

Proceeding Paper

A Survey on the Use of the Internet of Multimedia Things for Precision Agriculture and the Agrifood Sector [†]

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Abstract: The Internet of Things (IoT) has already penetrated an ever-increasing array of daily aspects of life. IoTs bridge the analog and digital worlds in an unprecedented manner and degree by providing in situ sensing. Adding to the IoT the capability to collect interrelated multi-modal sensing, the use of the Internet of Multimedia Things (IoMTs) has recently been exhibited to significantly enhance the role of Information and Communication Technologies (ICT) in numerous applications, and most importantly in agrifood systems. In this work, we review key recent works in the conjunction of the three domains of IoMT, agrifood and precision agriculture and present open research directions.

Keywords: Internet of Multimedia Things; precision agriculture; agrifood sector; open research directions



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1. Introduction

A combination of a plethora of factors, including (but not limited to) the man-made climate change crisis [1,2], the world's positive population growth, the ever-increasing penetration and ubiquitousness of ICT in almost all aspects of life, as well as the requirement for qualitative and quantitative nutrition of contemporary humans, all lend themselves to the amalgamation of contributing domains of precision agriculture/farming in agrifood systems. Agrifood systems, in their broadest sense, refer to crops, livestock, forestry, fisheries, and aquaculture [3], among domains producing food. Given this wide breadth of agrifood systems' contribution to food, their importance to humans cannot be overstated. Nevertheless, these systems are under strain and their sustainability is a multi-faceted challenge [4–6].

The ICTs for the collection of information and knowledge mining as well as the customised application of methods in the field, with, among other technologies, artificial intelligence, drones, and the various versions of Internet of Things (IoT) have been dubbed the latest, digital, (r)evolution of agriculture [7–10]. The central tenet of this evolution is the application of the appropriate method to the proper location at the right time and of the suitable intensity, i.e., the notion of precision farming [11]. Accordingly, in this work, we are motivated by the recent developments in ICT to address existing and new challenges of the agrifood domain. This work's contribution is in collecting, processing, homogenizing, and drawing a “bird's-eye view” presentation from research in multimedia IoT (IoMT), agrifood, and precision farming/cultivation, as well as their intersection. The rest of the work is organized as follows: Section 2 presents definitions and working examples of the three domains of IoMT, agrifood, and precision farming that act as pillars to our work. At the same time, Section 2 presents some of the key influential and recent works for each of the three domains of IoMT, agrifood, and precision agriculture, both as distinct directions as well as in conjunction. The work is concluded in Section 3, where open research directions that future research on the domain may draw upon are detailed.

2. Definitions and Working Examples

2.1. Agrifood

Agriculture has had a fair share of evolutionary periods the last approximately 10,000 years, each of which had, in turn, a profound effect on humanity [7,10,12]: the first agrarian revolution, approx. 10,000 BC, was driven by the transition from nomadic life to settlements, and thus organised agriculture with the aid and efficiency of tools such as ploughs; the second (17th–19th centuries) originated the practice of crop rotation, the initiation of technical methodologies to support human labour, as well as the reordering of farmland management the third (approx. 1910–2000) stemmed from extended use of complex mechanisation, the industrialisation of farming, as well as the use of fertilisation and genetic engineering on crops. These changes (key, among several others) allowed the evolution of the population from approx. 4 million in 8000 BC to 400 million in 1700s [13] to 6.1 billion in 2000.

Most of these advancements had a significant effect on more than crops' cultivation, reaching domains such as livestock, forestry, fisheries, aquaculture, etc. Thus, the term agriculture, in the context of this work, and as per the common definition "the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products" [14], is utilised in a broad manner, with focus on the production of nutritional outputs for humans from flora and fauna, thus resulting in the term "agrifood". Agrifood systems address the needs of a very significant part of humans' nutrition, which is colloquially referred to as "food from farm to fork" and the effects of unsuccessful such systems have grave consequences leading to "resources' pressure and human suffering" [3].

