAL VEHICLE (UAV)

Assoc. Prof. Simon White, University Drive, Bundaberg Qld 4670, Australia; s.c.white@cqu.edu.au (presenting author)

Dr. Richard Koech, Central Queensland University, University Drive, Bundaberg Qld 4670, Australia; r.koech@cqu.edu.au (co-author)

Dr. Chengyuan Xu, Central Queensland University, University Drive, Bundaberg Qld 4670, Australia; c.xu@cqu.edu.au (co-author)

A rapidly emerging technology platform being adopted in Australia agriculture is the use of multispectral and infrared sensors on board unmanned aerial vehicles (UAV). In high value crops such as horticulture, this technology could play a role in the remote assessment of irrigation system performance. One key indicator of irrigation performance/efficiency is distribution uniformity. For existing irrigation systems a catch-can test is currently used to assess distribution uniformity. However, due to time and labour constraints this test is normally only conducted during a single irrigation event at one sample location within the irrigation system. As such, it may not be representative of the field or season as a whole. For proposed irrigation systems, irrigation designers can use hydraulic simulation models to ensure the whole field irrigation design can achieved a predetermined level of distribution uniformity. However, it is far too common that irrigation systems are designed and installed without such modelling conducted.

This study was a proof of concept that routine UAV image capture of crop growth combined with a suitable parameterised hydraulic model could be used to evaluate irrigation system performance (in terms of distribution uniformity) under commercial field management and define what degree of impact non-uniformity in irrigation has on spatial crop performance through correlation analysis.

Results showed this concept is potentially more practical and comprehensive than conducting a catch can test or hydraulic simulation model in isolation and has the added benefit of accounting for other factors which influence spatial and temporal crop performance (i.e. seasonal conditions and irrigation scheduling management) in the analysis.

Keywords:

Irrigation

UAV

Drone

Precision Irrigation

Uniformity

Image-based nondestructive estimation of plant leaf area using deep learning

Dr. Yasuomi Ibaraki, Yamaguchi Univ. , Yoshida 1677-1 , Yamaguchi , Japan; ibaraki@yamaguchi-u.ac.jp (presenting author)

Mr. Junta Mizuhata, Yamaguchi Univ., Yoshida 1677-1 , Yamaguchi , Japan; u041gd@yamaguchi-u.ac.jp (co-author)

Plant leaf area is one of most important plant quantitative parameters for evaluating the growth or the canopy structure. Normally, leaf area is determined with destructive and labor intensive methods. In this study, plant leaf area was tried to be estimated simply using a single image obtained from above the canopy by machine learning. To develop a robust way for leaf area estimation, the relationships between projected area extracted from a plant canopy image and total area of leaves included in the image were investigated and the factors affecting the coefficient to convert projected area into leaf area were analyzed. One of the possible factors was leaf angle distribution and another was overlapping of leaves. Images of a single leaf were acquired while changing the inclination angle and were used for analyzing the angle effect. Images of plant canopies of several species were acquired at different growth stages for analyzing the overlapping effect. While the projected area was calculated from each image, total area of leaves contained in the field of view of the image was determined by using a scanner after detached. The ratio of the leaf area to the projected area was assigned to the each image as the conversion coefficient and used for deep learning. The conversion coefficient could be predicted using convolutional neural networks (CNN) from the image. The result suggested that deep-learning-based prediction of the coefficient to convert projected area into leaf area might be promising for easy estimation of leaf area using a single image.

Keywords:

Leaf area index, Machine learning, Projected area

Factors Affecting Bruising of Apples in Handling Operations

Prof. Dr. Bohdan Dobrzanski, IA PAN, University of Life Sciences, Department of Pomology and Nursery, ul. Leszczynskiego 58, 20-068 Lublin, Poland; bdob@ipan.lublin.pl (presenting author)

Jacek Rabcewicz, Research Institute of Horticulture, ul. Pomologiczna 18, 96-100 Skierniewice, Poland; jacek.rabcewicz@inhort.pl (co-author)

Tomasz Lipa, University of Life Sciences, Department of Pomology and Nursery, ul. Leszczynskiego 58, 20-068 Lublin, Poland; tomasz.lipa@up.lublin.pl (co-author)

Bruising at harvest, transport and loading-unloading operations are most exposed to damage, that it affected the quality of fruit. The fruit resistance to damage at transport is related to the variety and maturity stage, harvest date, type of packing and means used for transport, road surface and travel speed. The factors affected damage to fruit are: mechanical properties of fruit (skin and tissue), drop heights and various packing surfaces.

Estimating the mechanical strength of fruits 10 varieties of apple, including McItosh and Idared apples (both significant on polish marked), the resistance skin and flesh to destructive damage were

defined. To determine the response of the transport vehicles to the road surface, the values of acceleration and vibrations frequency were collected. After the harvest, the fruits were transported over a tarmac (55%) and on gravel (45%). The vibrations were recorded during each trip using three piezoelectric sensors (type KD-42). From each layer 100 fruits were taken at random (50 in contact with bin wall, 20 from the centre and 30 from between, to estimate bruising. Over 95% of vibrations on the road had accelerations below 1.5 g. Vibrations with accelerations exceeding 2.5 g were recorded for the forklifts and self-unloading trailer. The maximum recorded value of acceleration was 2.81 g, however, the maximum value of acceleration 5.22 g for the forklifts at the highest travel speed was observed. Damage resulting from impact indicated strong relationship between the damage and the energy transmitted between two fruits being in contact. On the other hand, the damage of fruit is strongly related to the container type. More extensive damage is caused by vibrations with higher acceleration values, even is their duration is short. Mechanical damage to transport strongly related to the reaction of vehicle to road surface.

Keywords:

apple, bruising, transport, vibration, acceleration, mechanical properties

Non-invasive "Electroplantogram" (EPG) of greenhouse crops and crops for real-time detection of water deficit

Dr. Cédric Camps, Agroscope, Research Division, Plant Production Systems, CH-1964 Conthey, Switzerland; cedric.camps@agroscope.admin.ch (presenting author)

Ms. Carrol Plummer, Chemin de Varmey 1, Crans-près-Céligny, Switzerland; carrol.plummer@vivent.ch (co-author)

By analogy with the electrocardiogram (ECG), the proposed term “Electroplantogram” (EPG) is a graphical representation of the digitized electrical activity of the plant. In the present study, non-invasive EPG of tomato and eggplant have been recorded and analyzed in order to detect water deficit of plant in real-time. Such perspective open the possibility to improve crop management efficiency (water, nutrient supply). The key innovations of the study are (1) monitoring directly at plant level to manage the crop and (2) performing monitoring of electrical signal of plant outside a Faraday cage.

