Abstract

Farmland contamination can hinder crop growth, pose significant risks to consumer health, and devastate entire ecosystems. With the recent rise in human-caused pollution, this issue has become increasingly apparent. Effective mitigation of such pollution primarily relies on monitoring the soil's contaminant levels. It is imperative to start with monitoring in order to accurately analyze the situation and apply potential solutions.

This project implements recent advancements in wireless sensors, unmanned aerial vehicles (UAVs, more commonly known as drones), and Internet of Things (IoT) systems to tackle the challenge of monitoring farmland contamination. The major steps of our process include using wireless sensor networks to make the data collection process more efficient, and then incorporating pre-programmed drones to deploy and retrieve the sensor's data. Ultimately, this eliminates the need for human involvement and reduces the potential risk of human contact with hazardous chemicals. Upon the drone's return, the data is then seamlessly transmitted and stored through IoT gateways to eventually reach IoT servers and data storages. This allows environmental researchers and agricultural professionals to access and analyze the data easily.

Mathematical models are also proposed to determine the minimum number of sensors required for efficient farmland monitoring. Furthermore, two sets of simulations were conducted based on this model. Before starting, certain parameters were held constant such as farmland perimeter, farmland area, minimum number of readouts needed to accurately evaluate the area, total monitoring time, time needed for a sensor to produce a readout, and more. The values of these constant variables were derived from historical research and realistic agricultural situations. In the first set of simulations, the impact of each sensor's detection area on the total number of deployed sensors was evaluated. It was determined that an optimal sensor detection area was 3.4 m^2, which needed 239 sensors to cover the area. After this value, further increasing the sensor detection area had no effect on limiting the amount of needed sensors as there is still a minimum amount of sensors required to meet the readout minimum. Second, the impact of each sensor's detection area on the total number of collected readouts was studied. It was determined that 3.4 m^2 was an optimal sensor detection area as it produced 20,076 readouts. Compared to the needed amount of readouts (set at 20,000), this value was perfectly sufficient without being wasteful of resources. Both sets of simulations appeared exponential at first glance, but were actually a piecewise function derived from mathematical equations listed earlier.

Having these models and simulations not only provides guidance on achieving efficient monitoring performance but also factors in IoT resource usage to facilitate sustainable agriculture. Our simulations demonstrate the applicability of using these IoT systems in a variety of different real-world situations. It is also important to note that this issue is a dynamic and multi-faceted problem. Therefore, it is imperative to consider numerous varying factors pertaining to each individual case. Our research's proposed IoT system helps determine how to implement a drone-aided sensor network into farmland that will increase efficiency, reduce the risk of contamination, and automate the entire monitoring process.