DETECTION OF THE COFFEE LEAF RUST USING DECISION TREES

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ABSTRACT

Throughout the history, coffee has become an important part of some countries' economy, creating employment and improving the first sector of the economy. Countries as Brazil, Vietnam and Colombia have now an exportation system based on coffee production and marketing. Because of this, the reduction on its cultivation can involve not only a clear decrease on its production rate, but a destabilization of the economy of thousands of people, who depends on it.

That's why concerned about the consequences that a plague as the coffee leaf rust can have in multiple topics, we have proposed to find a way of predicting and controlling this fungus based on decision trees considering the physicochemist data.

Keywords:

Data structures; coffee leaf; big O complexity; decision trees; algorithms; execution time; storage; CART algorithm

ACM keywords:

Information systems → Data management systems → Data structures → Data layout → Data compression

Theory of computation → Design and analysis of algorithms → Data structures design and analysis → Pattern matching

Theory of computation → Design and analysis of algorithms → Algorithm design techniques → Dynamic programming

Theory of computation → Theory and algorithms for application domains → Database theory → Data structures and algorithms for data management

1. INTRODUCTION

Nowadays, the principal kind of coffee used in exportations is the Coffee arabica, however, there is a fungus called Hemileia vastatrix, that affects this plant producing a disease known as coffee leaf rust which it first appearance was in XIX century and arrived in 1970 in Brazil and Colombia in 1980s, until becoming in a serious problem currently, because facts like climate change, have allowed this complaint spreads out.

Although Coffee arabica has troubles, some solutions were found out related with the management of the plant, like changing the way to irrigate (as dripping) the plant or controlling the humidity levels on the areas, because factors as warmness, humidity and the accumulation of water can be dangerous for the plant and can produce this fungus.

In addition, wireless sensors have had an important place, because they surveillance constantly coffee plants, sending information that can be used to predict the state and decide if coffee leaf rust is occurring, therefore, it opens the options to create algorithms in order to get a solution.

2. PROBLEM

The objective of this project is to design a time efficient algorithm which allow us to predict, in certain time, if the *Coffea arabica* has coffee leaf rust in a certain growing zone.

In this work, we have information about some important physicochemist variables such as soil pH, soil temperature, soil moisture, illuminance, environment temperature and humidity and a label of an expert who qualified whether the cultivation has or no coffee leaf rust.

So, the first input of the program would be the physicochemist variables and after that, receive a second input with the information (except the label), and finally the algorithm, considering some aspects, will say if the cultivation has or no coffee leaf rust.

With this algorithm, the study of this disease will improve and allows to coffee cultivators be careful, and finally the economy of coffee countries will be better.

3. RELATED WORK

3.1 ID3 Algorithm:

This algorithm is commonly used in machine learning which, from a dataset, creates a decision tree; to do that, it is necessary to know the entropy and the maximum gain information where first is related with the uncertainly or

probability of an event and the second with the difference between the entropy and one of its options. [1]

The decision tree is composed by root nodes, child or options nodes and leaf nodes, also has attributes. Besides, is recursively so it is based on iterations.

The algorithm start in a root node which has the dataset, after that the algorithm search for the best attribute according to the gain information we are looking for, then the set will be split by this decision until get a leaf node which give us the class or classification of that information through a binary answer like yes or no.
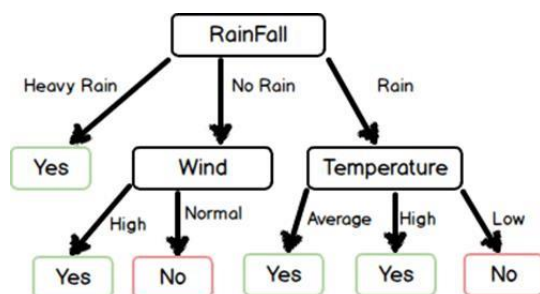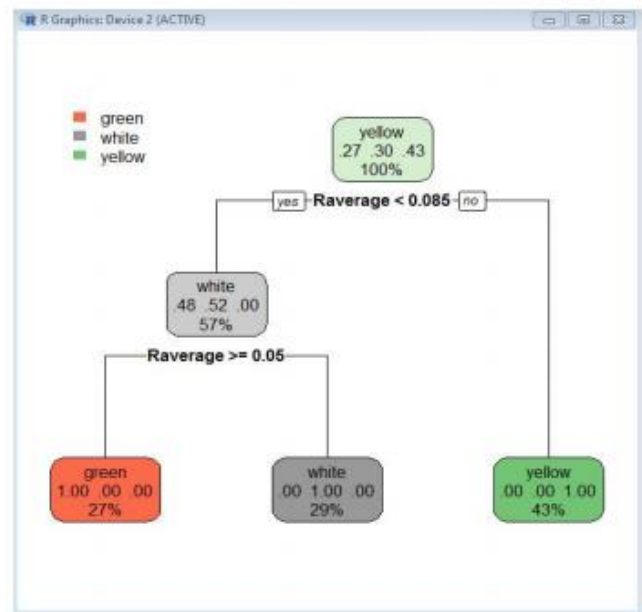

