Internet of Things and Remote Sensing

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The modern agriculture sector and food industry face population expansion, climate change, and Phytopathological adversities. Nanotechnologies and IoT can help achieve sustainability (Maksimovic *et al.*, 2017). Modern agricultural innovations include "real-time communication" and "wireless sensing," while "smart farming" uses ICT like remote sensing (Bastiaanssen *et al.*, 2000), cloud (Hashem *et al.*, 2015), and Internet of Things (IoT) (Weber *et al.*, 2010) to help farmers monitor field conditions from anywhere or with in-field high-tech support. Robotics help in seedling and plant management, fruit harvesting, plant protection, and weed control (Ampatzidis *et al.*, 2017). Remote sensing involves gathering qualitative and quantitative data via a satellite, aircraft, UAV/UGV, or probe. How agricultural systems change in location and time and how non-destructive sensing might reduce environmental consequences by avoiding resource depletion are significant to us. We can analyze molecular interactions and crop stress and its biophysical or biochemical characteristics (Mulla *et al.*, 2013), as well as detect (even at early stages) plant stress-induced variations (leaf area index, chlorophyll content, or surface temperature), resulting in a different fingerprinting than the healthy condition (Meroni *et al.*, 2010). Remote sensing for precision farming began in the 1980s with a few visible or near infrared bands, but was later developed as hyperspectral. As summarized in another work (West *et al.*, 2003), plant-related events can be monitored in different spectral regions: pathogen propagules in the VIS (depending on the pathogen), chlorophyll degradation (necrotic or chlorotic lesions) in the VIS and red-edge (550 nm, 650–720 nm), photosynthesis disturbance as fluorescence (450–550 nm, 690–740 nm) and in the TIR (8000–14,000 nm), and senescence. They can detect disease in agricultural crops. A hyperspectral radiometer was utilized to determine photosystem II photochemistry's intrinsic efficiency from leaf reflectance, specifically the ratio Fv/Fm of two leaf ChlF-derived parameters, which represent the variable and maximum fluorescence (Peng *et al.*, 2017). Stressed leaves reduce Fv/Fm substantially (leaf chlorophyll remains same). The slope of reflectance in the 700–900 nm spectral range increased along with this drop, with excellent correlation of the first derivative reflectance in the NIR areas with Fv/Fm.

Agricultural drones, often known as UAVs, can help with surveillance, sowing crops, battling pests, and crop monitoring. The "Sense Fly" (Sensefly *et al.*, 2020) farm drone eBee SQ communicates with eMotion Ag software to analyze multispectral images. The software directly uploads drone multispectral photos to cloud services, encompassing hundreds of acres, for accurate crop monitoring and analysis. Instead, aircraft and satellite technologies are fully characterized (Omasa *et al.*, 2006; Rudd *et al.*, 2017). The former covers satellite and aircraft remote sensors and agriculture applications (landsat and GIS data on land use and nitrogen flow, aerial hyperspatial data for wheat growth estimation or farmland analysis, and aerial Lidar Data for 3-D remote sensing for terrain and forests). The latter emphasizes the pros and cons of satellites, UAS, and ground sensors, emphasizing UAS versatility or the suitability of the two systems for specific applications (such as on-the-go processing for some ground sensors, allowing instant herbicide applications without data processing delays). Low-cost mini-UAVs for thermal and multispectral imaging are an extension of this technology (Bendig *et al.*, 2012). This study used a mini-UAV system (HiSystems' MK-Okto) with a payload of about 1 Kg to carry a handheld low-weight NEC F30IS thermal imaging system and a Tetracam Mini MCA four-band multispectral imaging system. The system acquired thermal and multispectral images with georeferencing for comparability. The 15-minute flight facilitates small-scale applications.

Remote sensing is also used for agricultural land use monitoring, crop yield forecasts, yield optimization, and ecosystem services (Weiss *et al.*, 2020). Remote sensing for environmental monitoring (Huete *et al.,* 2004) covers Earth's surface monitoring and characterisation, ecosystem sustainability, drought mitigation, human health, and other environmental studies.

