Data analysis required for vineyard disease prediction

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Abstract: *In this paper we will analyze what type of data we need in order to perform the research. Hence, we needed to gather a satisfying set of data that we will use for testing the initial model. In order to get to the right set of data, first it was crucial to identify the most common vineyard diseases in the Republic of North Macedonia. Furthermore, we needed to gather the data set from sensors from all available measuring stations in different vineyard locations. Finally, the aim is to develop an original model for vineyard disease prediction using the most appropriate machine learning algorithms. We present the latest results we have achieved as well.*
KEYWORDS*: MACHINE LEARNING, ALGORITHMS, VINEYARDS, VINEYARD DISEASES, PREDICTION, MACHINE LEARNING MODEL*

1. Introduction

In this paper we will analyze the type of data we need to acquire so we can perform the research. Hence, we needed to gather a satisfying set of data that will be used to test the initial model. In order to get to the right set of data, first it is crucial to identify the most common vineyard diseases in the Republic of North Macedonia. Furthermore, we need to gather the set of sensor data from all available measuring stations in different vineyard locations. They will be stored in a relational database using specific services. The services used for data collection, analysis and disease prediction of vineyards are also presented. We show some of the classical models for vineyard diseases forecast. The final aim is to develop an original model for prediction of vineyard diseases using the most appropriate machine learning algorithms. We will present the latest results we have achieved.

2. Problem Discussion

The agro-cultural sector is one of the most important sectors in the entire history of mankind and has a great impact on the quality of life. Agricultural crops need to be resistant from many external factors, and it is the Information and Communication Technologies (ICT) that can solve many problems farmers are facing nowadays. The Internet of Things (IoT), as a newer concept, encompasses a wireless sensor network of devices that are interconnected and can communicate without the need for constant human interaction. IoT is evolving with the development of wireless technologies, micro-services and the Internet. An IoT system consists of several smart devices with built-in processors, sensors, and hardware components that can be networked and connected. The IoT provides real-time status surveillance of a system, enabling owners to respond appropriately.

Agronomy is a science that deals with solving problems in agriculture. Nowadays, it uses IoT solutions that are already being used intensively for "smart cities" [1]. Some of the IoT applications in agriculture are: soil monitoring, plants, animals and "smart vineyards". Wireless sensor networks (WSN), as an additional tool for collecting data from the field, are of great importance for both increasing production and reducing production costs. Early detection, or prevention of plant diseases and infections, can prevent them from spreading and thus destroying most of the plantations.

2.1 Vineyard Diseases

The most common vineyard diseases in our region are the following:

a) Downy Mildew - (Plasmopara viticola)
b) Powdery Mildew (powdery mildew) - (Uncinula necator, Erisyphe necator)
c) Gray Rot (Botryotinia fuckeliana)
d) Black Spot on the Vine - EXCORIOSIS (Phomopsis viticola)
e) Grape Moths - Gray (Lobesia botrana) and Yellow Grape Moth (Eupoecilia / Clysia ambiguella)
f) Calepitrimerus Vitis and Eriophyes Vitis
g) Cicadas (Scaphoideus titanus, Empoasca vitis) and Grape Phytoplasmas
h) Weeds in Vineyards

3. Presentation of Data Gathered from Vineyard Plantations

The data set collected from measuring stations (Meteobot-Figure 1) already positioned in the wineries is obtained from the following sensors:

- Temperature, humidity and air pressure sensor;
- Rainfall sensor;
- Speed and wind direction sensor;
- Soil temperature sensor;
- Soil humidity sensor;
- Leaf moisture sensor;
- Global radiation sensor.

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Fig1: *Meteobot stations for data measurement on the field*

The data obtained from the measuring station (Pinova) in Kamnik Winery are presented on Figure 2 in the following manner:

