



University of Extremadura
Faculty of Science

Physics degree
Degree Final Project

**Developement of a FIWARE-based application
for tree species monitoring (dendrometry)**

Javier Fernández Aparicio
jfernandil@alumnos.unex.es

July 2020

--

Contents	1
Abstract	2
1 Introduction	2
1.1 Dendrometry, a formal definition	3
1.2 Arduino, multipurpose microcontroller	3
1.3 LoRa (Long Range)	4

Abstract

This document gives a detailed description of this project, which is focused on researching possible low-cost alternatives for wireless dendrometry systems. Currently there exist a lot of expensive and professional systems in the market, that's because this project is intended to reduce costs and increase the versatility, scalability and accessibility.

In order to reach these objectives the project will be supported over free software such as FIWARE[1] or free hardware such as Arduino[2] and RaspberryPi[3].

1 Introduction

This project arises itself from a direct interaction with professionals inside forestal sector. The original idea was to give technical coverage for particular necessities which professionals in this sector had to face off with. At this point is easy to notice this solution will need to be a distributed solution, due high samples dispersion. **As can be seen**, there are even remote techniques to predict this sample density/dispersion using remote methods which predicts **between 157-170 individuals per hectare**[4] (depending on the used model). So according to this and sample size determination theories, to get a great resolution could be necessary a big size for samples and the necessity of a big wireless network of distributed devices, since each device will correspond with an individual.

This is more or less, the definition of the IoT (Internet of Things) concept; according to [5] IoT concept comes from an earlier concept called M2M (Machine-to-Machine) communications. However, also according to [5] there is not an official definition for IoT concept, but

“based on the traditional information carriers including the Internet, telecommunication network and so on, Internet of Things (IoT) is a network that interconnects ordinary physical objects with the identifiable addresses so that provides intelligent services.” [6]

This, at least, covers a little part what this project is intended to do: “Interconnect ordinary physical objects with the identifiable addresses” to provide intelligent services. These physical objects are in this case ordinary dendrometers.

Over the years there have existed analog and manual dendrometers, thus data acquisition had to follow

a manual process in the same way. This could turn out bothering because the big size for this statistical population, **as it was exposed before**. So it was traditionally necessary to go there and as part of the field work, take individual by individual the whole sample data.

1.1 Dendrometry, a formal definition

The GEMET (General Multilingual Environmental Thesaurus) adopts the definition for *dendrometry* from [7]:

“The measuring of the diameter of standing trees from the ground with a dendrometer that can also be used to measure tree heights.”

This one is a bit wide definition because nowadays most dendrometry researches are focused on stem diameter; however, at this point could be interesting to extend this project to include also a sensor to heights measurement.¹

A lot of comercial dendrometry systems are available in the market, nevertheless more than single and manual dendrometers those are complex and professional distributed systems, consequently ¿like/as? has been already said, one of the most important objectives in this project is to research about the possibility to get lower the costs of the whole system, because those professional systems are still expensive. So this is intended to get a cheaper system and make it accessible to everyone who wants **to monitorize** one or more trees growth.

There are plenty types of dendrometers but according to [8] “It is possible to define two broad categories of dendrometer: those that contact the stem and those that do not”. This project is focused on the former kind, so for this project is being developed a “contact dendrometer” based on a linear potentiometer.

1.2 Arduino, multipurpose microcontroller

It’s not difficult to justify the use of such an interesting platform as Arduino. The adaptability is one of its strengths, therefore; it is able to acquire and process certain data coming from a set of sensors and manage it to send this via any plugged wireless network interface.

¹ This project is already considered extensive enough.

Due circumstances exposed in introduction section is needed an accessible and multipurpose platform **to be the basis for the device design itself**, this is to say the core part of the dendrometer is an Arduino microcontroller.

Since the idea is to produce a low-cost device in order to distribute a high number of them, it must be a simple design; that's because it consist only of three parts,

- **Linear potentiometer:** which is the sensor itself due is directly in contact with the stem. In order **to improve data acquisition it will be necessary to use a High Input Impedance Amplifier.**
- Arduino microcontroller: this is the core part for the device, it will be responsible for acquire linear potentiometer data and send it to a gateway through LoRa interface.
- LoRa interface: similar to other existing wireless interfaces, it is necessary to forward the sensor data to a concentrator (gateway). Usually and due its complexity these kind of interfaces are integrated circuits which are mounted on a PCB in order to obtain a pluggable card/shield.

1.3 LoRa (Long Range)

LoRa is a “long-range, low-power, low-bitrate, wireless telecommunications system”[9]. This is because some devices inside IoT paradigm tend to be economical and low-resources devices, in order to get them distributed/scattered, as it has been pointed. So this low availability along to their tendency to be distributed/scattered causes the necessity for a low-power consumption and a long-range telecommunication.

In a more general sense, there is a wider concept to include all these kind of technologies which fulfill the IoT communication requirements, this is the “Low-Power Wide Area Networks” (LPWAN)

“Colloquially speaking, an LPWAN is supposed to be to the IoT what WiFi was to consumer networking: offering radio coverage over a (very) large area by way of base stations and adapting transmission rates, transmission power, modulation, duty cycles, etc., such that end-devices incur a very low energy consumption due to their being connected.” [9]

It is important to note that **when talking about “low-power consumption”, in many cases it is actually meaning** battery-powered devices, for example.

By other hand, Lora can commonly refer to two distinct layers; a physical layer (LoRa itself) and a MAC layer protocol (LoRaWAN). The former one (the physical layer), is a proprietary technology developed by Semtech.

References

- [1] e. FIWARE Foundation. (2020). Fiware home,
[Online]. Available: <https://www.fiware.org/> (visited on 05/2020).
- [2] A. company. (2020). Arduino,
[Online]. Available: <https://www.arduino.cc/> (visited on 05/2020).
- [3] R. P. Foundation. (2020). Raspberry pi,
[Online]. Available: <https://www.raspberrypi.org/> (visited on 05/2020).
- [4] J. Mohammadi, S. Shataee, and M. Babanezhad, “Estimation of forest stand volume, tree density and biodiversity using landsat etm + data, comparison of linear and regression tree analyses”, *Biophysical Chemistry - BIOPHYS CHEM*, vol. 7, pp. 299–304, Dec. 2011.
DOI: 10.1016/j.proenv.2011.07.052.
- [5] A. Abdul-Qawy, E. Magesh, and S. Tadisetty. (Dec. 2015). The internet of things (iot): An overview,
[Online]. Available: https://www.researchgate.net/publication/323834996_The_Internet_of_Things_IoT_An_Overview.
- [6] H.-D. Ma, “Internet of things: Objectives and scientific challenges”, *J. Comput. Sci. Technol.*, vol. 26, pp. 919–924, Nov. 2011.
DOI: 10.1007/s11390-011-1189-5.
- [7] J. A. Dunster,
Dictionary of natural resource management.
1996,
ISBN: 9780851991481.
- [8] N. Clark, R. Wynne, and D. Schmoldt, “A review of past research on dendrometers”, *Forest Science*, vol. 46, pp. 570–576, Nov. 1999.
DOI: 10.1016/j.dendro.2009.06.008.
- [9] A. Augustin, J. Yi, T. H. Clausen, and W. Townsley, “A study of lora: Long range & low power networks for the internet of things”, *Sensors*, vol. 16, p. 1466, Oct. 2016.

DOI: 10.3390/s16091466.