Two case studies have been carried out. A first one aimed at to perform a long term monitoring of electrical signal in eggplant at nursery stage and analyze the electrical signal in case of water deficit. In this experiment we simulated a breakdown of the irrigation system. The results showed that it was possible to record a non-noisy EPG during several days. The electrical signal presented strong positive peaks each morning (10mV) at sunrise and at each irrigation (3 to 10mV). When an irrigation was lacking, a strong negative peak has been observed (-30mV). The experiment has been repeated 2 times with similar results.

In the second case study, tomato plant in greenhouse have been monitored for electrical signal. Similarly to eggplant, an irrigation breakdown leaded in a strong negative peak of the electrical signal (-40mV). After watering, EPG recovered its normal level the day after. A second irrigation breakdown leaded in a second strong negative peak of the EPG (-60mV).

Such novel approach need to be developed and adapted to professional greenhouse conditions. If future development bring satisfaction the greenhouse management of natural resources could be more efficient since it reply to plant behavior and because it could bring a real-time adaptations.

Keywords:

electrophysiology, electrical signal, water stress, irrigation system breakdown

Supporting the decision to harvest - a case study involving mango

Prof. Kerry Walsh, Sensors Group, Central Queensland University, Bruce Highway, North Rockhampton QLD 4702, Australia; k.walsh@cqu.edu.au (presenting author)

Dr. Zhenglin Wang, CQUniversity, North Rockhampton Qld 4701, Australia; z.wang@cqu.edu.au (co-author)

Mr. Anand Koirala, CQUniversity, North Rockhampton Qld 4701, Australia; a.koirala@cqu.edu.au (co-author)

Mr. Nicholas Anderson, CQUniversity, North Rockhampton Qld 4701, Australia; nicholas.anderson@cqumail.com (co-author)

The case study of a decision support tool supported by a range of sensor technologies is presented. This tool is supporting the decision to harvest (i.e. harvest maturation estimation) in the Australian mango industry. Fruit size and load information acquired before harvest supports orchard management decisions (e.g. labour and materials acquisition). Data is recorded and maturity modelled on a per block basis:

(i) a farm utility mounted imaging rig equipped with LED floodlighting is used in recording extent of flowering assessment, to inform select early harvesting, and/or heat sum models of fruit maturation;

(ii) wireless in-field temperature loggers also feed the heat sum models:

(iii) fruit dry matter estimated in field using handheld near infrared spectroscopy with rate of increase estimated and time to achieve a specified level estimated

(iv) fruit size can be estimated using either a mobile phone based application or using the utility mounted imaging rig (given camera to fruit distance estimation using the ToF camera)

(v) fruit load can be estimated using images acquired by the utility mounted imaging rig, with a correction factor for the proportion of occluded fruit linked to canopy structure

Night imaging was undertaken for the machine vision tasks to reduce light variability (e.g. sun-flares), background and interference to the infrared Time of Flight camera. A differential GPS receiver was used to trigger imaging of each tree. Common machine vision techniques such as Otsu's method, colour thresholding, morphological operations, Bayesian classifier and support vector machine were used to identify potential regions of interest (flowers or fruits) in the RGB images, with the false positive error reduced by an adaptable convolutional neural network classifier. All information is displayed in an interactive website foe ease of farm manager use.

Keywords:

decision support system, mango, machine vision, heat sums, degree days, near infrared spectroscopy

An efficient computational tool to discriminate olive cultivars through morphological parameters

Dr. Panagiotis Kalaitzis, Mediterranean Agronomic Inst. Of Chania, 85, Macedonia Str. P.O. Box 85, 73100 Chania, Greece; panagiot@maich.gr (presenting author)

Dr. Konstantinos Blazakis, Dep of Hort. Genetics Biotechnology, Mediterranean Agronomic Institute of Chania, 73100 Chania, Greece; blazakis@maich.gr (co-author)

Maria Ms. Kosma, Dep of Hort Genetics Biotechonology, Mediterranean Agronomic Institute of Chania, 73100 Chania, Greece; kosma@maich.gr (co-author)

Mr. George Kostelenos, Kostelenos Olive Nurseries, 18020 PorosTrizinia, Greece; info@kostelenosfytoria.gr (co-author)

Dr. Luciana Baldoni, Italian National Research Council, Institute of Biosciences and Bio-Resources, CNR-IBBR, 06128 Perugia, Italy; luciana.baldoni@ibbr.cnr.it (co-author)

Dr. Marina Bufacchi, Italian National Research Council, Inst for Agr. Forest Systems in the Med, CNR-ISAFOM, 06128 Perugia, Italy; marina.bufacchi@isafom.cnr.it (co-author)

The morphological analysis of olive fruits, leaves and endocarps may represent an efficient tool for the characterization and discrimination of cultivars and the establishment of relationships among them. In recent years, much attention has been focused on the application of molecular markers,

due to their high diagnostic efficiency and independence from environmental and phenological variables. Here, we present a semi-automatic methodology of detecting various morphological parameters. With the aid of computing and image analysis tools, we created semi-automatic algorithms applying intuitive mathematical descriptors that quantify fruit, leaf and endocarp morphological features. In particular, we examined quantitative and qualitative characters such as size, shape, symmetry, contour roughness and presence of additional structures such as nipple, petiole, endocarp surface roughness, etc.. We illustrate the performance and the applicability of our approach on fruits, leaves and endocarp images from international olive cultivars mainly from the Mediterranean Basin. Moreover, we will discuss the applicability of our methodology in the direction of olive cultivar identification based on morphological parameters. In addition, this methodology was also applied for the description of other crop species such as tomato, grapevine and pear. This allows to describe crop morphologies efficiently and robustly in a semi-automated way.

Keywords:

Morphological analysis; Image analysis; olive; fruit; leaf; endocarp; olive cultivar identification; morphological analysis of crop species.