IoT can help sanitary certification and provide industrial data for traceability. Prunus spp. were identified, stored, and tracked using RFID microchips. plants (Luvisi *et al.,* 2011) and grapevine clonal selection (Pagano *et al.,* 2010). RFID has been utilized to identify all plants through ampelographic, genetic, and sanitary examinations. RFID can also be used to retrieve propagated material (Luvisi *et al.,* 2012), tag mother plant vineyards, and certify products. Video processing, cloud computing, and robotics can detect tomato borer insects with appropriate phytosanitary treatment management (Rupanagudi *et al.,* 2015). Real-time tomato crop video is supplied to a cloud application for processing. Image analysis instructs a robot to spray pesticides totally autonomously to monitor the farm. A vineyard-wide wireless sensor network with self-powered nodes was also proposed (Perez-exposito *et al.,* 2017). Epidemiological models on VineSens' hardware and software platform avoid diseases like downy mildew, helping farmers manage and save money by reducing phytosanitary treatments. The software allows users to collect weather data from various vineyard locations using a web-based interface on desktop or mobile devices. Remote sensed imagery and geospatial image processing using unmanned aerial vehicles (UAVs) with advanced hyperspectral, multispectral, and digital RGB sensors and terrain-based data are also used for crop management and insect pest detection (Vanegas *et al.,* 2018). Systems like "Arable" and "Semios" monitor crops. The former sends weather and plant measurements to the cloud, allowing real-time access to stress, pest, and disease indicators through a software platform (Arable *et al.,* 2020). The letter installs remote-controlled pheromone dispensers, pest camera traps, soil moisture sensors, and leaf-wetness devices in each orchard block using a proprietary mesh network (Semios *et al.,* 2020).

Airborne platforms using multispectral and thermal cameras can monitor pathogens like Xylella fastidiosa (Xf) (Poblete *et al.,* 2020), selecting spectral bands that are sensitive to Xf symptoms (blue bands paired with thermal area). Another study used aerial hyperspectral imagery and Sentinel-2 satellite data to construct a 3D radiative transfer modelling approach (3D-RTM) to assess olive orchard Xf infection dynamics (Hornero *et al.,* 2020). Sentinel-2 time-series imaging indicated spatio-temporal markers for monitoring Xf virus damage across wide areas. Other agricultural uses are discussed (Cheng *et al.,* 2017; Polo *et al.,* 2015; Vazquez-arellano *et al.,* 2016) and current big data analysis research in agriculture is reviewed (Kamilaris *et al.,* 2017). Another study showed how nano-networked small sensors might collect fine-grained data from objects and hard-to-reach regions (Balasubramaniam *et al.,* 2013). A comprehensive overview covers architectures, areas, trends, potential and obstacles (Cruz *et al.,* 2019).

References

Ampatzidis, Y., De Bellis, L., Luvisi, A. (2017). Pathology: Robotic Applications and Management of Plants and Plant Diseases. *Sustainability, 9,* 1010.

Arable—Decision Agriculture. Available online: https://www.arable.com/ (accessed on 7 October 2020).

Balasubramaniam, S., Kangasharju, J. (2013). Realizing the Internet of Nano Things: Challenges, Solutions, and Applications. *Computer, 46,* 62–68.

Bastiaanssen, W.G.M., Molden, D.J., Makin, I.W. (2000). Remote sensing for irrigated agriculture: Examples from research and possible applications. *Agric. Water Manag., 46,* 137–155.

Bendig, J., Bolten, A., Bareth, G.(2012). Introducing a low-cost mini-UAV for thermal-and multispectral-imaging. Int. Arch. Photogramm. *Remote Sens. Spat. Inf. Sci., XXXIX–B1,* 345–349.

Cheng, X., Zhang, Y.-H., Wu, Y.-Z., Yue, Y. (2017). Agricultural Pests Tracking and Identification in Video Surveillance Based on Deep Learning. In International Conference on Intelligent

Computing, Springer: *Cham, Switzerland*, pp. 58–70.

Cruz Alvarado, M.A., Bazán, P. (2019). Understanding the Internet of Nano Things: Overview, trends, and challenges. *E-Cienc. De La Inf., 9,* 152–182.

Hashem, I.A.T., Yaqoob, I., Anuar, N.B., Mokhtar, S., Gani, A., Ullah Khan, S. (2015). The rise of "big data" on cloud computing: Review and open research issues. *Inf. Syst., 47,* 98–115.

Hornero, A., Hernandez Clemente, R., North, P.R.J., Beck, P.S.A., Boscia, D., Navas Cortés, J., Zarco-Tejada, P. (2020). Monitoring the incidence of Xylella fastidiosa infection in olive orchards using ground-based evaluations, airborne imaging spectroscopy and Sentinel-2 time series through 3-D radiative transfer modelling. *Remote Sens. Environ., 236,* 111480.

Huete, A. (2004). Remote Sensing for Environmental Monitoring, Academic Press: New York, NY, USA, pp. 183–206.

Kamilaris, A., Andreas, K., Francesc, X.P.-B. (2017). A review on the practice of big data analysis in agriculture. *Comput. Electron. Agric., 143,* 23–37.

