Red Palm Weevil Treatment Robot

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***Abstract*—Annually, palm trees face a threat from palm AIDS, a condition caused by the infiltration of the red palm weevil into the tree trunk. This pest silently gnaws away at the palm tree without clear early symptoms. Symptoms typically manifest when it's too late to save the tree. To address this issue, we have developed a robot equipped with sensors including sound, radiological imaging, and soil moisture and acidity sensors that promptly detect signs of infestation. This robot employs two arms to administer therapeutic treatments upon receiving signals from the interconnected sensor circuit. Our experiments have successfully demonstrated the robot's ability to respond effectively to the presence of the insect as indicated by sensor signals.**

Keywords— Palm trees, Robot, Insect, Sensors.

I. Introduction

The red palm weevil is a small beetle that mainly attacks date trees, devours the palm, and then descends to the tip of the tree to lay its eggs. Each beetle lays thousands of eggs. The larvae that emerge from the eggs then devour the tree and may kill it in just a few months. The red palm weevil is widely considered the world's most damaging insect pest of palm trees. The red palm weevil is usually attracted to unhealthy palm trees, but it often attacks healthy palms as well. The red palm weevil larva feeds inside the apical growth point of the palm, causing severe damage to the palm tissues and weakening the structure of the palm trunk [1], [2].

The following symptoms may appear on palm fronds affected by the red palm weevil: (1) The presence of tunnels on the stem or base of the fronds. (2) Infested palms may make "gnawing" sounds caused by the larvae feeding inside. (3) Aspiration of viscous fluids from the tunnels. (4) Appearance of chewed plant material (excrement) at the external entrances to the feeding tunnels and a very distinctive “fermented” smell. (5) cases of empty pupae and dead red palm weevil bodies in and around badly infected palms, and (6) trunk breaking, or palm crown falling off [3]–[5].

International trade in live palms is the most likely channel that has allowed this pest, which probably moves as eggs, larvae or pupae hidden within the palm, to move over great distances. The red palm weevil may spread easily to new areas because it has traveled with its food supply, or there are ornamental trees or other palms nearby that it could infest once the larvae have finished developing and emerge as new adults that abandon their original plant. Adult weevils are strong fliers and can fly up to 900 meters (~900 yd) at a time and can move up to 7 kilometers (~4.3 mi) in 3-5 days [6]–[9].

Palm cultivation in Palestine is widespread in the Jericho region, the Jordan Valley, and the Gaza Strip, especially in the cities of Deir al-Balah and Khan Yunis. The date sector in Palestine is one of the pillars of the agricultural economy. According to the statistics of the Ministry of Agriculture, in September 2021, the number of palm farms in Palestine reached 571, containing It has 311 thousand palm trees, employing more than 5,000 workers, and the value of its exports is about 35 to 40 million dollars annually, and the date production for the 2021 season is estimated at about 13,000 and a half tons. The Palestinian local market consumes 6,000 tons of dates in the West Bank and Gaza Strip. Annually, 60% of the Palestinian production of dates goes to the local market, and only 40% of the production is exported from the Palestinian Medjool variety, where the per capita annual consumption is estimated at about 900 grams of dates [10]–[12]. Hence, our thinking began to discover and develop an actual solution for this weevil, and that was through designing a robot capable of locating the weevil inside the tree and treating it. The environmental and terrestrial elements of the tree are also monitored and checked permanently, and this limits the spread of this weevil and preserves the Palestinian economy [13]–[15].

The main objective of this study is the early detection of the entry of the red palm weevil into the trunk of the palm tree before it begins to multiply and gnaw the trunk from the inside in an initial attempt to eradicate palm AIDS. An innovative and more accurate detection method to directly control the weevil was developed. Economically, the red palm weevil causes financial losses estimated at millions of dollars annually, whether through lost production costs or pest control costs. Hence, the project reduces processing costs for farmers and prevents huge material and agricultural losses, thus preserving the agricultural and economic wealth of the country from the annual palm crop. Environmentally, the palm tree is considered one of the largest trees in size, so the property of capturing a large amount of carbon dioxide gas from the air was one of the most important characteristics of the palm tree, which makes it the ingredients for solving global warming and climate change problems. Accordingly, the project maintains a balanced ecosystem by preserving on palm trees, and using an innovative treatment method that is less harmful to the environment by reducing the use of chemical pesticides and avoiding their potential harm at the environmental and human levels.

