Automation and IoT for controlling and analysing the growth of crops in agriculture

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Abstract. This study is aimed at presenting modern automation systems and the Internet of Things in an agricultural complex. The paper provides an overview of the available technologies in world practice, and also discusses the development of the “Scientific Production Firm “Sady Chechni” in the field of automation of production for monitoring and analysis of crop growth in the laboratories of the company. IoT is representing a useful resource in present days, in order to maximize crop production, thanks to data obtained directly from the fields and the real time analysis. From disease prevention to resource optimization, are ones of the advantages provide from the current methods and technologies. There are still advances to make and challenges to overcome, in order to fulfil the demand for future years’ populations.

1. Introduction
Since the invention of the conveyor, the workflow automation procedure has been improved and used in almost all industries. Automation of the process of controlling the reproduction and growth of crops is not an innovation for a modern agricultural society. There are many scientific works that describe certain processes of plant growth and types of monitoring. In the case of the project of microclonal propagation of fruit crops, it is planned to use modern machine vision technologies, engineering design solutions and a conveyor base.

Improving the means of productivity in crops and all type of agricultural areas is of primordial relevance in recent years. Estimations show that to be able to supply the growing population, productivity must increase in about 70% considering the current global standards [1].

In order to achieve the goal, an update of actual cropping and agricultural procedures is essential, since the amount of resources consumed in actual practices, and land occupation necessary makes increasing the production to required quantities, but it is practically impossible and highly counterproductive due to the subsequent environmental impact.

There are already important inconvenient in agriculture in regions in the world due to climate change, modifying the usual availability of resources, soil condition and water shortage, so efficiency and resource optimization is a critical topic in global agriculture [2].

Recent methods and advances aim to improve the efficiency of crops and the growing speed, with other major impacts in the productive sector and industry, like cost reduction. One of the implementations with most potential in this matter is the use of IoT or “Internet of Things” technologies, which has been introduced over the last decade in multiple applications with considerable results.
A brief collection of application of IoT systems and technologies are mentioned, and the uses and advantages are analysed, also the benefits these technologies are and will be granting to the industry. Lastly, the challenges and barriers that are in the way of introducing or applying the technologies in every crop.

Studies from countries analysis and particular crops are presented and discussed, including the different methods and complementary options among the technologies researched.

2. Automation and IoT in agriculture

2.1. Literature Review

With the climatic change, historical data has become more and more useful in order to a precise forecasting of the climatic condition. Moreover, in developed countries we can't rely on weather forecasting infrastructure in order to receive more precise climatic information. That is why, researchers from the University Tunis El Manar, in Tunisia, developed a prototype of late blight prevention decision support system based on sensor network and cloud IoT[3]. This plant disease, responsible for the famous Irish potato famine, was monitored and controlled thanks to an inexpensive arrange with sensors, allowing the farmers to be noticed when to use the correspondent fungicides to prevent the disease, thanks to the climate data processed and analysed through IoT.

Similarly, Balamurugan [4] and Muangprathub [5], used sensors, arrangement of Arduino, software, IoT cloud systems and apps, to interconnect, collect and analyse data from crops, focusing in soil moisture and humidity, as well as climate conditions. The idea was to establish an ideal situation for watering the crops to improve growing and keep the ideal temperature and moisture conditions for a better fertilizer performance and crops health. With these interconnected system, farmers received notice when the time was optimum or conditions were getting closer to condition that could compromise the crops. Also, the latter, designed a system were farmers could set an automated moment for watering, if certain conditions were reached, or if the farmer preferred, to activate manually through an app the irrigations systems. This enhance productivity, not only thanks to automation, but to the energy, focus, and time saving, which now may be invested in other activities and maximize production. Since, there is a need for less resource and personal to monitor and attend the crops, the amount of products cultivated can increase.

Also, if both technologies, the one monitoring for diseases and the automated/manual irrigation system could be integrated, there is a chance for go even further and automate even the pests and disease control, doing it only when necessary and conditions are favourable, diminishing the use of this chemicals and saving resources [6][7].

For a qualitative approach to the stage of creating an automated monitoring system for micro clonal propagation of fruit and berry crops, a literature review of similar projects and projects having similar ideas for process automation were carried out.

2.2. Automation and IoT implementation

The closest to the idea of implementing the automation procedure is the work of Professor Indra Vasil from the University of Florida. In his study "Scale-Up and Automation in Plant Propagation: Cell Culture and somatic cell Genetics of Plants”, where studies relate to the propagation of lily tubers, the professor gives a diagram of a sample of a mechanical system. This system is a robotic system containing a camera for observation and sensors that provide signals about the status of the tuber [8].

In the usual propagation of lilies in an agar medium, the process usually proceeds in the following stages:

- removal of the formed roots,
- removal of flakes of newly formed microbulbs
- transferring these flakes to a vessel with fresh medium.
The initial plan of the system included an attempt to solve these three main steps. The problems that were expected and encountered included:

- the variability of the size and shape of microbulles obtained in vitro, which may affect the efficiency of the automated operation of the system,
- the roots will have a variable size and create various degrees of complexity during the transfer.

Both of these obstacles were overcome in the design of an automated system.

Scientists of Scientific Production Firm "Sady Chechni", located in the Chechen Republic, Russia, are going to implement similar technology in their laboratories. This firm is engaged in research in the field of microclonal propagation of fruit crops [9]. An automation system should accelerate and improve laboratory productivity, and the Internet of Things technology should make the monitoring and data collection process visual and convenient.