Increasing water use efficiency in wine grape vineyards with variable rate drip irrigation

Dr. Luis A. Sanchez, E&J Gallo, 1541 Cummins Drive, Modesto, CA 95358, United States of America; luis.sanchez@ejgallo.com (presenting author)

Mr. Brent Sams, 1541 CUMMINS DR, MODESTO California 95358, United States of America; brent.sams@ejgallo.com (co-author)

Dr. Nick Dokoozlian, 1541 CUMMINS DR, MODESTO California 95358, United States of America; nick.dokoozlian@ejgallo.com (co-author)

Spatial variability in soil properties, such as water holding capacity, causes variability in fruit yield and quality. Ideally, irrigation should be applied differentially throughout the vineyard in order to compensate for soil variation and to optimize both fruit yield and quality. A variable rate drip irrigation (VRDI) system was established in 2012, and ran from 2013 to 2015 in a 4.05-ha area inside a drip-irrigated Cabernet Sauvignon vineyard measuring 12.5 total ha. Based on the 2012 yield map, the VRDI area contained the full range of yield variation present in the vineyard (14.4 to 28.1 tons/ha). The VRDI area was split into 140 15x15-meter irrigation zones which were watered independently during the three seasons using weekly schedules based on estimated actual ET. Irrigation was managed with the objective of decreasing spatial variability, while maintaining high yields. Irrigation hours were scheduled using reference evapotranspiration from a nearby weather station and crop coefficients (Kc), multiplying NDVI by a 1.1 factor. This factor was calculated using data from previous seasons over many mature vineyards and varieties as the ratio of NDVI (from Landsat 7 or 8) and a Kc calculated with the METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration) energy balance model. An additional management factor, varying from 0.5 to 1.0, was implemented to provide proportionally more water to lower yielding zones and decrease NDVI and yield variability. Compared to an adjacent, 4.05-ha, conventionally drip irrigated section of the vineyard (CDI), VRDI decreased spatial dependency and structure in 2013 and 2015.

VRDI also increased yield and water use efficiency in all three years by an average of 10 and 12 % respectively.

Keywords:

variable rate drip irrigation, VRDI, wine grapes, Vitis vinifera L., yield map

Detection of crop water status using uav mounted sensors

Mr. John Coulombe, 56 Welch Str, Elliott Heads 4670, Australia; j.coulombe@cqu.edu.au (presenting author)

Prof. Phil Brown, Building 8 University Drive , Bundaberg Queensland 4670, Australia; p.h.brown@cqu.edu.au (co-author)

Dr. Richard Koech, Building 8 University Drive, Bundaberg Queensland 4670, Australia; r.koech@cqu.edu.au (co-author)

Dr. Cheng-Yuan Xu, Building 8 University Drive, Bundaberg Queensland 4670, Australia; c.xu@cqu.edu.au (co-author)

Advances in precision agriculture technologies allows crop management targeting specific needs of individual plants or regions within a crop at specific times rather than at the whole of crop level used in traditional crop production systems. Irrigation is one of the most important inputs in horticultural production systems, but current management practices typically do not allow precise delivery of irrigation inputs where and when they are required within a crop. Multispectral and thermal imagery has the potential to directly assess crop water status at a spatial scale not possible with current soil sensor probe systems, and thus contribute to improved irrigation decision making. Relationships between multispectral and thermal imagery data, gathered using a UAV system, and crop water status were determined in a tree cropping system (macadamia) and a vegetable system (chilli). Different combinations of data inputs were found to provide the best approximation of crop water status. Areas within a crop where water stress led to reduced transpiration could be detected in advance of any visible signs of water stress, and patterns of variability detected by the sensors within a crop were also linked to differences in plant yield and quality.

Keywords:

Precision agriculture, multispectral, UAV, thermal imaging, crop water status

Early detection of disease infection in chilli crops using sensors

Mr. Lafta Atshan, 2a Buss st., Bundaberg South, Bundaberg QLD 4670, Australia; l.atshan@cqu.edu.au (presenting author)

Assist. Prof. Simon White, CQUniversity Drive, Bundaberg QLD 4670, Australia; s.c.white@cqu.edu.au (co-author)

Management of diseases is a key aspect of profitable chilli crop production, and early detection of disease incidence is therefore an important aspect of crop management. Visual crop assessment is the most commonly used approach but is expensive where labour costs are high and tends to be unreliable, especially at low levels of infection. Alternative cost-effective approaches for detection of diseases and pests at an early stage are therefore desirable. This project has focused on the potential of sensor technologies to detect pests and diseases in crops earlier than is currently possible. Experiments were conducted to determine if multispectral and/or thermal imagery could be used to detect disease infection at the individual leaf and whole plant levels. The experiments involved an initial disease inoculum production step followed by application of inoculum to plants under greenhouse conditions and regular assessment of those plants plus control (not inoculated) plants using both visual and sensor assessment. Changes in plant responses were characterised, and were found to occur before visual symptoms of disease were present. Field assessment of the technology in commercial crops also generated promising results.

Keywords:

Multispectral, Thermal imagery, chillies, disease management.

Vision-based System for Detecting Grapevine Yellow Diseases Using Artificial Intelligence

Assist. Prof. Yiannis Ampatzidis, 2685 SR 29 N. Immokalee, Florida 34142, Southwest Florida Research Education Cen, University of Florida, United States of America; i.ampatzidis@ufl.edu (presenting author)

Assist. Prof. Albert Cruz, 9001 Stockdale Highway, California State University, Bakersfield, Bakersfield California 93311, United States of America; acruz37@csub.edu (co-author)

Roberto Pierro, Via del Borghetto, 80, Department of Agriculture, Food and Environ, University of Pisa, 56124 Pisa, Italy; rob.pierro@outlook.it (co-author)

Alberto Materazzi, Via del Borghetto, 80, Department of Agriculture, Food and Environ, University of Pisa, 56124 Pisa, Italy; alberto.materazzi@unipi.it (co-author)

Alessandra Panattoni, Via del Borghetto, 80, Department of Agriculture, Food and Environ, University of Pisa, 56124 Pisa, Italy; alessandra.panattoni@unipi.it (co-author)

Luigi De Bellis, via Prov.le Monteroni, Department of Biological and Environmental, University of Salento, 73100 Lecce, Italy; luigi.debellis@unisalento.it (co-author)

Andrea Luvisi, via Prov.le Monteroni, Department of Biological and Environmental , University of Salento, 73100 Lecce, Italy; andrea.luvisi@unisalento.it (co-author)

Grapevine yellows (GY) represent a serious threat due to severe symptoms and lack of healing treatments. Yellow diseases of grapes have been detected worldwide; among GYs, Flavescence dorée is classified as quarantine pest in Europe, while Bois noir is endemic but still dangerous. Both pathogens caused the same symptoms and health monitoring programs are carried out worldwide.