3.2 C4.5 Algorithm

This sequence of paths to do a decision tree is like ID3 algorithm but allow you to extend the strategy to more applications, for example, you can use this algorithm both for discrete and continues variables. As ID3 algorithm, C4.5 create a decision tree based on a training information, so it classifies the information of a certain data.

One of the advantages of this method is a process called pruning which is useful for huge data and improves efficiency ignoring information could be in a bigger generalization., avoiding overfitted (an ID3 algorithm problem).

Has the same structure of ID3 algorithm trees, with nodes, leaves and branches, where the course is also according to the entropy and information gain, starting to calculating the best attribute to split the training information, decreases the entropy until get a decision, because while the iteration divides the data, in each one is will be easier to choose the class of the information, due to information gain is bigger and bigger when entropy is smaller; that is, for each attribute calculate the potential data by a test to get the best attribute to branch on until end the tree. [2]

Regarding to the project this kind of algorithms to generate a classifiers trees based on a dataset and aspects which influence in the decision, would be good to implement in order to find out if from a physicochemist information of Coffee arabica, this plant has the coffee leaf rust.

3.3 C5.0 Algorithm

This Algorithm is considered by a lot of people the "upgrade" of the C4.5 Algorithm. It is the industry standard for the construction of decision because of its ease to solve most of the problems out of the box and the facilities it has for users to applicate it. [3]

Its structure is closely alike to C4.5's and uses the same information for building the tree (As it is entropy and information gain) but has new implementation for improving processing speed, memory and efficiency. [4]
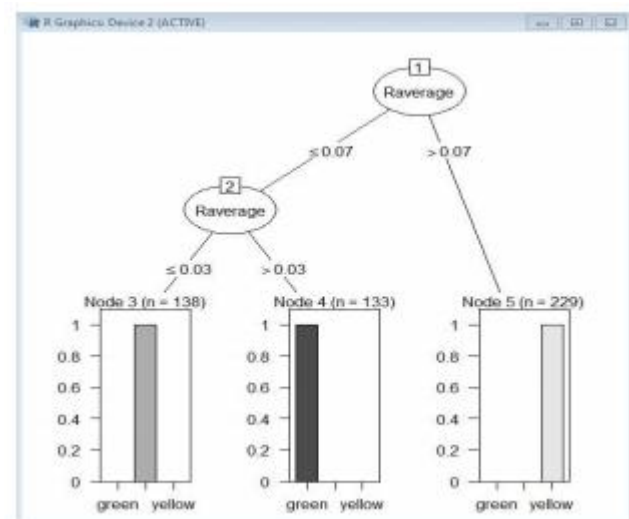

3.4 CART Algorithm

The CART model is a decision tree model which is not only used for classification but for regression too. Its structure is very similar to other decision trees' but its difference with the rest is in the way the tree is built.

The CART algorithm is based, instead of Entropy and information gain values, in the Gini index function, which simplifies the way to define the pureness of the nodes and leaves.

It is also easy to use because of the ease how it can give a good interpretation of the data, only needing it to be a good representation of the problem. [5]
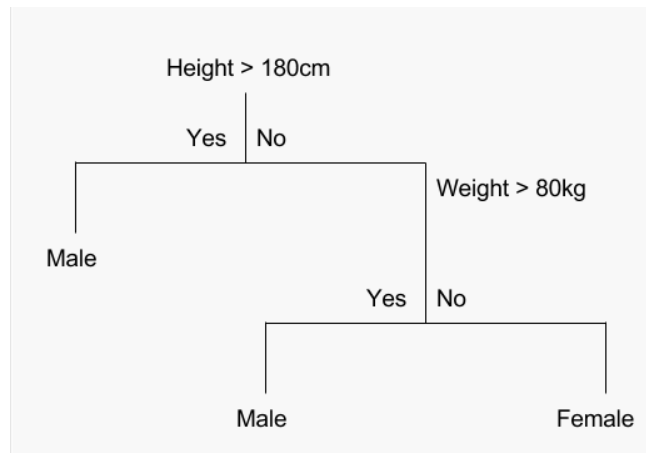
4. DATA STRUCTURE

