# PLANTS DEMO - Enabling Mixed Societies of Communicating Plants and Artefacts

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**Abstract**: Several applications, such as precision farming, military field monitoring and seismic activity monitoring require reliable and extended lifetime deployments of potentially a very large number of wireless sensor and actuator nodes. As hardware becomes cheaper and smaller, more of these applications are likely to appear, particularly as these miniaturised nodes offer the opportunity for the electronics to be embedded unobtrusively into everyday objects. This paper will present results from an EU funded project, PLANTS. PLANTS is a research project devising a novel technology that will allow plants to control their own environments. Using this technology, plant signals are detected, analysed and an appropriate response activated. The PLANTS system automatically responds to a plant's needs

## 1. Introduction

According to the U.S. National Research Council, precision agriculture is defined as a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production [1]. It is a rapidly growing industry with heavy emphasis on large-scale farming and uses remote sensing techniques for high volume crop production. At present the vast majority of sensing techniques being used are remote techniques, such as satellite infrared imaging for monitoring soil moisture. Plant and agricultural sciences research have provided some detailed understanding of plant response patterns. Use of electronics in this regard has focused on system level forecasting of cropping and yields [2], precision farming techniques [3], remote sensing and devices for analysis of the surrounding ecosystem parameters [4]. There has been an extremely limited amount of research on dynamic interactions between digital systems and plant ecosystems. State-of-the-art is represented typically by remote monitoring, such as in [5], but such

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a system is largely an operator-dependent support system rather than an automated software decision-making system for maintaining optimal plant growth conditions. Wireless networks equipped with crop/plant sensors would afford farmers the opportunity to use other methods of getting data on their crops rather than relying exclusively on a single sensing method.

## 2. PLANTS Project

The specific objectives of PLANTS, an EU-funded 5th framework project [6] project are:

· To study plant eco-systems in order to understand sensing and communication mechanisms, which will be used as models for the specification of the plant-artefact interfacing mechanisms.

· To design and develop sensors and sensor networks, which will be implanted around and in plants and will transform biological signals into digital signals.

· To design and develop biosensors and actuators, which will provide artefacts with the ability to induce complex responses from plant-life and perceive their environment in a plant-like way.

· To design and implement specific middleware (ePlantOS) in order to integrate complex distributed systems of sensors and artefacts into a balanced eco-system, for the purposes of non-predictive study of selected plant-life and interaction with its environment (people included).

PLANTS deals with precision agriculture on a smaller scale by using both remote and contact sensors. The project aims to develop a management system where the plants' needs for water, nutrients, light, pests and disease control are detected. The sensors are implanted around and on plants, as part of a wireless network, to transform biological signals into digital signals. The decision-making software interprets these signals and, if necessary, autonomously toggles the appropriate actuators in order to provide the ideal growing conditions to the plants.

## 3. PLANTS Demo

Plant temperature affects plant growth and, ultimately, plant productivity. If a plant is stressed due to inadequate watering or high temperatures this causes a drop in photosynthesis levels. Plant temperature fluctuations can indicate two stresses, viz. water stress and temperature stress. The former would mean the plant requires irrigation while the latter generally means that the environmental temperature is high and misting would cool the plant. Three types of sensors had to be interfaced for the PLANTS project; ethylene sensor, soil moisture sensors and thermistors for assessing leaf temperature. Figure 1 shows the layout of the sensor network system. A test-bed was developed in a greenhouse where strawberry plants were fitted with sensors listed above and actuators including high power lights and valves for implementing an irrigation and misting system. The sensors were interfaced to the Tyndall25 motes [7,8] and data was wirelessly relayed to the system base station (PDA or laptop) via the RF transceiver layer. Based on the sensor readings the operating system then determined if it was necessary to take action. In the first experiment which was undertaken, ambient temperature and leaf temperature were logged continuously. If the temperature differential between leaf and ambient exceeded 0.75°C, this was indicative of plant overheating and that irrigation was required. Anything on or above this threshold would have triggered the water pumps to turn on for any user specified time period e.g. 60 seconds in this case. This resulted in a reduction in water consumption and also meant that irrigation of the plants would only occur when the plant itself required it.

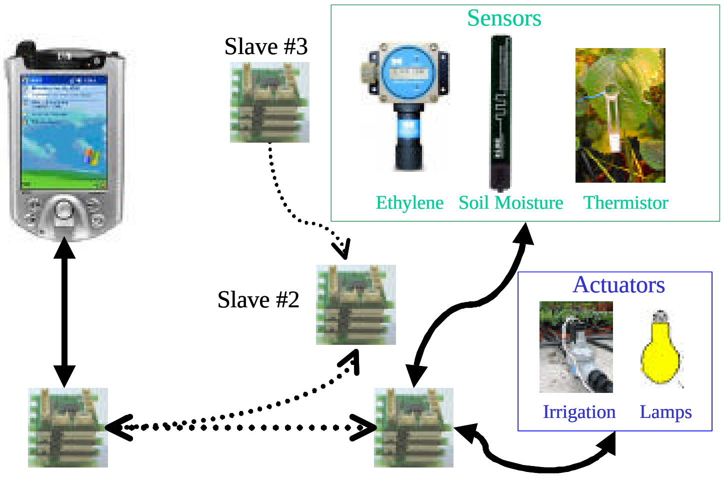


**Fig 1**. PLANTS sensor network system

Figure 2 shows the temperature differential between the thermistors with the 0.75°C threshold marked across the graph. As can be seen from the graph, when the plant overheated and the differential between thermistors crossed the threshold, the pumps were triggered which brought about a reduction in leaf temperature. This graph also demonstrates the reliability of the system control over an extended time period.

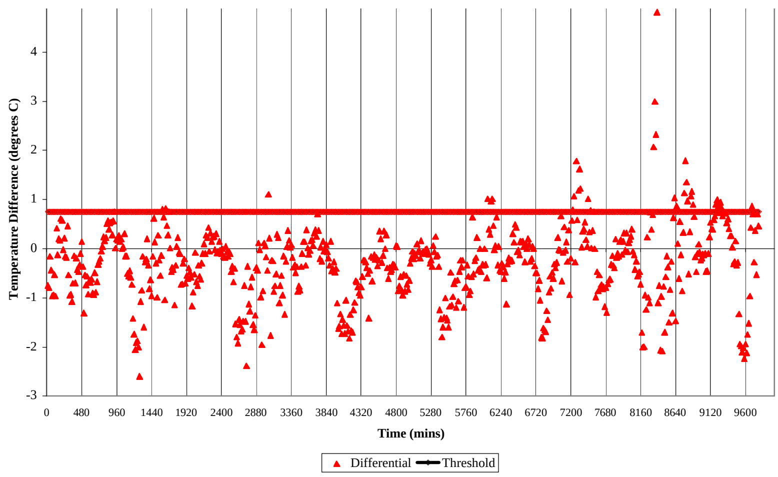


**Fig 2.** Temperature differential between leaf and ambient


**Fig 3.** PLANTS Demo in operation

## 3. References


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