The diagnosis of the pathogen strongly relies on symptom identification, because analysis of infected but asymptomatic grapes may lead to high rates of false-negative due of the low concentration of the pathogen and its erratic distribution in the host. Furthermore, the main GY symptoms, such as leaf discoloration, bunch drying and irregular wood ripening, are quite typical, among other diseases, and outstanding in late summer, making recognition of GY a difficult task. The aim of this work is to develop a tool for supporting sampling procedures. Leaves of Bois noir-infected plants (previously tested by qPCR) were collected in July-October, 2017.

Grapevine yellow was detected in a dataset of 322 images and six diseases. Other than grapevine yellow, the diseases include downy mildew, esca disease, grapevine leafroll, powdery mildew and Stictocephala bisonia. A linear support vector machine (SVM) classified features from a pre-trained convolutional neural network—AlexNet trained on ImageNet. The system obtains a 92.0% accuracy and a Matthew's correlation coefficient of 0.832. For reference, a baseline system with local binary patterns (LBP) and color histogram with a SVM obtains only 26.7% and -0.124 respectively. Our work shows promise for automatic detection of grapevine yellow by computers. Future work will focus on improving the sensitivity of the system and implementation on drones with Nvidia Jetson. This system could reduce the rate of false positive/negative in large-scale vineyard monitoring.

Keywords:

Grapevine yellows, artificial intelligence, machine learning, deep learning, vision-based, disease detection

Factors affecting the adoption of precision agriculture technology by Florida vegetable growers

Ms. Shirin Ghatrehsamani, 2685 SR 29 N. Immokalee, Florida 34142, Southwest Florida Research Education Cen, University of Florida, Immokalee Florida 34142, United States of America; sh.samani@ufl.edu (co-author)

Assist. Prof. Tara Wade, 2685 SR 29 N. Immokalee, Florida 34142, Southwest Florida Research Education Cen, University of Florida, Immokalee Florida 34142, United States of America; tara.wade@ufl.edu (co-author)

Assist. Prof. Yiannis Ampatzidis, 2685 State Road 29 North Immokalee, Immokalee Florida 34142, United States of America; i.ampatzidis@ufl.edu (presenting author)

Advances in farm technology typically help growers use inputs more efficiently and reduce environmental impacts. They can also help to reduce yield variability by mitigating the effect of weather variability, improving nutrient management, reducing competition from weeds, and optimizing pest management. A better understanding of the economic drivers of vegetable growers is needed to increase the use of technology that mitigates growers' negative impact on ecosystems.

A needs assessment survey was conducted to assess University of Florida extension agents' opinions regarding growers' informational demand. Roughly 80%-90% of agents said growers are interested in

pest scouting, soil mapping, and data acquisition systems. Other responses rage from 60% for harvesting logistics to 77% for variable rate technology. Despite the benefits and grower interest in precision agriculture technology (PAT), technology adoption among Florida vegetable growers is low.

This study investigates the factors that affect growers' adoption of PAT. The study will use survey data being collected from Florida vegetable growers. The dependent variable is a binary indicator of whether the grower uses PAT. Coregressors such as crop mix, yield goals, crop acres, access to extension agents, risk aversion variables, and grower demographics will come from the survey. Other coregressors such as growing season weather variability, commodity and input prices, and soil variables come from auxiliary sources. Logit regression analysis will be used to assess the effect of these variables on the likelihood of PAT adoption. We expect acres, access to extension, yield goals, weather variability, and commodity prices to be positively correlated with PAT adoption. Input prices and risk aversion may have negative effects.

This analysis could provide a richer understanding of the factors affecting PAT adoption and help determine the importance of weather, risk, and field specific variables. These factors could then contribute to conservation policy design related to PAT.

Keywords:

precision farming, technology adoption, survey, vegetable

Do multispectral and thermal IR high-resolution UAS-borne imagery help in phenotyping the tree response to water stress at field? Case studies in apple diversity population and varietal assays

Prof. Dr. Jean Luc Regnard, AGAP, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, 2, place Viala, 34060 Montpellier Cedex 2, France; jean-luc.regnard@supagro.fr (presenting author)

Ms. Magalie Delalande, AGAP, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, 2 place Viala, 34060 Montpellier, France; magalie.delalande@inra.fr (co-author)

Dr. David Gómez-Candón, AGAP, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, 2 place Viala, 34060 Montpellier, France; davidgomezcandon@gmail.com (co-author)

Dr. Aude Coupel-Ledru, AGAP, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, 2 place Viala, 34060 Montpellier, France; aude.coupel-ledru@inra.fr (co-author)

Mr. Sylvain Labbé, Tetis, Univ Montpellier, AgroParisTech, CIRAD, CNRS, Irstea, 500 rue Jean-François Breton, 34093 Montpellier, France; sylvain.labbe@teledetection.fr (co-author)

As breeding fruit varieties for adaptation to drought becomes new challenge, it is necessary to assess genetic resources and new varieties under water restriction. Availability of affordable high-resolution sensors acquiring in multiple narrow visible (VIS) and near infrared (NIR) wavebands allows accurate computation of vegetation and/or stress indices (e.g. NDVI, GNDVI, MCARI, PRI). These indices reveal phenotypic modifications of individual plant cover structure and/or leaf functions. Moreover, as

transpiration is limited by stomatal closure, increase in canopy surface temperature (Ts) measured by thermal infrared (TIR) camera is precocious indicator of plant response to water deficit, and TIR imagery was recently used for calculation of proxies for stomatal closure in apple tree (Ts_excess, CWSI, WDI). In the experiments presented, VIS/NIR and TIR signatures were acquired weekly on apple trees submitted to normal and limited irrigation scenarios during summer, while soil water status was continuously and spatially monitored. Sensors were embarked on Unmanned Aerial Systems (UAS) whose frequent revisit allowed establishment of temporal variation of indices, which was of particular interest since irrigation withholding caused non-concomitant progression of water stress in the varieties. A semi-automated chain of image processing was developed, to compute indices within individual trees. Parallel to airborne imagery, leaf and stem water potential and stomatal conductance were measured in planta, while IPL (proxy for photosynthetic function) was computed. Robust correlations were established between indices and field measurements, and particular relevance was shown for the information acquired by a 6-channel VIS/NIR narrowband sensor. This phenotyping procedure opens an avenue for further genome-wide association studies in apple genotypic collections, while typology of apple cultivar response to soil water deficit was shown in assessment assays. Beyond characterization of water stress response at tree level, calculation of water use efficiency was possible.

