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Detection of 'Stem and Root Borer' Pest in Trees using Embedded Platform

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Abstract:

Stem and Root Borer pest (SRB) is known to cause huge financial losses to commercial crops and tremendous destruction of forests reserves all over the world. The pest being nocturnal and entire life span spent beneath the bark is invisible to the farmer during day time. Tree shows sickly appearance only in the later stage of infestation where the recovery is impossible hence timely detection of the presence of CSRB infestation is of prime importance to the benefit of the farmers in the State. In this paper, we have proposed the embedded system design which will be able to perform the prompt and accurate detection of the pest infestation. The entire system will be designed on ARM7 embedded platform which has Prediction Model running on it. The Prediction model will accurately detect the status of tree by measuring the chlorophyll and conductivity of the tree.

Keywords: Embedded, SRB, conductivity, chlorophyll Prediction Model.

Introduction

SRB infests the vital bark portion of yielding commercial crops like Cashews and Mangoes, and leads to the gradual death of such infested trees. In case of Cashew plantations, Cashew Stem and Root Borer (CSRB) Plocaederus ferrugineus pest is rarely visible and the damage is sporadic in nature.

It is observed that the pest population of CSRB increases over the years resulting in constant loss of tree population. Thus, over a length of time the yield outcome in a given plantation gets depleted. In case of severe borer pest attacks, there is significant reduction in cashew nut yield causing torment to the farmers [1]. Also, there exists evidences of several other cases of beetles attacks, mentioned as follows:

1) the Japanese cypress bark beetle, Phloeosinus rudis, Phloeosinus bicolor and Phloeosinus thujae killed numerous shrubs and trees of Cupressaceae in The Netherlands, in the summer of 2004 [2].

2) Extensive beetle outbreaks by mountain pine beetle (MPB), on the lodgepole pine and ponderosa pine have destroyed over lakhs of km^2 of forest throughout British Columbia and the western United States [3].

3) A tree-killing bark beetle, Dendroctonus frontalis is a destructive forest pest in the southeastern United States. It has three consistent fungal associates, Entomocorticiumsp. A,Ophiostoma ranaculosum and O. minus[4].

4) In Norway, Ips typographus is the major tree-killing bark beetle attacking spruce Picea abies. Two symbionts (Grosmannia penicillata and G. europhioides) produced large amounts of 2-methyl-3-buten-2-ol (MB), indicating that fungal symbionts can de novo produces the beetles' aggregation pheromone [5].

Apart from causing heavy financial losses to commercial crops, the damage to tress by the bark beetle has got ample severity for the following reasons:

1) In case of forests, the insect damage causes the carbon sink to turn into carbon source [3]. The emissions of monoterpene and SOA (secondary organic aerosol) concentrations, have been scaled up to a 4-fold increase in monoterpene emissions and up to a 40% increase in SOA concentrations in some years (as observed lodgepole pine response), as result of Beetle infestations.

2) The damaged forests trees being dry, are highly inflammable, thus enormous area of dead forests attacked by such pests are susceptible to forest fires[6] . However, the cashew (Anacardium occidentale L) is an important commercial plantation crop with an enormous potential for foreign currencies and the only source of income in remote locations in the State of Goa. Thus, this

research is to develop an embedded system for detection of 'Stem and Root Borer' pest in cashew trees.

History and Background

Cashew cultivation in India during 2004-05 concerned on area of 820 thousand hectares of land and produced 500 thousand tons of raw nuts (Directorate of Cashew and Cocoa Development REPORTS, 2005-06).

One of the major causes of yield reduction in cashew is the infestations by insect pests, which results in moderate to heavy loss of the crop yield depending on level of insect pest population.

The two major insect pests a) Cashew Stem and Root Borer (CSRB) scientifically known as Plocaederus ferrugineus, and b) Tea Mosquito Bug (TMB) scientifically known as Helopeltis antonni, cause considerable decrease in yield in most of the cashew growing regions of our country.

The extent of attack of Cashew Stem and Root Borer (CSRB) was assessed in different cashew plantations of Forest (David and Ananthakrishnan, 2004). Reports reveal that Departments of Kerala and Tamilnadu were found be 7-20 per cent and 30-35 per cent loss, respectively (Misra and Basu Choudhary, 1985). In Guntur and Prakasam districts of Andhra Pradesh, the infestation was recorded up to 40 per cent (Arjuna Rao, 1978; Ayyanna and Rama Devi, 1986).

