ARTIFICIAL INTELLIGENCE AS A MONETARY ASSET IN AGRICULTURE

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Abstract

Focus of Artificial intelligence (AI) implementation in agriculture and its multiple facets has been increasing in recent years since the expanded use smart technologies promise to provide higher efficiency and better quality of production. This paper presents a concept of employment of a smart soil humidity monitoring device based on Low Power Wide Area (LPWA) Networks and Machine Learning (ML) algorithms.
Key words: IoT, artificial intelligence, soil humidity, cost-effective

1 Introduction

The accelerated omnipresence of the Internet-of-Things (IoT) technologies and solutions has reshaped nearly every industry including "smart agriculture" where current agriculture methods are being re-examined whilst creating novel opportunities and challenges [1]. Huge amounts of accumulated IoT data are now seen as a monetary asset due to their scientific, social and economic value in numerous disciplines and industries. Along with the expansion of IoT interconnected devices came the rapid evolvement of Artificial intelligence (AI), encompassing new computational capacities of software algorithms and hardware deployment in the IoT environment. The latter has undoubtedly brought momentous alterations in manufacturing, finance, trade, and medical care, where these cutting-edge technologies and industrial model innovations are expediting the transformation of traditional industries [2]. One such transformation is occurring within the agriculture sector where the implementation IoT device appears to be an efficient pathway for productivity improvement by reducing some of the major issues farmers are facing and thereby increasing their profits [3]. According to predictions, in the next thirty years the world population will reach an increase of roughly 25% from the current figure topping 9.8 billion and it is expected that approximately 70% of the world's population will inhabit urban areas [1]. This growth will be followed by the increase in food supply. In that regard, agriculture production must substantially rise to keep up with the market demands while at the same time coping with "traditional" issues like unpredictable environmental conditions. The crucial parameter in a more efficient production is the proper use of water resources in irrigation, since the agriculture sector consumes 85% of the available freshwater resources across the world [4]. Other than the latter becoming an environmental problem, it is also a great financial issue. Literature reports that irrigation development done by funded projects now averages $480,000$ per square km, depending on location - the capital cost for new irrigation capacity in China is 150,000 $ per square km, in contrast to Africa where the capital costs are 1,000,000–2,000,000 $ per square km [5]. Therefore smart water management and irrigation could be done by employing proper IoT infrastructure for soil humidity monitoring, thus resulting in financial and energy benefits [6].

Nowadays, small and medium-sized enterprises (SME) sector is considered as the backbone of the economy and it is of a particular importance to examine how the agricultural SMEs are adopting novel technologies, since research have reported on many unsuccessful technology implementations heavily due to SMEs owners/managers not fully adopting and understanding overall benefits of novel technologies [7]. With that regard, this work presents a concept of employment of a smart soil humidity monitoring device that can be easily adopted by SMEs. Benefits of such an adaptation are twofold: one is the better water management resulting in lower production costs and the other is lower energy and infrastructural cost. The concept presented in the following is based on previous scientific research results, showing a cutting-edge solution which can significantly reduce the costs and improve the battery lifetime of a soil humidity sensing device by employing AI.

2 Research finding and implications

Research conducted in [6] and [8] provided a strong scientific background for development a soil humidity sensing device by exploiting desirable features of Low power wide area networks (LPWA), such as LoRa. Namely, in [6], a LoRa-based I2C soil moisture sensor device was deployed to collect ground truth data about soil humidity and temperature (sampling rate of 5 minutes) for a period of several months. Data was onward sent over a radio channel to two LoRaWAN gateway devices that collected signal strength measurements from the sensor devices. Extensive data analyses showed a noticeable correlation between Received Signal strength (RSSI), Signal-to-Noise ratio (SNR) and a particular soil humidity class, as depicted in 2 (left). Such a negative correlation was observed over time, where the increased humidity affected the signal strength so it decreased, as can be seen in Figure 2 (right).

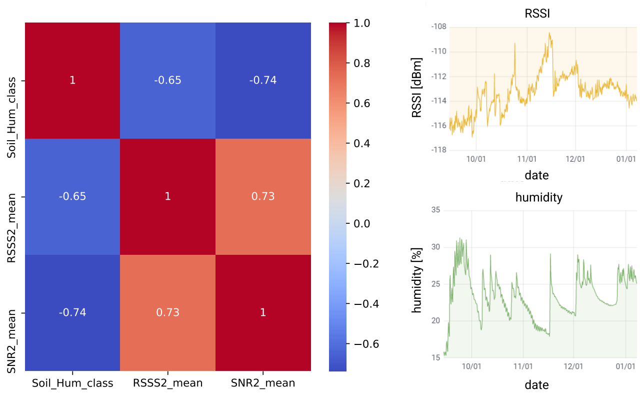

Figure 1: Decrease of Humidity is followed by increase of RSSI

Figure 2: Correlation between RSSI, SNR and Soil humidity classes from gateway two data (left), Decrease of Humidity is followed by increase of RSS (right).

