Project No.	Project Title	
2021-01-133	Water Stress Detection in Banana Plants Using Machine Learning	
Academic Advisor	**Co-Advisor**	
Prof. Boaz Lerner		
Team Members		
Yotam Baron		
yotambar@post.bgu.ac.il		

Abstract

The banana is the fourth largest fruit worldwide in terms of production volume. Diseases and stresses in plants such as water stress cause significant loss of crops. Therefore, the task of identifying diseases and stresses in plants, as well as understanding their development process, are critical matters. Using a botanical expert for this purpose, especially at the orchard level, is an expensive and inefficient solution. Therefore, there is a great need in automatic, especially machine learning (ML), tools that can deal with this issue in a cost-effective, fast, and accurate manner.

To build a model that could detect and explain the process of water stress in banana plants, we conducted an experiment, with our close partner Rahan Meristem, where 192 banana plants were randomly divided into four treatment groups and grown in a greenhouse for 41 days. During the first 13 days, all plants received an optimal amount of water (100%). From the 14th day forward, each group of plants received a different amount of water - 100%, 80%, 60%, and 40% of the optimal amount of water. Data extracted from images of the plants taken by RGB, thermal, depth, and multi-spectral cameras were processed by us and used to train an ML model based on a Bayesian network (BN). The BN graphical model was used to identify and analyze the development of water stress in the plants by measuring changes in the connections between variables (nodes) in the graph representing plant characteristics.

The stress-detection performance of our model was compared to a human expert, once classifying the plants based on their images and once based on physically inspecting them in the greenhouse, and to five state-of-the-art algorithms. Our model identified 70% of the plants in stress in day 20 for the first time and never less than 45% of them since then. Although in the greenhouse, the expert detected stress already on day 15, his detection rates in days 20-28 were never higher than those of our algorithm, and when he evaluated images, he detected stress also during the five days before the stress has even begun. The F1 (trading precision and recall) performance of our model was usually superior to at least three of the five competing algorithms in almost all days. All competing algorithms show similar stress-detection performance during all experiment days including those before the stress has begun, demonstrating unacceptable false alarm rate.

Unlike all other competitors, our model provided important information on the development process of the plants' water stress. The stress first affects the temperature of the banana plant, then the size of its leaves, and finally the number of leaves it has and various color indices. The proposed system – using processed data from images of the plants taken by different cameras and a BN model for predicting and understanding the plant's stress process – can be a worthy replacement for the human expert, and consequently allow the farmer accurate and specific care for plants in a quick and a cost-efficient manner.

Keywords: water stress, Bayesian networks, detection rate, biotic and abiotic stress