Keywords:

remote sensing, Unmanned Aerial System, Malus × domestica, abiotic stress, vegetation indices, reflectance, thermography

Comparing deep-learning networks for apple detection to classical `hard-coded´ algorithms

Author(s):

Mr. Kushtrim Bresilla, Viale Fanin, 46, 40127 Bologna, Italy; kushtrim.bresilla@unibo.it (co-author)

Ms. Alexandra Boini, Viale Fanin, 46, 40127 Bologna, Italy; alexandra.boini@unibo.it (co-author)

Mr. Giulio Perulli, viale fanin 46, 40127 Bologna, Italy; giulio.perulli@unibo.it (co-author)

Assist. Prof. Brunella Morandi, Viale Fanin, 46, 40127 Bologna, Italy; brunella.morandi@unibo.it (co-author)

Prof. Luca Corelli Grappadelli, viale fanin 46, 40127 Bologna, Italy; luca.corelli@unibo.it (co-author)

Assist. Prof. Luigi Manfrini, Università di Bologna, 40127 Bologna, Italy; luigi.manfrini@unibo.it (presenting author)

Preferred presentation method:

During recent years, with the increase of production in Agriculture, the need for more precise tools and practices has increased too. One of those practices is the estimation the fruit crop load. Computer vision techniques such as histogram of oriented gradients and edge/color detection have been using to extract features thus recognizing fruit based on shape and color. Existing methods usually rely heavily on computing multiple image features, which makes the whole system complex and computationally expensive. In this study we compare those classical detection algorithms to new

state-of-the-art convolution neural networks (CNNs). Specifically, we compare and contrast two types of algorithms for apple detection in the tree. The first approach refereed as “hard-coded” uses commonly feature extraction filters (edge -detector, color filtering, corners). On the other side are techniques using “CNNs” like (residual networks, sliding window, regional dividers). More than thousand images of apple trees were taken during the season 2017 from flowering time to harvest. Same pictures have been processed through both techniques and based on results, the trade-offs of both techniques have been compared. For “hard-coded” algorithms, with few pictures we were able to appreciate its performance, while with CNNs, huge number of labeled pictures were needed to be more than 50% accurate. However, when we used a different picture from other dates or completely new variety, the “hard-coded” algorithm failed to detect thus had to be rewritten to accommodate new changes. In other hands CNNs were very flexible and were able to detect apples even though the picture taken-date was changed or picture from another variety way used.

Keywords:

Computer vision, convolution neural networks, fruit recognition, precision agriculture.

Decision support systems for fruit growing: Perfrutto and Irriframe: integration for the optimized management of the production and irrigation

Assist. Prof. Luigi Manfrini, Università di Bologna, 40127 Bologna, Italy; luigi.manfrini@unibo.it (presenting author)

Dr. Marco Zibordi, viale fanin 48, 40127 Bologna, Italy; marco@hkconsulting.it (co-author)

Assist. Prof. Brunella Morandi, Viale Fanin, 46, 40127 Bologna, Italy; brunella.morandi@unibo.it (co-author)

Mr. Kushtrim Bresilla, Viale Fanin, 46, 40127 Bologna, Italy; kushtrim.bresilla@unibo.it (co-author)

Ms. Alexandra Boini, Viale Fanin, 46, 40127 Bologna, Choose a country; alexandra.boini@unibo.it (co-author)

Mr. Giulio Perulli, viale fanin 46, 40127 Bologna, Italy; giulio.perulli@unibo.it (co-author)

Dr. Stefano Anconelli, Via Masi 8, 40137 Bologna, Italy; anconelli@consorziocer.it (co-author)

Prof. Luca Corelli Grappadelli, viale fanin 46, 40127 Bologna, Italy; luca.corelli@unibo.it (co-author)

The analysis of fruit growth performance, as predictive algorithms of fruit growth become available for an increasing number of species, is one of the novelty regarding precision systems. A budding “start-up” from the University of Bologna has developed a protocol of precision fruit growing, called “Perfrutto”, which is being adopted commercially, as it allows to forecast size class distribution and yield of an orchard, several months before harvest. This information is highly valuable both for the grower and for the marketer. They allow the grower, technicians and orchard operators to promptly adjust the orchard management during the season, getting the production closer to the most profitable quality/yield ratio and optimizing orchard resource inputs. On the other hand, the marketers can start earlier to organize their marketing campaign and the logistics involved, while reaping the benefits of the improved quality of the product. Perfrutto decision support system is

going to be integrated to an already tested irrigation scheduling system based on the water balance method and called “Irriframe” designed by the “Consorzio per il Canale Emiliano Romagnolo (CER)” of the Emilia-Romagna Region. The union of the two DSS will be supporting an optimized management of the production and irrigation.

Keywords:

Precision Horticulture, Water Management, fruit quality,

The effect of gas pressure and application height of a weed flamer on weed control in orchards

Assoc. Prof. Selçuk Arslan, Uludag Univesity Faculty of Agriculture, 16059 Bursa, Turkey; sarslan@uludag.edu.tr (presenting author)

Prof. Dr. Nihat Tursun, Inonu University, Faculty of Agriculture, Department of Plant Protection, Malatya, Turkey; ntursun@hotmail.com (co-author)

The aim of this experimental study was to compare the effect of gas pressure and height settings of flame torches on thermal weed control in orchards. A tractor mounted broadcast weed flamer with 2.0 m working width was used to apply the LGP doses of 15, 30, 45, 60, 75, and 90 kg/ha. Two different settings of gas pressures and torch heights were tested, i.e. 0.2 MPa with 250 mm vs 0.25 MPa with 200 mm, to determine which setting was better for weed control. The ground speed was varied approximately from 1.8 km/h to 8.1 km/h to apply the desired LGP doses for each pressure setting. The dose-response curves of weed specie common to all orchards were found at 1, 7, and 14 day-after-treatment (DAT) at 2-4 leaf, 6-8 leaf, and 10-12 leaf growth stages. The weed specie observed in both tests were Convolvulus arvensis, Cynodon dactylon, Sorghum halepense, and Xanthium strumarium.