It was further researched if soil humidity can be estimated from signal strength by employing two different Machine Learning (ML) algorithms, namely, Support Vector Regression (SVR) and Long Short-Term Memory (LSTM). Both algorithms achieved very good estimation accuracy, SVR had $MSE = 0.0243$ and $MAE = 0.0487$, where as LSTM had MSE and MAE errors of 0.00018 and 0.01043, respectively. Finally, a prototype of LoRa beacon device is presented and compared with I2C sensor in terms of energy consumption and sensor lifetime. It was shown that the overall energy consumption will be decreased by 10mA and the battery lifetime increased to approximately 4.33 years when employing the beacon device. Therefore, the proposed beacon would only send information about signal strength from which the estimation of soil humidity is done using ML which can be employed on MCU. Research conducted in [8] has expanded ML algorithm testing and presented and IoT Wallet system that depicts the data flow from an end user perspective, by allowing the user to manually register the sensor device to TTN service, as well as to visualize the data stored in the database.

3 Smart irrigation concept

Based on the research findings, the smart irrigation concepts can be presented from an agricultural SMEs point-of-view and are depicted in 3.

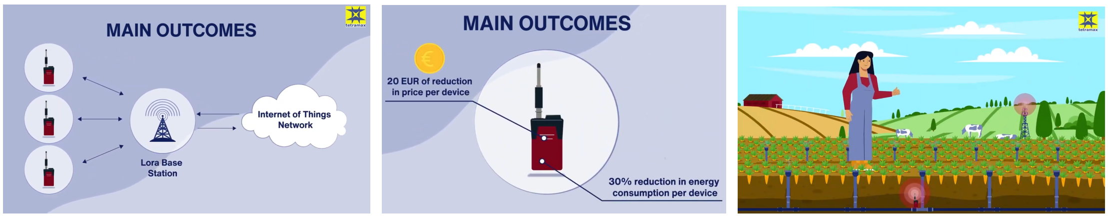

Figure 3: Smart irrigation concept

The strong pillars of the proposed concept are in the reduction of risk in terms of nodes deployment (LoRaWAN technology/bandwidth; data rate; long range). Furthermore, as cost-effective/prolonged battery lifetime solution for soil monitoring, it will consequently provide opportunities for an optimal automatic irrigation system. This will finally result in increased usability. These features reduce the initial costs of production and can attract new investments, which is particularly important for SMEs. Due to the optimal functionalities that satisfy the agricultural need, the proposed beacon device is half of price than those already in the market, with a prolonged battery life of up to 10 years. This way, the device becomes of increased usability, moreover in applications where conventional solutions are not appropriate (remote areas). When considering smart irrigation system market, it is already established, and there are plethora of manufacturers (sensoterra, Libelium, spiio), successfully solving the soil humidity sensing task. However, these solutions are based on data processing received from the power hungry sensor and transmitting the sensed data. The prices of given sensors, depending on the available supporting architecture reach about 200 EUR for Sensoterra nodes or about 4000 EUR for Libelium solution. In contrast, the solution proposed in this paper offers novel, soil humidity sensor-free cost/energy efficient device (MCU that periodically wakes up radio module-with 30% reduction in energy consumption) and a related ML algorithm that satisfies the same performance as the alternative products. It is reasonable to assume the sell price of 70-100 EUR per given node, while relying on cost-effective architecture (LoRaWAN). Research show that from 2020, farmers will be using 75 million connected devices [4] which only emphasises the importance of deployment of cost/energy efficient devices that would reduce the overall production cost.

When looking for expanded usage, smart cities can benefit from optimal water consumption in green areas. To enable the previously outlined smart functionalities, it is important to have a low-power sensory system to sense the soil humidity and thus ensure prolonged battery lifetime, especially in remote areas where battery replacement is a demanding task. On the other hand, it is important that the sensing feature is cost effective, aiming at reducing initial costs for investors and encouraging its implementation.

4 Conclusions

This paper depicts a novel cost-effective concept of soil humidity sensing based on LPWA technology and appropriate ML techniques. The proposed nonconventional sensing can be achieved by exploiting well-known phenomena in radio communications: the underground beacon device signal strength will change once the soil humidity changes. Cost benefits for SMEs are discussed in terms of production cost reduction and lower energy and infrastructural costs.

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