Luvisi, A., Panattoni, A., Bandinelli, E., Rinaldelli, M.P., Triolo, E. (2012). Propagative material of grapevine: RFID technology for supporting traceability of "basic" and "certified" material along the wine production chain. *Adv. Hortic. Sci., 26,* 39–43.

Luvisi, A., Panattoni, A., Bandinelli, R., Rinaldelli, E., Pagano, M., Triolo, E. (2011). Implanting RFIDs into Prunus to facilitate electronic identification in support of sanitary certification. *Biosyst. Eng., 109,* 167–173.

Maksimovic, M., Omanovic-Miklicanin, E. (2017). Green Internet of Things and Green nanotechnology role in realizing smart and sustainable agriculture. In Proceedings of the VIII International Scientific Agriculture Symposium "AGROSYM 2017", pp. 2290–2295.

Meroni, M.R.M., Colombo, R. (2010). Characterization of leaf physiology using reflectance and fluorescence hyperspectral measurements. In Optical Observation of Vegetation Properties and Characteristics, Maselli, F.M.M., Brivio, P.A., Eds., Research Signpost: Trivandrum, India.

Mulla, D.J. (2013). Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. *Biosyst. Eng., 114,* 358–371.

Omasa, K., Oki, K., Suhama, T. (2006). 5.2 Remote Sensing from Satellites and Aircraft, ASABE: St. Joseph, MI, USA.

Pagano, M., Bandinelli, R., Rinaldelli, E., Panattoni, A., Triolo, E., Luvisi, A. (2010). RFID technology for clonal selection purposes. *Adv. Hortic. Sci., 24,* 282–284.

Peng, Y., Zeng, A., Zhu, T., Fang, S., Gong, Y., Tao, Y., Zhou, Y., Liu, K.(2017).Using remotely sensed spectral reflectance to indicate leaf photosynthetic efficiency derived from active fluorescence measurements. *J. Appl. Remote Sens., 11,* 026034.

Pérez-Expósito, J.P., Fernández-Caramés, T.M., Fraga-Lamas, P., Castedo, L. (2017). VineSens: An Eco-Smart Decision-Support Viticulture System. *Sensors, 17,* 465.

Poblete, T., Camino, C., Beck, P.S.A., Hornero, A., Kattenborn, T., Saponari, M., Boscia, D., Navas-Cortes, J.A., Zarco-Tejada, P. J. (2020). Detection of Xylella fastidiosa infection symptoms with airborne multispectral and thermal imagery: Assessing band set reduction performance from hyperspectral analysis. *ISPRS J. Photogramm. Remote Sens., 162,* 27–40.

Polo, J., Hornero, G., Duijneveld, C., García, A., Casas, O.(2015). Design of a low-cost Wireless Sensor Network with UAV mobile node for agricultural applications. *Comput. Electron. Agric., 119,* 19–32.

Rudd, J.D., Roberson, G.T., Classen, J.J.(2017). Application of satellite, unmanned aircraft system, and ground-based sensor data for precision agriculture: A review. In Proceedings of the 2017 ASABE Annual International Meeting, St. Joseph, MI, USA, 16–19 July, p. 1

Rupanagudi, S.R., Ranjani, B.S., Nagaraj, P., Bhat, V.G., Thippeswamy, G. (2015). A novel cloud computing based smart farming system for early detection of borer insects in tomatoes. In Proceedings of the 2015 International Conference on Communication, Information & Computing Technology (ICCICT), Mumbai, India, pp. 1–6.

Semios. Available online: https://semios.com/ (accessed on 7 October 2020).

SenseFly-The Professional's Mapping Drone. https://www.sensefly.com/ (accessed on 7 October 2020).

Vanegas, F., Bratanov, D. (2018). A Novel Methodology for Improving Plant Pest Surveillance in Vineyards and Crops Using UAV-Based Hyperspectral and Spatial Data. *Sensors, 18,* 260.

Vázquez-Arellano, M., Griepentrog, H.W., Reiser, D., Paraforos, D.S. (2016). 3-D Imaging Systems for Agricultural Applications—A Review. *Sensors, 16,* 618.

Weber, R., Romana, W. (2010). Internet of Things. Legal Perspectives, Springer: Berlin/Heidelberg, Germany.

Weiss, M., Jacob, F., Duveiller, G. (2020). Remote sensing for agricultural applications: A meta-review. *Remote Sens. Environ., 236,* 111402.

West, J.S., Bravo, C., Oberti, R., Lemaire, D., Moshou, D., McCartney, H.A. (2003). The potential of optical canopy measurement for targeted control of field crop diseases. *Annu. Rev. Phytopathol., 41,* 593–614

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