At 14 DAT, the required doses for 90% control at 6-8 leaf stages were 56, 117, 106, and 57 kg/ha, respectively for C. arvensis, C. dactylon, S. halepense, and X. strumarium at 200 mm height with 0.25 MPa whereas these figures were 65, 155, 148, and 77 at 250 mm with 0.2 MPa. Similar trends were found for growth stages of 2-4 leaf and 10-12 leaf. The LPG doses needed for 90% control at 2-4 L stage was lower, as expected, with 40, 144, 100, and 47 at 0.25 MPa with 200 mm height setting compared to 44, 189, 126, 61 kg/ha for the setting of 0.20 MPa with 250 mm. Depending on weed specie, the cost of application may be saved 10 to 20% by optimizing the gas pressure and torch height.

The increased gas pressure with reduced application height increased the efficiency of flaming using the weed flamer developed for research purposes. Further increase in pressure required faster ground speeds, which in turn decreases the exposure time of weeds to flame. Thus, gas pressures greater than 0.25 MPa was not deemed applicable. Similarly pressures less than 0.20 MPa resulted in

very low ground speeds, especially at high LPG doses, which results in very poor field capacity. Different types of gas nozzles could be developed without introducing issues related to field capacity or flame efficiency due to exposure time.

Keywords:

Wee flamer, LPG dose, dose-response, pressure, torch height

Early Detection of Pistachio Botryosphaeria Panicle Blight Disease Using In-Field Spectrometry

Assist. Prof. Alirzea Pourreza, Department of Biological and Agricultural E, 2030 Bainer Hall, University of California, Davis California 95616, United States of America; apourreza@ucdavis.edu (presenting author)

Mr. German Zuniga-Ramirez, Kearney Agricultural Research Extension C, 9240 S. Riverbend Ave., Parlier California 93648, United States of America; gzunigaramirez@ucanr.edu (co-author)

Dr. Themis Michailides, Kearney Agricultural Research Extension C, 9240 S. Riverbend Ave., Parlier California 93648, United States of America; tjmichailides@ucanr.edu (co-author)

Botryosphaeria Panicle Blight (caused by Botryosphearia dothidea), is a major disease of pistachios in California. It first became a serious problem in Sacramento Valley in the late 1980s, but a couple of decades later, the disease caused a significant yield reduction in San Joaquim Valley (California) as well. Botryosphaeria is known as the major threat to the California pistachios. Unfortunately, Botryosphaeria disease has a long latent period and the earliest symptoms appear in late April to May, if the temperature is warm enough. Dead or partially infected buds can show symptoms such as dead areas as early as mid-summer. However, a significant portion of potentially infected buds remain non-symptomatic. Conventional early detection practice suggests collecting up to 100 buds from random locations throughout the grove and processing them using BUDMON (bud monitoring) technique. The BUDMON technique is highly sensitive and capable of diagnosing the samples with little or no visual symptoms. However, it requires sample collection/preparation, laboratory effort/cost, and it takes at least one week to have the diagnosis results. Therefore, number of samples to be collected for BUDMON test is limited by the available budget for disease monitoring; while, an optimum Botryosphaeria management requires a maximized monitoring in which high special and temporal resolution data must be available. In this study, an in-field spectral measurement tool called KOBIN Proximity was developed to evaluate and diagnose pistachio bud samples while they are in a non-symptomatic stage. KOBIN Proximity is able to conduct a non-destructive bud examination in the field and deliver the diagnosis result in real-time. The preliminarily results of this study demonstrated the potential for early Botryosphaeria identification using spectral analysis in the range of ultra violet, visible, and near infrared. Further improvement is being conducted to enhance the diagnosis accuracy and robustness.

Keywords:

Botryosphaeria, disease, pistachio, spectral analysis, machine learning

Micro irrigation in India: An option for Improving Water Productivity and Profitability

Dr. Harishchandra Prasad Singh, Chairman, CHAI; formerly DDG,Hort,ICAR, Confederation of Horticulture Associations , 249, Sector 18A, Dwarka, 110078 New Delhi, India; hpsingh2008@gmail.com (presenting author)

Babita Singh, Director,CHAI, 249 D, Sector 18A, Dwarka, New Delhi, 110078, India; drbabita9@gmail.com (co-author)

In India, during the last decade declining water availability to agriculture, has been a matter of discussion, and among various policies and technological packages, water management has received focus for realizing high water productivity. Among various strategies of water management, micro-irrigation proved as success story in many horticulture crops and also in cereals, pulses, sugarcane and cotton. Micro-irrigation technology is bound to maximize the synergistic interactions of improved cultivars, water and fertilizer and could be seen as the congruence of sustainability, productivity, profitability and equity. Since micro-irrigation greatly enhances water, fertilizer and energy use efficiency and promotes precision horticulture, the sustainability could be achieved without the burden of environmental degradation. Horticulture has to gain much for meeting the challenge of more production with declining land and water by adoption of efficient techniques towards high water productivity. Trials conducted on micro irrigation and fertigation on more than 50 Horticultural crops (fruits, vegetables, tubers spices, plantation crops and ornamental crops) have clearly demonstrated a savings of 50-80 % in water, 30-50 percent in fertilizer, 50-100 % enhancement in yield and improved quality of produce besides containment in incidence of the diseases. At present, India has coverage of about 9 million hectares in micro- irrigation with a plan to cover about 69 million hectares by 2030. Institutional support system linked with public and private enterprise and concerted efforts with identified destination involving all the stakeholders keeping the technology at driving seat and farmers as center of attention is bound to have faster and inclusive growth with the policy of per drop more crop, to achieve highest productivity of water. There is success story across the country for enhancing water productivity and enhancing farmers' income across the country. The paper deals with growth and impact of micro-irrigation and also innovations in technology and delivery.

