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An Alert System on the Presence of Myriapods in Peanut Farms in Senegal

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Abstract

In Senegal, agriculture remains one of the most important sectors of the economy and the culture of peanut is one of the pillars in this domain. Unfortunately, the expansion of this culture is constantly hampered by attacks from several enemies such as the myriapods. These attacks can happen as early as during the germination but also during the fructification of the plants. As a defense solution, farmers use pesticides that often are hostile to the environment. The goal of this project is to build an early detection system that can warn farmers about the presence of the myriapods before the onset of the first attacks. Our proposed solution will be composed of a network of sensors that collect data (environment, soil acidity/composition, etc…), a computing system that uses the collected data to infer whether the insects are present or not, and a communication system that delivers alerts and advices to the farmers. Early detection of myriapods will allow farmers to use better and more environment-friendly defense solutions. We envision to efficiently build such system while keeping its price as low as possible.

Keywords: agriculture, peanut, myriapod, sensors, alert system, ICT, environment protection

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1. Introduction

Senegal is situated in the far west of the African continent, between the 12th and 16th degrees North and the 11th and 18th degrees West. Its population, according to the national agency of statistics and demography, is of 14’799’859 inhabitants [7].

Agriculture plays a very important role in the economy of the country. It is the main activity of people living in rural areas and depends largely on raining season. Among agricultural activities carried in Senegal, the culture of peanut is one of the most predominant. This is mostly due to historic reasons that date back to the colonial era. Unfortunately, for a long time, the development of this culture has been hampered by many factors, including the absence of rain, the lack of information on the state of the soil, and the attacks of animals (insects and beasts), just to name a few.

Among the insects and beasts, enemies of the peanut plants, the myriapods (more precisely the Julida) constitute the most dangerous ones. Myriapods attack the peanut plants during two different phases of their development. The first attacks can appear as early as during the germination of the plants. As soon as the seedling raises the superficial crust of the soil, the Julida penetrate the cracks of the earth. They attack the cotyledons, then the rootlets and the hypocotyl axis of the seedling and erode its cortex. If the central axis is not sectioned, the plant can survive but the injuries constitute entry points for other pathogens such as the Aspergillus Niger. The damage during this phase can reach 5-to-10% loss in the production.

Attacks during the fructification phase are the most destructive ones. During this phase, the Julida first sever the plants gynophores, then enter the soil where they eat or perforate the young pods. The penetration of the Aspergillus Niger becomes also easier after these attacks. At this stage, the damage can reach up to 30% of the final production.

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To fight against these enemies, chemicals products are used [11] during both phases. Unfortunately, not only these chemicals can cause health issues in the long term [12], but, they also contribute to the deterioration of the environment. Furthermore, the excessive use of such chemicals has made the Julida more resistant to their effects, which unfortunately has prompted farmers to use even more dangerous chemical.

In this project, we intend to implement an early detection and alert system that gives to farmers information about the presence of the Julida. Early knowledge about the presence (or not) of the myriapods will help farmers take appropriate measures to protect their crops and increase their production. It will also permit them to use as little as possible chemical or even use other solutions that are friendlier to the environment.

An ideal solution would be to build a device that can detect the presence of the Julida way before they start infesting the farm. However, such a solution is challenging to design. To the authors' knowledge, there does not exist, to date, any sensors to detect myriapods. And even if such a sensor existed, it would need large scale deployment in the farm, which will probably lead to high costs. Given this, the next best option is to use environment data to infer the presence of the Julida, as we propose next.

Our proposed solution will be based on three main components: (1) A network of sensors that collect environmental data such as temperature, humidity, soil composition, and ph. These parameters combined, constitute a good indicator on the presence of the Julida according to the studies by Dominique and Yves GILLON [1] [2]. (2) A computing system that uses the collected data to infer whether or not the insects are present. This will be based on algorithms that combine the different parameters to infer the presence of the myriapods. (3) A communication system that delivers alerts and advices to the farmers. The alerts inform farmers about the apparition of threats in their farms while the advices will guide them on which appropriate measures to take for a given situation.