On this matter, Big Data technologies are playing an essential, reciprocal role in this development. Machines are equipped with all kind of sensors that measure data in their environment that is used for the machines' behaviour. However, this varies from feedback mechanisms like a thermostat regulating temperature, to deep learning algorithms, like implementing the right crop protection strategy [10].

IoT and other mechanisms are the mean to acquire data from fields, and Big Data presents the way to handle these amounts of data to take the most advantage from it. The review of distinct applications of Big Data into agricultural areas were analysed, and found that not only crops and farms were the target, but the whole logistic from planting to packing and delivering the products, this to optimize and give first steps in automation of the whole chain process of farming [11].

The next step, following Big Data implementation, is how the decisions making process could be relied more onto systems capable of handling and analysing the information in short time. An approach to this was proposed in SPF “Sady Chechni”, where cloud systems and data were combined with artificial intelligence and deep reinforcement learning, moving towards smart agriculture in its totality.

In the study, a system was developed that thanks to the layering data processing and analysis, including artificial intelligence, crucial decisions could be made real time to save even more resources than previous researches, since not only the moment for watering could be monitor, but the system could decide how much water would be necessary for an optimal growing. This is a first stage, this kind of system could regulate other type of resources, and make decisions real time to improve results. Also, this is not limited to crops, but to all the chain of production, and achieve a more sustainable and efficient way of farming [12].

Globally, these technologies are being developed and applied in different ranges of action, but achieving results. Europe is a major exponent implementing these types of techniques, and it has a big impact, since is a major exporter and producer of a variety of fruits and vegetables, or derivatives. However, developing countries like Brazil, are already implementing this source of technologies. The main focus in the South American country has being specifically into fields’ data collection, due to the low investment required in sensors and equipment [13].

The principal uses for IoT and data collection are the ones mentioned earlier, like temperature and moisture, but also soil conditions other than water content, but acidity. This helps prescript and balance soil acidity levels for a maximum performance of other additives, like fertilizers, plague control, and crops health.

2.3. Benefits
First, the most noticeable and direct advantage of implementing IoT’s is the economy of tangible and intangible resources, like fertilizers and time, to put examples respectively.

But there is more than just minimizing resources expenditure, implementing these mechanisms make the use of resources more valuable, using the quantities required in the moments were more benefits will be obtained – potential reduction of environmental impact.
It also provides options for remote monitoring at any given time, with capacity to include imaging monitoring.

It provides the opportunity for automation and potential improvements in areas beyond planting and cropping, could help to analyse the land before even planting, and after the fruits and vegetables were collected from the ground.

The use of artificial intelligence, leveraged by combining with other internal and external Big Data sources such as weather or market data or benchmarks with other farms, to create deep learning networks and optimize procedures even specify them for every specie cropped, thanks to collective networks and open source IoT mechanisms worldwide [14].

Lastly, the first stages of implementation which do not required of advance Big Data processing and potent servers to control all the agricultural and commercial activities are, in essence, very cheap. Whether the intention is to apply the monitoring and IoT technologies in big agricultural emporiums or family lands, the costs are really low, and contrasted with the benefits to obtain from the investment makes it is highly attractive.

2.4. Barriers and challenges
Regarding the technology adoption different barriers on farms are still present, and a reported number of challenges. A common one is regarding the availability of this technologies and knowledge-ability of those wanting to introduce these benefits into their cropping process.
Farmer’s population are not necessarily familiarized with technology, in fact, in many countries, like Brazil, a considerable number of the population who dedicate to agricultural activities have low education or even illiterate, so, implementations of this kind makes it really difficult for them to adopt or understand without qualified personnel involved or proper mentoring.
For those who can manage the technical aspects of the implementation, it requires an investment and depending on the level of IoT and analysing systems wanted, implies getting specialized equipment including the integration of computer systems. This brings a problematic situation because farmers are not loyal to one brand and tend to acquire equipment from several companies. This would not be an issue if there was compatibility and integration among the available tools on the market, but this is not a common case, so having equipment from different companies in unavailable and limits adoption of automated and smart farming systems.

Another barrier is a geographical one, since telecommunications are difficult in rural areas, regarding the country, and the lack of stable access to Internet and information from the processing and analysing systems affects directly all possible advantages provided by the mechanisms.

Considering some of the previous barriers, there are challenges to face now, and this goes to every level of the agricultural activity:

- Simplification of the steps and a friendlier interface for those users with low technical knowledge, so it is possible for people in different levels to implement it.
- Improvement of telecommunication infrastructures and connectivity in distant areas.
- The possibility of connectivity among multiple databases, and integration within systems for the possibility of network data exchange.

Advancing the Big Data processing available and make it more suitable for agricultural environments and data, that may create inconvenient among current systems [15].

Planning for integration of society and approach to those in the agricultural industry to maximize the impact of the advances, which happen too fast for different sectors of the population, and since communication and analysis technology advances quicker than agricultural science, a gap is created between the two fields.

3. Conclusion
A broad vision on the current situation of IoT implementations in agricultural areas, focused on crop growing and improving was achieved, but is noticeable that the mechanisms and technologies are still in development.

There are multiple areas to develop and IoT represents a primordial tool for achieving more efficient and sustainable crops in short and long term.

Data collection from crops, including environmental information, and qualities of the area like humidity, temperature, soil acidity and moisture, and crop monitoring in real time, with possibilities of remote control and automated analysis are available and can already increase the benefits and optimize processes for increase production and better results.

Integration and works on telecommunications infrastructure and education to agricultural population is required.

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