The objectives of this study can be summarized as follows:

- Designing an electronic piece that receives data from sensors, sound sensor, infrared thermal imaging sensor, moisture sensor, PH sensor and temperature sensor.
- Designing a robot that carries different methods of examination and treatment for the weevil, and receives data related to the palm tree and takes an appropriate decision based on it.
- Using an innovative treatment technique, which is electromagnetic waves of a certain amount and specifications.
- Programming an application that receives the data coming from the sensors and shows it to the user.

II. METHODOLOGY

After studying this problem completely and scrutinizing it, it was found that it is possible to solve the problem by making a robot and using sensors for palm trees. The robot receives the signal from the sound sensor attached to the thermal imager installed in the tree. When an insect approaches the tree detected by a thermal imaging camera, the sound sensor senses the signal as soon as it enters the trunk of the palm where the trunk is being bitten and gives me an initial warning. Then the warning comes to the bot, where the bot goes to the tree from which the alarm was issued. The robot performs a comprehensive and immediate examination of the tree and the soil and records all data related to the tree and the insect. After confirming that it is that insect, the robot changes its position until it performs the treatment. The treatment is performed using the robot arm with electromagnetic radiation in the place where the insect is, which is not harmful to the tree, as the treatment only works to kill the insect in proportions.

A solution to the problem of the red palm weevil, and this was done by means of sensor techniques on the palm tree. This technology can detect the weevil, whether inside or outside the tree. When this weevil is sensed, a signal is sent to the robot, and the robot moves towards the tree from which the alarm came, so that the robot performs a treatment based on Electromagnetic radiation kills it without affecting the values of the tree.

Various methods have been employed to detect red palm weevil infestations in palm trees, each with its own set of advantages and limitations. Traditional trunk inspection involves making holes in tree trunks, but it's inaccurate and can potentially increase the risk of infestation. Pheromone sensors detect volatile compounds, but their accuracy is compromised by other insects. Canine detection is highly accurate but dependent on trained dogs. Acoustic sensors, which listen for weevils' feeding sounds, can be expensive and not consistently accurate. Our innovative approach incorporates artificial intelligence, utilizing a robot equipped with an IoTree-Agrint sound sensor system and motion/infrared sensors. This method shows promise in providing accurate and efficient red palm weevil detection.

The beginning of any analysis requires a complete knowledge of the weevil being dealt with. From here, the research centers conducted a complete study of the insect, where multiple analyzes were conducted for the early detection of the weevil. Initially, the visual check is most prevalent among growers, but the weevil has reached advanced stages and spread all over the trunk. With the development of technology, more effective methods were found, which was developed and linked together to obtain the highest accuracy in reading, as follows:

Analysis of the sound of gnawing caterpillars inside the trunk of the palm tree:

A pilot study was conducted inside a room. Table 1 shows the Biting pattern of the insect, Table 2 shows the eating pattern.

TABLE I. FREQUENCY OF BITING PATTERN OF RPW.

Activity	Frequency (Hz)	Sound (dB)
Normal biting	1651	-19.6
Slow Biting	1588	-24.2

TABLE II. FREQUENCY OF EATING PATTERN OF RPW.

Activity	Frequency (Hz)	Sound (dB)
Clear Eating	2219	-17.2
Slow Eating	1163	-15.2

In terms of treatment, a robot using EV3 Lego as a prototype as shown in Fig. 1 have been designed. It has one arm it carries a treatment technique, that emits microwave (electromagnetic waves). This robot is equipped with an ultrasonic wave sensor to avoid obstacles during its movement and determine the direction of its movement.

This robot receives the signal from the three sensors installed on the tree and linked together in one electrical circuit. After receiving the signal and informing it of the injury to the palm tree, it moves towards the coordinates of the affected tree and determines the location of the internal injury based on the signal coming from the sensors. Accordingly, it treats the tree with electromagnetic waves in the right place to eliminate weevil.

When a signal is sent to the robot by the sensors to move for treatment, the farmer is notified on his phone that the palm tree has been infected with RPW.

In the first design of the robot, the wheel system on two models was designed, in the case of its design Chain was high balance and was commensurate with its function so that it would enter the farms and walk on uneven ground, but the speed of the robot began to decrease, the required tape in the required sizes was not available in the markets, so the second model was resorted, which is a design with wheels with a large diameter in order to increase stability. In addition, the required parts were available and their price is low as shown in Fig. 2.