Due to the indirect approach (use of environment data to detect the presence of Julidas), our system will very likely have a high false positive rate. However, we believe that this rate can be reduced by backing each detection with an onsite investigation. As such, our system is rather a tool to determine when to pay closer attention to a given field.

Bearing in mind that cost can constitute a barrier for the adoption of any technology in the developing world, we aim at leveraging the development of new cheap IoT and sensor technologies to build an efficient system that that requires low maintenance and has a low price tag.

2. Lifestyle and Living Environment of the Myriapods

2.1. Lifestyle

Myriapods belong to the family of arthropods which are invertebrate animals with a segmented body and jointed appendages. The arthropod family is divided into four groups, namely, the diplopod, the chilopod, the pauropod and the symphiles.

Diplopods are the arthropods found in the farms in Senegal. Among diplopods, the Julida (Polydesmus, Blaniulus, Tachypodoiulus, Schizophyllum) are the most known ones. There exists a variety of species of Julida and five of these species are harmful to the culture of peanut [11]. They have a cylindrical body, are usually dark or even black in color, and are capable of rolling into a spiral shape in face of a threat. They are herbivores (as opposed to other diplopods such as the scolopendrids) and their alimentation is mostly based on dead leaves, mushrooms and other plants. They live in areas where humidity is always high, so that the food that they consume contains an important quantity of water.

During the dry season, the myriapods are in diapause, buried under the ground. After the first rainfalls appear, they massively come to the surface in the search of favorable conditions (temperature, soil composition, humidity, etc…). As soon as the peanut seedling raises the superficial crust of the soil, they start their devastating attacks, as described above. Another vague of attacks occur later during the fructification of the plants.

2.2. Localization

This section is based on the study by the Guillon brothers [1] who analyzed soil data gathered from a peanut field located in the region of Sine Saloum, Senegal during the period of August 1974 to July 1975. They collected 22 samples of soil, each covering a surface of 4m2 and having a depth between 30cm and 80cm.

The analysis has shown that the in-depth distribution of the Julida varies throughout the year. During the rainy season, from July to October, 50% of the Julida are on the surface or within the first 10 centimeters below it. During the dry season, 90% are between 10cm and 70cm underground, with the highest concentration being between 20 and 30cm. There is typically no vertical migration during the estivation period.

The detailed analysis of the vertical distribution throughout the year shows a lot of variations. From the beginning of August to the end of September, the majority of the Julida are on the surface. During the month of October, they start migrating underground. For example, the fraction of Julida found in the first 10 centimeters, on the samples collected during the month of October, varies as follows: 71% on the 1st, 24% on the 8th, 19% on the 15th, 10% on the 22nd, and 0% on the 29th. The depth-wards migration starts when the climatic conditions of the dry season start appearing: sudden increase in evaporation, high variance of the daytime temperatures and decrease in humidity. During the dry season, from November to June, there is a very low portion of the Julida in the first 10 centimeters. Before the end of this season (during the month of May), the climatic conditions start to reverse: less evaporation, less variance in daytime temperature and more humidity and the Julida start appearing in the first 10 centimeters, with the majority appearing only after the first rainfalls. This suggests that the cited parameters could be used as indicators for the localization of the beats.

