ASSIGNMENT 3 : The Literature Review

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Internet of Things in agriculture with arable farming

INTRODUCTION

Internet of Things is not only where communication between humans and machines take place, but also where communication between machines take place . As objects in everyday life interact with one another (Kumar, et al., 2019). Example of an IoT application is , IoT mobile application that can provide real time information on soil nutrition and characteristics (Dhanaraju, et al., 2022) . IoT has various application in agriculture such as , concentrating on accurate sowing by utilizing remote-controlled tractors to minimize seed wastage, maximizing plant spacing to provide the greatest potential output per acre , etc (Sinha & Dhanalakshmi , 2022) .

According to Prăvălie *et al* (2021) global arable lands cover almost 10% of the Earth's land area. Most arable lands are in Asia with 37.2% , followed by Africa with 19.8% , North and Central America 15.1% , etc. The importance of arable land is huge , as wheat that is part of arable farming provides a fifth of food calories and protein to the worldwide population. It is the most cultivated crop in the world (Erenstein *et al.*, 2022).

Therefore, this literature review focuses on the main research question which is , how can IoT devices communicate effectively with one another in an arable farm .To answer the main question we will firstly look at , the errors of hardware and software as well as their solutions. Then the network range issues of IoT devices as well their solutions. Lastly , the IoT device damages from unfavourable environmental conditions and the solutions to that.

IoT devices hardware and software

How can hardware and software errors for IoT devices be solved in an arable farm ? Reasoning behind IoT devices having hardware and software errors could be , because not all IoT devices are compatible with one another to integrate in one whole system in the arable farm. These hardware and software errors relate to the interoperability of IoT (Villa-Henriksen *et al.*, 2020) .

Noura, Atiquzzaman and Gaedke (2019) state that , Interoperability is the ability of IoT devices communicating and exchanging data/information with one another without human intervention . The interoperability issue can be solved by utilizing gateways. Gateways improves interoperability by bridging two or more IoT devices with different data specifications, standards , communication technologies . Gateway enables interoperability between different types of protocols. Although , it has its limitation as handling multiple different IoT devices interacting with one another with specific connectors can be quite difficult . As, the specific connectors design can be quite complex and time-consuming .

Another study by Albouq *et al* (2022) says API can be another solution . API stands for Application programming interface , API's enables IoT devices to be called from the main system , so that they can provide data in the form required by the caller.

Both studies above focus on similar solutions to solve interoperability issues . However, one suggestion can be that a technical supervisor or expertise should be near the arable farm to implement these solutions to the devices. As farm owners or farm employees might not have enough knowledge to handle, mange or operate the IoT devices .

Network range of IoT devices

Which methods can be used to solve network range issues for IoT devices in an arable farm? Arable farm sizes are big. Some IoT devices might cover enough network range to transfer or connect data to another device due to the size of the farm. LoRaWAN network range can be a solution to the network range issue (Villa-Henriksen *et al.*, 2020).

According to Wang *et al* (2021) LoRaWAN stands for long range wide area network , it is a set of communication protocols and system architecture based on long range network. LoRaWAN network can be optimized for lower power consumption and battery-powered sensors .Therefore, it can be categorized with as LPWAN which stands for low power wide area network .

The advantage of this network is as stated in the name , it is a long-range wide area network , it can cover large communication range of up to 10km and more . Therefore , farmers can use this network/technology to connect IoT devices they are far away from each other in arable lands. However, this network can be owned by the third party ,which means that it can have questionable operational expenses , therefore that can increase costs on farmer owners (Fujdiak *et al.*, 2022) .

Sigfox network is just like LoRaWAN , in a sense that it also provides lower power consumption of network and long-distance network communication . One major advantage of Sigfox is that it has low interference and noises of transmission of data . Therefore , it means there is less chances of data being interrupted when being transferred across IoT devices (Khan, 2019) .

Although , a drawback is that it transmits small bits of data , compared to LoRaWAN which transmits large bits of data at a quicker rate . Therefore, transferring larger bits of data can be more helpful as more data is being sent at a quicker rate , hence it can speed up the process of the work being done. Therefore that can lead to less time being wasted (Levchenko *et al.*, 2022) .

Both networks above provide a solution to solve network range issues on IoT devices in an arable farm. However, one important factor that farm owners must consider when implementing one of these networks , is the security of the network. Farm members must ensure that the network is not being accessed by unauthorized members or hackers . Unauthorized members or hackers accessing data could lead to data being stolen , manipulated , or corrupted.

IoT devices environmental conditions

What techniques can be used to protect IoT devices from unfavourable environmental conditions in an arable farm ? IoT devices can have severe damage from unfavourable environmental conditions such as, intense rainfall for example can cause heavy water flow going to devices. Therefore, leading to devices having damage in their performance or total complete failure of the device . Some protection techniques should be used to protect IoT devices from unfavourable environmental conditions in an arable farm. One of these techniques could be RFID tags (Villa-Henriksen *et al.*, 2020).