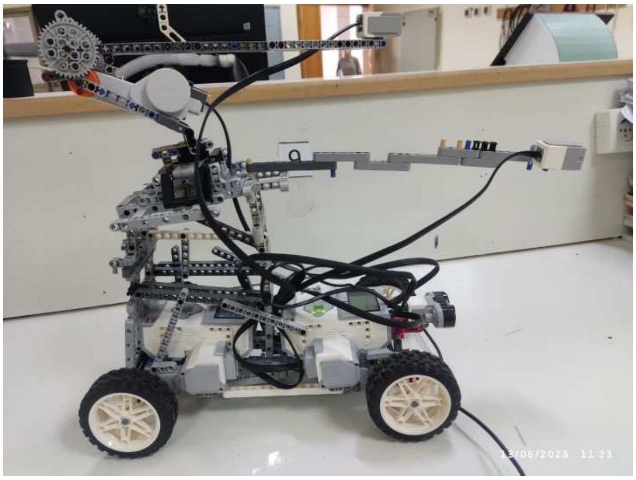

Fig. 1. Red Palm Weevil Treatment Robot

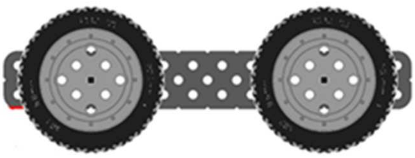

Fig. 2. Robot base.

In the design of the sensors, a circuit containing two sensors together in the microcontroller was designed, the first is a thermal sensor to sense the temperature of the palm tree, and the second is a sound sensor to sense the sound of the insect when it approaches the palm tree. Fig. 3 shows the whole design with all sensors needed.

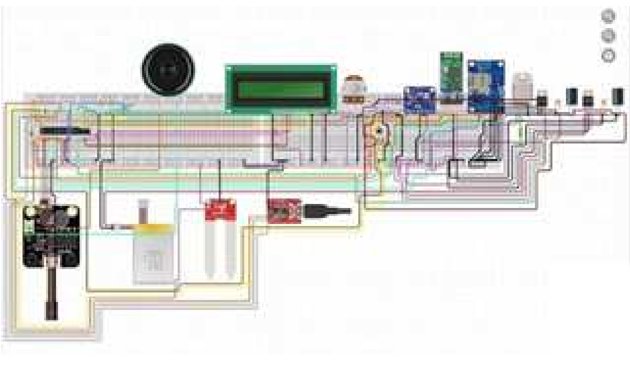

Fig. 3. Final design with all sensors needed.

III. Results

At the end of our project, authors reached the following results:

- One electronic circuit was designed that includes more than one sensor to reach the highest accuracy with one output signal (audio sensor, infrared imaging sensor, soil moisture sensor, soil pH sensor, and soil vital values sensor).
- An initial robot was designed that avoids obstacles in its path and replaces manpower. It works with artificial intelligence technology. It has arm for treatment, and the treatment is divided into two parts: electromagnetic radiation (microwave).
- An application was programmed for our project that stores all the data coming from the sensors and the robot and shows it to the user permanently.

On the economic side, the project limited the possibility of an environmental disaster at the level of palm farms, as the spread of the weevil may lead to a material loss estimated at US dollars. Methods of spraying with chemical pesticides, special injection methods, and treatment mechanisms are very expensive, in addition to the costs of manpower due to the mechanisms of periodic spraying for a preliminary procedure to avoid possible injury, and it may be useless in some cases.

On the environmental side, the disadvantages of getting rid of trees in the event of infection through burning have been eliminated, thus reducing the spread of greenhouse gases, in addition to getting rid of chemical emissions resulting from spraying pesticides periodically, whether for prevention or treatment. A balanced environmental system has also been preserved, as well as all our study technologies were powered by clean solar energy, and this ensures the sustainability of the solution.

Our study was distinguished from similar projects by the fact that the accuracy of detecting the weevil and its immediate treatment is much higher than similar technologies. In terms of the detection process, the system that was designed shortens a great deal of time compared to traditional methods that require taking a biopsy in laboratories and examining it to ensure the presence of the weevil. This process takes time. It leads to an exacerbation of the problem and greater agricultural and material losses. In addition to the time factor, the robot of our project receives data from sensors periodically and with high efficiency compared to other robots that receive data from applications only, and the stability of the robot is high, which allows it to move more steadily in the farm, avoiding any obstacles. Thus, the accuracy of the project has reached approximately 85% of the sensors, robot, and application.

IV. Conclusions

Our study presents an innovative solution for detecting and treating red palm weevil infestations in palm trees. We've developed a robot with advanced sensors that can detect the weevil's presence early, both inside and outside the tree. Our treatment method using electromagnetic radiation is eco-friendly and cost-effective. The project offers economic and environmental benefits, reducing losses in palm cultivation and minimizing the carbon footprint of pest control. The robot's high accuracy and mobility make it a promising tool for addressing this critical issue in palm farming, with an accuracy rate of approximately 85%.

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