Keywords:

India, horticulture, micro-irrigation, fertigation, growth and impact, technology

Multi-scale high-throughput phenotyping of an apple tree core collection under water stress condition

Dr. Benoit Pallas, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; benoit.pallas@inra.fr (presenting author)

Magalie Ms. Delalande, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; magalie.delalande@inra.fr (co-author)

Dr. Aude Coupel-Ledru, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; aude.coupel-ledru@inra.fr (co-author)

Dr. Frédéric Boudon, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; frederic.boudon@cirad.fr (co-author)

Dr. Jérôme Ngao, UMR PIAF, Univ. Clermont Auvergne, 63100 Clermont-Ferrand, France; jerome.ngao@inra.fr (co-author)

Mr. Sébastien Martinez, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; sebastien.martinez@inra.fr (co-author)

Ms. Sylvie Bluy, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; sylvie.pierru-bluy@inra.fr (co-author)

Dr. Evelyne Costes, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; evelyne.costes@inra.fr (co-author)

Prof. Dr. Jean-Luc Regnard, UMR AGAP, Avenue Agropolis TA A10803, 34398 Montpellier, France; jean-luc.regnard@supagro.fr (co-author)

Large genotypic variation in traits related to plant performance under contrasted environmental conditions has been reported but phenotyping them on large population remains a challenge for trees grown in orchards. We currently investigate or adapt new technologies for phenotyping developmental and adaptive traits in an apple tree core collection composed of more than 1000 individuals and grown under well watered and water stressed conditions. Targeted traits are associated with tree architecture which determines many traits of plant functioning such as light interception efficiency and transpiration, photosynthesis or water use efficiency. At the tree scale, T-LIDAR scans associated with new reconstruction algorithms are used for extracting variables related to the vegetative development (plant leaf area and its spatial distribution; number and length of axes). At the leaf scale, chlorophyll fluorescence has been measured on all the trees of the collection for determining a semi-empirical index (IpL index) previously shown to be a good proxy of photosynthesis activity. Multi-spectral and thermal IR airborne imaging is also carried out in summer in order to compute spectral indices that reveal phenotypic features over the whole field assay. The validity of high-throughput indicators are being assessed at both tree and leaf scales, through in-planta measurements of plant functioning such as architecture digitizing and leaf gas exchanges. Most of the traits collected exhibit a large variability with highly significant effects of water stress and genotype suggesting that methods are relevant for genetic studies. In that context, GWAS analyses are undertaken to identify genomic regions associated to the trait variation. In forthcoming works some of the parameters quantified in this study will be used to complement functional structural plant models for in-silico exploring the interaction between tree architecture and functioning under contrasted environments.

Keywords:

architecture, photosynthesis, transpiration, T-LIDAR, chlorophyll fluorescence, multi-spectral airborne imaging

Design and implementation of a low cost microcontroller in controlled environment agriculture

Ana Ms. Ms. Montoya, The National University of Colombia-Medelli, Medellin, Colombia; apmontoy@gmail.com (co-author)

Dr. Murat Kacira, Dept. of Agric. and Biosystems Enginering, 1177 East 4th Street, Room 403, Shantz Building, 38, Tucson, AZ 85721-0038, United States of America; mkacira@email.arizona.edu (presenting author)

Mr. F. A. Obando, National University of Colombia-Medellin, Medellin, Colombia; faobando@unal.edu.co (co-author)

Monitoring and control equipment in controlled environment agriculture (CEA) tend to be expensive. Arduino is one of the most popular low-cost open-source microcontroller´s platforms employed in prototyping and industrial applications. In agricultural field, this hardware has been used to monitor and control different variables in food production systems. This paper presents design and implementation of such microcontroller system with two applications in CEA systems. The first application implemented an Arduino based system to monitor temperature and relative humidity gradients in a greenhouse. This system employed low cost aspirated psychrometers to monitor the greenhouse air temperature and humidity. The temperature and humidity inside an aeroponic growing bed is also measured. Additionally, the system monitors the pH an electrical conductivity (EC) of the nutrient solution with sensors, allowing the connection of several in the same device. In the second application, a low-cost system was constructed to monitor plant related, environmental and irrigation variables. Plant temperature and plant growth are monitored using IR temperature sensors and low-cost cameras. Also, air temperature and humidity are measured. Besides, the system employs low cost sensors to monitor the pH, EC, dissolved oxygen and temperature of the nutrient solution in the hydroponic growing system. The low-cost system can be employed to monitor the growth and health of a crop in CEA. The information of the developed systems is saved in microSD memories. The microcontroller platform allows to access the collected data using mobile devices through Bluetooth and internet protocols. The systems have the capability to send alarm messages to the user if monitored variable are out of desired range. These systems allow the connection of standard and low-cost sensors lowering the cost of hardware for environmental monitoring and control in CEA. Therefore, microcontroller low cost systems are a flexible tool to monitor environmental, irrigation and plant related variables in CEA.

Keywords:

Greenhouse, vertical farm, monitoring, control, crop health and growth

Light interception measurement using digital image of plug tray pakchoi seedling in greenhouse

Assist. Prof. Jingjin Zhang, Rm 1-101B, School of Agri. Bio., 800, Shanghai, Shanghai, 200240, China; jj.zhang@sjtu.edu.cn (presenting author)

Industrialized pakchoi seedling production by plug tray substrate cultivation in greenhouse has been widely adopted because of its high efficiency and quality. Light interception reflects the capability of crop intercepting incoming radiation which has been reported to highly correlate to crop yield and quality. However, for pakchoi seedling such small plant, existing measurement method using photosensors is not suitable. This study investigated the potential of using digital image of pakchoi seedling canopy to measure light interception. The incoming radiation and transmitted light and reflected light of signal pakchoi leaves was measured by using a spectrometer. Characteristic wavelengths were obtained which reflected light absorption. Consecutive digital images of plug tray seedlings canopy were acquired during the entire growth period. At the same time, gray images of canopy were acquired by mounting lens filters at characteristic wavelengths. Reference light interception was measured by self-made ceptometer using photosensors. Image analysis was applied to build the correlation between reference light interception and canopy images. Preliminary results showed R component of image was best correlated to reference light interception, showing the potential of using digital image to measurement light interception of plug tray pakchoi seedlings. Further results are under analysis.

Keywords:

light response; machine vision; spectrum; modeling

Analysis of aerodynamic problems in greenhouses and development of an educational simulator using virtual reality

Mr. Rack-woo Kim, Seoul National University, Seoul, Korea (Republic of); rack88@snu.ac.kr (presenting author)

Prof. In-bok Lee, Seoul National University, Seoul, Korea (Republic of); iblee@snu.ac.kr (co-author)

Mr. Sang-yeon Lee, Seoul National University, Seoul, Korea (Republic of); tkddus613@snu.ac.kr (co-author)

Mr. Uk-hyeon Yeo, Seoul National University, Seoul, Korea (Republic of); uhyeo@snu.ac.kr (co-author)

The protected horticulture industry in Korea has grown since 1990 and the installation area of protected horticulture has increased to 52.526 ha in 2015. However, Korea has a distinct seasonal climate, and the ambient temperature changes extremely according to the season. Therefore, It is important to maintain the environmental condition inside the greenhouse to optimum condition for crops through cooling, heating, and ventilation.