The symptoms of CSRB pest damage [7] in initial stage of attack, is the secretion of resin and fibrous material at the ground level of the infested tree, by the tree in its defense. During later stages of attack, the infested tree canopies show a sickly appearance and green leaves turn yellowish and fall prematurely. In acute stages of attack, the branches dry off and bark on the trunk starts splitting. At this stage, large quantity of chewed fibers and resins (commonly known as 'frass'), are seen as big lumps at the base of the CSRB infested tree.

To prevent the spread of pest infestation, the two aspects to be considered are:

1) Reduction of pest population in a given location,

2) Rescuing the trees in initial stages of infestation.

To achieve these aspects, the CSRB infested trees should be identified in the initial stages of infestation during the nut collection period and marked suitably.

Treatment of all such initially infested trees should be done at a time. Also, the trees which have yellowing of the canopy and/or have more than 50% of the bark circumference damaged should be uprooted and pest stages in the root zone should be destroyed. This approach is called 'Phytosanitation'. This method helps curb down the pest population in a given location and leads to lesser new incidences of the pest in the subsequent years.

Thus, the accurate and prompt detection of the presence of CSRB infestation is required, because

1) The infested trees with 50% or more damage of the bark circumference, or with the leaf canopies yellowed, do not recover from the damage[1].

2) The trees are becoming more vulnerable for pest insects such as phloeosinus species, as the summer drought and heat waves are predicted to be increased upon the climate change.

Thus, it is concluded that, the timely detection of the presence of CSRB infestation is of prime importance to the benefit of the farmers in the State.

Proposed Methodology and expected outcome

The ultimate goal of this research is to develop an Embedded System, which will be capable to indicate status of the given tree whether it is infested or not. The implementation of this system will be based on design comprising of the results obtained after series of certain analysis procedures. The following is the broad construction:

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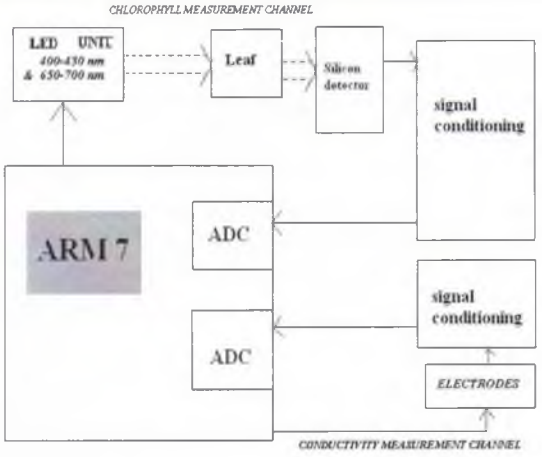

The Proposed embedded system unit will have three major sub-blocks:

1) ARM7 unit: This is the heart of the entire system which controls the operation of the two channels, Conductivity measurement channel and Chlorophyll measurement channel.

ARM will be loaded code of Prediction model, to obtain the decision about the status of a productive plant, w.r.t. presence of infestation. Its working will be designed based on the inferences (i.e. range of data values) obtained at the end of the certain analysis procedures. The data memory of ARM will be stored with data of pre-determined values, which are belonging to the conductivity measurement and chlorophyll measurement.

2) Conductivity measurement channel: It will comprise of electrodes, which will be inserted within the bark portion (at height of around 1 mt. from ground) of tree under consideration. The input to the electrodes will be frequency signal from the ARM 7. The Electrodes output is then conditioned and given to ADC of ARM 7 Board. The design of Conductivity measurement channel will be for the purpose of detecting the continuity of food & water channels (i.e. phloem & xylem) in the tree. Thus its role would be to verify or to determine the passage of nutrients to the plant [8][9][10][11].

3) Chlorophyll measurement channel: It will comprise of LED unit (to emit the light wavelength for the detecting the concentration of chlorophyll [12][13][14][15] i.e. 650-700 nm, 400-450 nm), leaf, silicon detector (to detect the absorbance phenomenon) and a signal conditioning unit (to convert the output of the detector to suitable level for ARM 7). The input to the LED unit will be voltage signal from the ARM 7 unit. The output of the signal conditioning unit will be converted to digital form by ARM 7.

The design of Chlorophyll measurement channel will be based on the Beer lambart law.

Beer lambart law states that the transmittance (T) of material sample is related to its optical depthτ and to its absorbanceA as

$$T = \Phi_e^t / \Phi_e^i = e^{\tau} = 10^{-A}$$

where Φ_e^t is the radiant fluxtransmitted by that material sample and Φ_e^i is the radiant flux received by that material sample.

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