2.2. Internet of (Multimedia) Things

The group of technologies within the Internet of Things (IoT) categorisation provide an intermediary between the physical and virtual worlds and a layer of interconnected, distributed and in situ sensing and processing of information [15]. Under the umbrella of IoT, a wide diversity of variations as to the "thing"'s capabilities, characteristics and scenarios of application have been proposed [16]. Herein, we focus on the variety of IoTs that enhance common IoT sensors, focusing solely on scalar measurements, found in most agrifood scenarios by providing both scalar and interrelated multi-modal information, based on which a wealth of more advanced agrifood decision scenarios can successfully be met, i.e., the Internet of Multimedia Things (IoMT). IoMTs offer unique advantages in the digitisation of agrifood processes in all aspects of the "from cultivator to consumer" chain.

Visual stimuli information, such as images and/or videos, has been shown to have a wide breadth of applications in agriculture, especially when used in conjunction with computer vision methods [17]: identification of cultivation's products as per size, shape, colour, holistic condition and potential output/yield [18], over-accumulation or deficiency of nutrients [19], invasive species and pests [20], as well as estimation of developmental parameters of the cultivation. Similarly, auditory cue sensors are more common than expected in various sensor sets used in agriculture [21] for purposes such as invasive species and pest identification [22], rainfall estimation [23], soil characteristic evaluation [24], *volume measurement* of agricultural products [25], and many more.

Moreover, IoMTs can support ICT services that will promote high-quality products by: (a) providing consumers with details about each product and producer (origin, certifications, farming practices, milling and packaging details, historical facts, producer's page, contextual information, review from other consumers, etc.); (b) providing producers with suggestions and support from experts to improve the quality of their products and to be guided through a sustainable cultivation process (reducing water and pesticide usage, having access to local meteorological information, etc.); (c) providing consumers with specific information (understandable scientific details about each product, nutraceutical analysis, etc.) and suggestions from experts; and (d) creating a social-level web of interactions where all interested parties can comment, review, interact and state their opinion

about the products, generating a culture of informed consumption, digital promotion and a “crowd-based acceptance certification”.

2.3. Precision Farming

Precision (or smart) agriculture/farming/cultivation (or “Agriculture 4.0”), in this context almost all synonymous, has been dubbed the fourth agrarian (r)evolution. A healthy discussion as to this (r)evolution’s necessity and its envisaged positive and/or negative consequences is already underway [26]. One of the most dramatic results of this evolution is expected through the integration of all stakeholders of agrifood, even at the conceptual level, thanks to the ICT advancements, as described in Section 2.2.

Artificial intelligence represents a pillar of precision farming [27] in order to achieve processes oriented at soil sciences and soil-specific cultivation management, the management of geoinformation, calculation of fertilisation rate, customisation of cultivation solutions based on site-specific characteristics and the use/definition of cultivation management zones, extended use of high-precision location information of assets and cultivation, yield mapping, methods for variable rate of herbicides/pesticides, high specificity adaptable irrigation rate, near real-time remote, high precision and various sensing measurements, automatic cultivation asset navigation and work-load mechanisation through drones/robotics, and proximal sensing of cultivation and its environment [11].

3. Conclusions

The fourth agrarian (r)evolution is upon us, and a number of interesting open research directions exist: the philosophical and ethical quandaries posed by extensive dependencies on technological advancements and AI; the inclusivity of precision agriculture’s methods to all stakeholders (from policy-makers, to producers, to consumers); the mitigation strategies for the unexpected and/or unwanted (side-)effects of the evolution; the balancing of the role of technological innovations vs. innovations in information analysis and decision support in the evolution; the environmental parameters of the evolution (e.g., the footprint of the life-cycle of all parts of the evolution), and many others. As with all new and exciting ventures, the fourth agrarian (r)evolution needs to evolve to its best self in order to reap the benefits and address in the best possible way the nutrition of humankind.

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