

# Coffee Leaf Rust Detection Using Convolutional Neural Network

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**Abstract**—Rust is a severe disease affecting many productive coffee regions. It is caused by a pathogenic fungi that attacks the underside of coffee leaves and it is characterized by the presence of yellow-orange and powdery points. If not treated, rust can cause a drop in coffee production of up to 45%. In this sense, this paper presents a contribution to the problem of rust identification that doesn't use "handcrafted" features, i.e., features extracted according to rules established by human programmers. Instead, we propose to train a Convolutional Neural Network (CNN) to learn to identify rust infection. We evaluated our CNN in a set of images provided by an expert and comparison results show that our approach is able to detect the infection with a high precision, as corroborated by the high Dice coefficient obtained.

**Index Terms**—texture analysis, convolutional neural network, coffee leaf rust

## I. INTRODUCTION

Nowadays, Brazil is the world's largest exporter of green coffee, accounting for 30% of world coffee production [1]. According to [2], pests and diseases are a very common problem in coffee farms. Among them, rust is a severe disease affecting coffee plantations in Brazil. Rust is caused by an endophytic fungus that attacks the leaf of adult coffee, especially older plants, and if not properly controlled can cause up to 45% reduction in coffee production [3].

In this context, image processing and machine learning techniques can help in the identification process of different plant diseases by speeding up the process or by detecting infections in early stages. In [4] the authors propose a spray robot to detect different leaf diseases using image processing in order to decide which pesticide to apply to the leaf. The work in [5] uses different machine learning techniques to detect rust infection in wheat leaves. A clustering approach can also be used to classify rust disease in wheat leaf images [6]. Rust detection is also the focus of the work proposed in [7], which uses graph pattern matching to detect signals of infection. The recognition and classification of visual symptoms of leaves affected by fungal disease is proposed in [8]. To accomplish that, the authors proposed a methodology based on Radon

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transform and SVM. In [9] the authors propose the use of a non imaging spectroradiometer in order to analyze the spectra of infected and non infected leaves.

In fact, computational methods can be very useful to evaluate characteristics present in the coffee leaves and, consequently, to facilitate and expedite the task of identifying coffee diseases, such as rust. Many computational techniques can be used in rust identification, such as different methods of image processing and texture analysis, besides machine learning techniques, such as deep learning [10], [11]. Deep learning is a set of machine learning algorithms that attempt to learn a pattern using different levels, each level corresponding to a different degree of abstraction. It has been used in several areas and for different types of data, such as images, sounds or texts. Deep learning techniques have demonstrated great advances in many works aiming pattern recognition in images, proving to be effective for both the generation and classification of patterns.

This paper aims to model and train a convolutional neural network for the detection of rust infection in coffee leaves. The remaining of the article is so organized as follows: Section II presents the concepts involved in a convolutional neural network and the Tensorflow library used to build the neural network. In Section III we describe the dataset used in the experiments. Section IV describes the experimental procedure used to detect rust, the network structure, how to perform data augmentation, and how we built training and validation sets. Section V reports the achieved results while conclusions and future work are presented in Section VI.

## II. CONVOLUTIONAL NEURAL NETWORK

Convolutional Neural Networks (CNN) are one of four categories of deep learning methods, along with restricted Boltzman machines (RBM), autoencoders, and sparse coding. The main characteristic in CNN is the existence of convolutional layers that act as receptive fields in the neurons, being its main application the processing of visual information [12]. Along with convolutional layers, CNNs also present pooling and fully connected layers [10], [13]. These three layers are what defined the main structure of any CNN and they are briefly described as follows.

The convolutional layer is responsible for applying a convolution operation to the input data. This operation acts as