Mulloni and Donelli (2020) states that , RFID stands for Radio Frequency Identification. RFID is a type of tracking system that uses radio frequency to search , locate , track , identify and communicate with devices and people. RFID technology can be used in a way that can benefit the arable farm and the farm members. For example, there is heavy winds and mistiness in the farm. The IoT devices might get blown away from the winds and you might not see the devices exactly where there are due to the mist . RFID tags can help trace down the devices and locate where they are and can protect the devices from getting lost or stolen . Also, the farmer can retrieve the devices , before they get hit by any hard surface or fall in the water. Hence , those factors could be led to IoT devices being damaged.

A drawback is that RFID tags can be of high cost to insert in every IoT device and system. High costs can lead to high overall costs in the firm for farmers. Therefore high costs can also lead to lower profits for businesses (Landaluce *et al.*, 2020) .

Another study by Cremona, Comelli and Pire (2022) mentions about visual-inertial odometry. Visual-inertial odometry is automated robots that monitors soil levels , helps with weed and pest control , takes images and videos of the growing crops , etc . This technology can be used to protect IoT devices , as if there is heavy hails of rain and severe thunderstorms in the farm, and the farm owners or members might not be able to retrieve the IoT devices from the farm. The robots can retrieve the IoT devices for them , so that they can protect the IoT devices from being damaged. Although , a setback can be if the robots are able to handle the capacity of heavy thunderstorms and hails , they can damage themselves before trying to retrieve other IoT devices.

Conclusion

This review aimed to answer the main research question which was how can IoT devices communicate effectively with one another in an arable farm ? The main question was broken into separate factors . Firstly , hardware and software errors of IoT devices like interoperability was discussed . Then , mention of gateway and APIs was stated in detail to fix the issues. Secondly, network ranges issues of IoT devices in an arable farm . Solutions to that were Sigfox and LoRaWAN networks. Lastly IoT device damages from environmental conditions . Hence, that can be solved by RFID tags/readers and visual-inertial odometry.

Bibliography

Albouq, S.S. *et al.* (2022) 'A Survey of Interoperability Challenges and Solutions for Dealing With Them in IoT Environment', *IEEE Access*, 10, pp. 36416–36428. Available at: https://doi.org/10.1109/ACCESS.2022.3162219.

Cremona, J., Comelli, R. and Pire, T. (2022) 'Experimental evaluation of Visual-Inertial Odometry systems for arable farming', *Journal of Field Robotics*, 39(7), pp. 1123–1137. Available at: https://doi.org/10.1002/ROB.22099.

Erenstein, O. *et al.* (2022) 'Global Trends in Wheat Production, Consumption and Trade', *Wheat Improvement: Food Security in a Changing Climate*, pp. 47–66. Available at: https://doi.org/10.1007/978-3-030-90673-3_4/FIGURES/6.

Fujdiak, R. *et al.* (2022) 'Insights into the Issue of Deploying a Private LoRaWAN', *Sensors 2022, Vol. 22, Page 2042*, 22(5), p. 2042. Available at: https://doi.org/10.3390/S22052042.

Khan, I. (2019) *Suitability of LoRa, Sigfox and NB-IoT for Different Internet-of-Things Applications*. Available at: https://trepo.tuni.fi/handle/10024/117535 (Accessed: 3 March 2024).

Landaluce, H. *et al.* (2020) 'A Review of IoT Sensing Applications and Challenges Using RFID and Wireless Sensor Networks', *Sensors 2020, Vol. 20, Page 2495*, 20(9), p. 2495. Available at: https://doi.org/10.3390/S20092495.

Levchenko, P. *et al.* (2022) 'Performance Comparison of NB-Fi, Sigfox, and LoRaWAN', *Sensors 2022, Vol. 22, Page 9633*, 22(24), p. 9633. Available at: https://doi.org/10.3390/S22249633.

Mulloni, V. and Donelli, M. (2020) 'Chipless RFID Sensors for the Internet of Things: Challenges and Opportunities', *Sensors 2020, Vol. 20, Page 2135*, 20(7), p. 2135. Available at: https://doi.org/10.3390/S20072135.

Noura, M., Atiquzzaman, M. and Gaedke, M. (2019) 'Interoperability in Internet of Things: Taxonomies and Open Challenges', *Mobile Networks and Applications*, 24(3), pp. 796–809. Available at: https://doi.org/10.1007/S11036-018-1089-9/FIGURES/5.

Prăvălie, R. *et al.* (2021) 'Arable lands under the pressure of multiple land degradation processes. A global perspective', *Environmental Research*, 194. Available at: https://doi.org/10.1016/j.envres.2020.110697.

Villa-Henriksen, A. *et al.* (2020) 'Internet of Things in arable farming: Implementation, applications, challenges and potential', *Biosystems Engineering*, 191, pp. 60–84. Available at: https://doi.org/10.1016/j.biosystemseng.2019.12.013.

Wang, Hao *et al.* (2021) 'A Study on Key LPWAN Technologies', in *Journal of Physics: Conference Series*. IOP Publishing, p. 012011. Available at: https://doi.org/10.1088/1742-6596/1871/1/012011.