In general, temperature and humidity in the greenhouse were controlled for environment control. Meanwhile, temperature and humidity are generally influenced by air flow. However, due to the invisible characteristics, it is difficult to accurately analyze the air flow. Therefore, many agricultural workers have difficulty in environmental control and monitoring in greenhouses. To solve this problem, Computational Fluid Dynamics(CFD) was used to analysis, however, some agricultural workers have difficulty in understanding the CFD simulation results. To make the analysis results easy to be understood, a visualization technique which visualizes the CFD simulation results is necessary. Recently, along with the 4th Industrial Revolution, virtual reality (VR) technology is emerging.

Therefore, the purpose of this study is to develop an educational simulator using VR for greenhouse worker. 1-2W type 3-span greenhouse was selected as the target greenhouse and the tomato crops were selected as the target crop. To construct educational simulator, image model of greenhouse and tomato was designed. The tomato image model was implemented in the virtual reality using 3D scanning model. The major aerodynamic problems occurring in greenhouses were analyzed for the simulation cases by field investigations and literature investigations. Based on the investigation results, CFD was used to analyze the aerodynamic problems. The user interface of the virtual reality access system was also designed. Finally, the educational simulator was developed to enable users to experience various aerodynamic phenomena in the greenhouse using VR.

Keywords:

Computational fluid dynamics, Greenhouse, Virtual reality

Cybernetic system controlling plant growth factors

Mr. Alexander Braslavskiy, 2F.,No.65,Sec.3, Xinyi Rd.,Taipei, Taiwan, 10651 Taipei, Chinese Taipei; fg1@lgt.tw (co-author)

Ms. Ching Yi Huang, 2F.,No.65,Sec.3, Xinyi Rd.,Taipei, Taiwan, Taipei, Chinese Taipei; jean@lgt.tw (presenting author)

In this paper we propose a new experimental platform patented (patent no. I60962) in Taiwan – a cybernetic system controlling plant growth factors. For practical usage of this cybernetic system for controlling plant growth factors we create a remote control center with 450 phyto laboratories for short and tall plants. Any person who has Internet access can use our phyto laboratories. This cybernetic system for controlling plant growth factors gives an opportunity for scientific institutions, universities and anyone who has interest in experiments of plant growth to create their own formulas of macro and micro elements by adjusting its composition and concentration. On the basis of the culture medium we provide different water sources and opportunity of changing water properties to experiment different ways of plant growth. Cybernetic system for controlling plant growth factors comprises a set of standard factors with additional options: automatic lighting spectrum control by nanometers, temperature control including the temperature near stem and many other factors. Phyto laboratories give an opportunity for researchers to use various gases to improve the quality and accuracy in experiment and permit reception of all the information about research in real-time.

Keywords:

cybernetic system controlling plant growth factors, macro and micro elements, remote control, phyto laboratories

RGB IMAGING FOR MONITORING QUALITY PARAMETERS OF SWEET POTATO DURING DRYING

Dr. Norhashila Hashim, Dept.Biol & Agric. Engineering, Faculty of Engineering, University Putra Malaysia, Malaysia; norhashila@upm.edu.my (presenting author)

Preferred presentation method:

This study investigated the potential of using RGB imaging for monitoring the quality attributes of sweet potato during drying. Digital images of sweet potatoes were captured after every 1 hour of drying, for drying temperatures of 50 - 70 °C and slice thickness of 4 mm, respectively. Similarly, reference properties of moisture content and colour coordinates were measured after every 1 hour under the same drying conditions, using conventional methods. It was observed that there were strong correlations between the RGB parameters and the measured quality properties. RGB parameter showed good correlation with the change of moisture content, L* and a* colour properties of sweet potato for all drying conditions with R2 > 0.5. Thus, this study has shown that RGB imaging can serve as a non-destructive tool for detecting the changes in the quality of agricultural product during drying.

Keywords:

Drying; Image analysis; Digital imaging, Sweet potatoes; Quality attributes: Drying; Image analysis; Digital imaging, Sweet potatoes; Quality attributes

Life Cycle Assessment (LCA) of Biomass Production Using Conservation Agriculture

Dr. Anna Vatsanidou, CERTH-IBO, Dimarchou Georgiadi 118, Volos, Greece; vatsanidou@gmail.com (co-author)

Prof. Ana Louisa Fernando, UBIA,Campus de Caparica,2829-516 , Caparica, Portugal; ala@fct.unl.pt (co-author)

Dr. Chris Cavalaris, UTH, Fytokou str., 38446 N. Ionia Magnesia, Volos, Greece; chkaval@uth.gr (co-author)

Dr. Thomas Bartzanas, CERTH-IBO, Dimarchou Georgiadi 118, 38333 Volos, Volos, Greece; thomas.bartzanas@gmail.com (presenting author)

Prof. Theofaonis Gemtos, UTH, Fytokou str., 38446 N. Ionia Magnesia, Volos, Greece; gemtos@uth.gr (co-author)

Theuse of biomass for energy production has been seen as a promising option to reduce the use of non-renewable energy sources and the emissions from fossil fuel carbon.

A three year experiment was carried out from 2012 till 2015 in Central Greece to assess the environmental impact of using different tillage practices (conventional, Reduced and No tillage) for seedbed preparation, in a double cropping per year rotation for biomass production. Detailed data were collected for all inputs and practices taking place during the experiments. The Life Cycle Assessment methodology was chosen for the environmental impact analysis and the Sima Pro software was used. One kg of biomass dry matter was chosen as the functional unit. Taking into account that the functional unit selection can affect the environmental results, a sensitivity analysis was performed considering two different functional units (area and energy value).

The 1st year of the experiment reported here, showed that the most important impact categories contributing to the total environmental impact were: Fossil and Land transformation CO2(Climate Change), Human toxicity, Particular matter formation, Agricultural land occupation, Water, Metal and Fossil depletion. The emissions due to fertiliser application and diesel fuel consumption, as well as of their production, were the processes with the greater influence on the overall environmental burden. The comparison among the tillage treatments revealed that reduced tillage, using strip tillage for row crop and disc harrow for winter crops, had the best environmental performance, presenting the lowest emissions in all impact categories. When the area was used as FU, No till treatment found to have reduced environmental impacts in the most impact categories. Comparison between the prevailing in the area monoculture cotton crop with the proposed double energy crop rotation, using mass and energy value FU, showed that cotton crop had higher environmental impact.

Keywords: (

Biomass, Energy, Precision Farming, LCA