Figure 1: Hash Table of objects form the class node, which contains every physicochemical characteristic of the data set and the label, which says if the plant has or not leaf rust
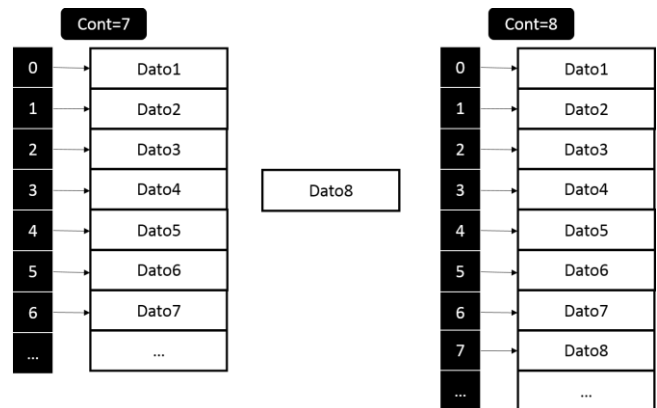
4.1 Operations
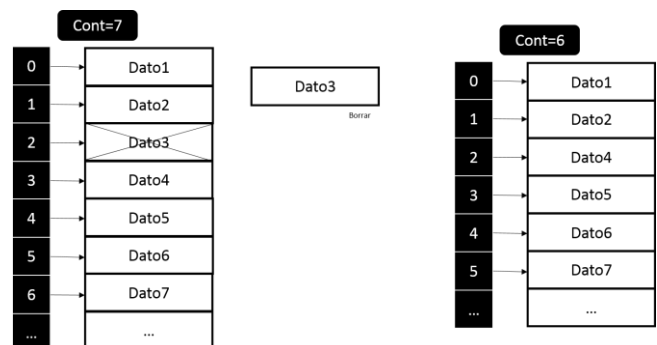

Figure 2: Representation of the adding function

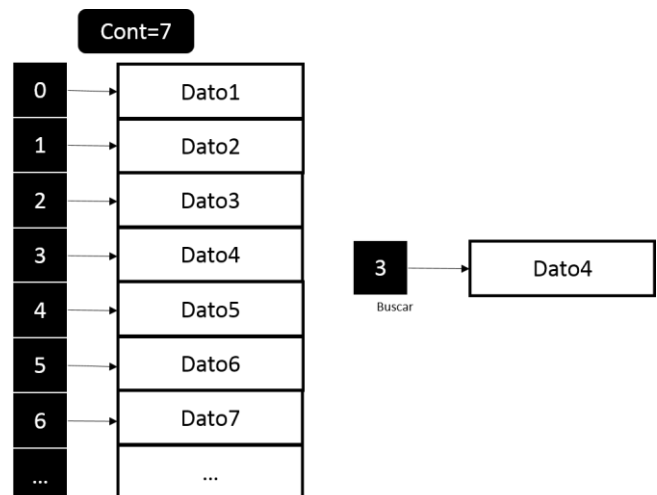**Figure 3:** Representation of the deleting function

Figure 4: Representation of the searching function

4.2 Why this data structure?

We decided to work with this data structure because it let us add, search and delete components from the structure with a complexity of O(1) and because it can help us to make a good use of a decision tree for predicting the presence of the coffee leaf rust on the plant.

4.3 Complexity

Method	Complexity
Reading a Data Set	O(n)
Adding	O(1)
Searching	O(1)
Deleting	O(1)

Table 1: Complexity of methods

4.4 Execution time

Method	Best time	Worst Time	Average Time
Adding	0.000244140625 ms	0.0126953125 ms	0.000739746 ms
Searching	0.000244140625 ms	0.0009765625 ms	0.0004443359375 ms
Deleting	0.072509765625 ms	0.126953125 ms	0.0004443359375 ms

Table 2: Execution time of methods

4.5 Data structure storage

	Dataset1 (data_set.csv)	Dataset2 (data_set_test.csv)	Dataset3 (data_set_train.csv)
Data Structure	1MB	0.6 MB	0.7 MB

Table 3: Data structure storage

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