For the horizontal distribution, four different environments was studied: under the trees, under the stumps, inside the termite mounds, and on the bare field (far from the trees, stumps, and termite mounds). On the bare field, the density of the Julida varies between 4 and 20 per m2. Also, their weight varies between 0.5 and 9 grams. Under the stumps, the density varies between 13 and 34 per m2. This gives an average density larger than that of the bare fields. However, the weights of the Julida tend to be smaller (between 1.4 to 4 grams). Samples taken under the trees show a higher density (between 21 and 106 Julida per m2) with a weight varying between 10 to 36 grams. This contrast is even more pronounced during the dry season. Indeed, under the trees, we have lower temperature and higher humidity, but more importantly, there are more dead leaves, which constitute one of the main alimentation of the Julida. Inside the termite mounds, the density reaches 110 Julidas per m2. The weight can also go as high as 158 grams. The density decreases from the center to the peripheries. The analysis of the soil humidity shows that it is highly correlated with the density of Julidas.

In summary, the study in [1] can serve as a guidance about which environment the Julidas are most likely to be found and which parameters to monitor in order to localize them. Based on this, we plan to build our early detection platform described in the following section.

3. Proposed Architecture

Figure 1 shows the architecture of our proposed early detection system, which will be based on three main components described in the next sections.

3.1. Sensors for Data Collection

The study in [1][2] indicates that to detect the presence of the Julidas, one could track parameters such as temperature, humidity, soil composition, and ph in the environment that are favorable to their lifestyle. We plan to monitor those parameters on the surface and under the ground by making use of a network of sensors.

There are many challenges to designing such sensors: they need to be accurate, their energy consumption must be efficient and the cost to build should be as low as possible. Today, there are off-the-shelves sensors [13] that meet the first and last requirements, however, the price tag is very high. This constitutes a barrier for farmers in developing regions. As an alternative, we plan to leverage the existence of cheap components to build sensors with low price. Once available, the sensors will collect the data to be feed to the detection unit which will make the decision on the presence of the beasts.

3.2. Detection Unit

The hypothesis derived from the study in [1] is that the presence of the Julidas is strongly correlated with a number of environmental factors (temperature, humidity, soil composition, ph). We would like to first test such a hypothesis by using data generated from the sensors described in the previous section. This step, which can also be viewed as a calibration phase, will help us understand the dependency between the cited parameters and the presence of the myriapods. Understanding such dependence is key to designing the detection algorithm which will then combine the different parameters to infer the presence of the myriapods. The output of the algorithm will be sent to the farmers using a communication network.

3.3. Communication Network

The communication system delivers alerts and advices to the farmers. The alerts inform farmers about the apparition of threats in their farms (i.e., the decision of the detection unit) while the advices will guide them on which appropriate measures to take for a given situation. The messages will be sent to terminals owned by the farmers (flip phone, smart phones, and tablets) in the format of text and voice.

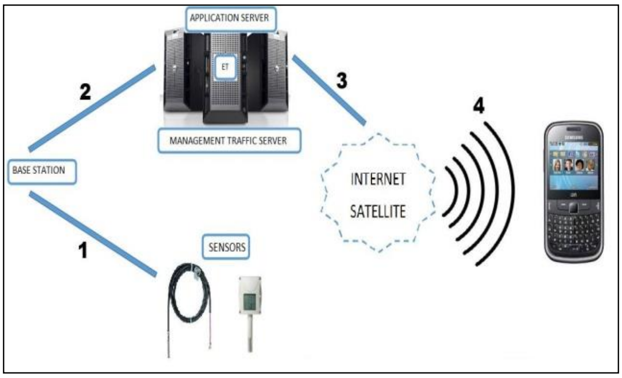

Figure 1: Alert System

4. Conclusion

The goal of this project is to implement an early detection platform that will inform farmers about the presence of enemies of plants as well as the status of their cultures. The expected benefits of an early detection and alert system are numerous. Mostly, it will allow farmers to use better and more environment-friendly defense

solutions. Also, farmers could benefit from best practice advices.
There are challenges facing the implementation of such a platform: the system has to be efficient, it needs to be low cost, and it should require very low maintenance. To meet these challenges, we are planning to leverage the existence of cheap components to build sensors with low price, use low cost communication systems such as the Long Distance Wifi, and build our platform on top of affordable computing technologies such as Raspberry Pi.

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