PinovaSoft v1.5.112.	Temp. zraka	Vlaga zraka	Temperatura tla	Vlaga tla	Najveca brzina vjetra	Brzina vjetra	Vlaga lista	Padaline	Tocka rosista
27.09.2019 03:50:00	15.7	86.8	20.9	72	0	0	100	0	13.5
27.09.2019 03:40:00	15.8	86.8	21	72	0.2	0.2	100	0	13.7
27.09.2019 03:30:00	15.8	87	21	72	0.2	0.2	100	0	13.7
27.09.2019 03:20:00	16	86.6	21	72	0	0	100	0	13.8
27.09.2019 03:10:00	16	86.5	21.1	72	0.8	0.4	100	0	13.8
27.09.2019 03:00:00	16.1	86	21.1	72	0	0	100	0	13.8
27.09.2019 02:50:00	16	85.7	21.1	72	0.6	0.6	100	0	13.6
27.09.2019 02:40:00	16.1	85.6	21.1	72	0	0	100	0	13.6
27.09.2019 02:30:00	16.1	85.5	21.1	71	0	0	100	0	13.7
27.09.2019 02:20:00	16.2	84.8	21.1	71	0	0	100	0	13.7
27.09.2019 02:10:00	16.2	84.1	21.2	72	0.4	0.4	100	0	13.5
27.09.2019 02:00:00	16.1	84.9	21.2	72	0.2	0.2	100	0	13.6
27.09.2019 01:50:00	16.4	83.7	21.2	72	0.4	0.4	100	0	13.6
27.09.2019 01:40:00	16.8	81.1	21.3	71.5	1.2	0.6	100	0	13.6
27.09.2019 01:30:00	17.2	77.6	21.3	71	0	0	0	0	13.2
27.09.2019 01:20:00	17.1	77.7	21.3	71	0.6	0.6	0	0	13.2
27.09.2019 01:10:00	17.1	79.5	21.3	71	0	0	0	0	13.5
27.09.2019 01:00:00	17.2	78.1	21.3	71	0	0	0	0	13.3

Fig.2 *Type of data gathered from Kamnik Winery measuring station*

The data obtained from the measuring station (Meteobot) in Bela Voda Winery are given on Figure 3 in the following manner:

PinovaSoft v1.5.112.	Temp. zraka	Vlaga zraka	Temperatura tla	Vlaga tla	Najveca brzina vjetra	Brzina vjetra	Vlaga lista	Padaline	Tocka rosista
27.09.2019 03:50:00	15.7	86.8	20.9	72	0	0	100	0	13.5
27.09.2019 03:40:00	15.8	86.8	21	72	0.2	0.2	100	0	13.7
27.09.2019 03:30:00	15.8	87	21	72	0.2	0.2	100	0	13.7
27.09.2019 03:20:00	16	86.6	21	72	0	0	100	0	13.8
27.09.2019 03:10:00	16	86.5	21.1	72	0.8	0.4	100	0	13.8
27.09.2019 03:00:00	16.1	86	21.1	72	0	0	100	0	13.8
27.09.2019 02:50:00	16	85.7	21.1	72	0.6	0.6	100	0	13.6
27.09.2019 02:40:00	16.1	85.6	21.1	72	0	0	100	0	13.6
27.09.2019 02:30:00	16.1	85.5	21.1	71	0	0	100	0	13.7
27.09.2019 02:20:00	16.2	84.8	21.1	71	0	0	100	0	13.7
27.09.2019 02:10:00	16.2	84.1	21.2	72	0.4	0.4	100	0	13.5
27.09.2019 02:00:00	16.1	84.9	21.2	72	0.2	0.2	100	0	13.6
27.09.2019 01:50:00	16.4	83.7	21.2	72	0.4	0.4	100	0	13.6
27.09.2019 01:40:00	16.8	81.1	21.3	71.5	1.2	0.6	100	0	13.6
27.09.2019 01:30:00	17.2	77.6	21.3	71	0	0	0	0	13.2
27.09.2019 01:20:00	17.1	77.7	21.3	71	0.6	0.6	0	0	13.2
27.09.2019 01:10:00	17.1	79.5	21.3	71	0	0	0	0	13.5
27.09.2019 01:00:00	17.2	78.1	21.3	71	0	0	0	0	13.3

Fig.3 *The type of data obtained from the measuring station in Bela Voda winery*

4. Services for collection, analysis and prediction of vineyard diseases

The system is called the Smart Eco Cloud Service (SECS), which will be an interactive decision support system (DSS) for disease and pest management during the production of grapes from the vineyards.

On-line data from Meteobot meteorological stations will be used to operate this system. They are installed in a number of wineries where we can obtain historical data from previous years (for model testing), and the on-line data will be used for on-line possible disease prediction. It is also possible to obtain data from weather forecast models, and thus predict possible problems that could arise. The ECS system and the simulation models will be carefully developed in collaboration with specialists (agronomists) and with worldwide confirmed information.

The system needs to be constantly evolving, based on user feedback and new knowledge in disease and pest biology.

4.1 Data Collection Service (DCS)

The data collection and storage service uses an API to access data from the Meteobot stations. The platform from all available stations sends data to the access point of our server, which then sends it to the service bus. The DCS service operates as a consumer of this data from the highway, formatting and storing it in the database for further processing.

4.2 Analysis Service (AS)

The task of this service is to present, visualize or serve the stored data of the DCS service to the user in a form understandable and important to him. This service has an API through which we can extract statistical data and perform certain calculations. The analysis of this data is performed on-line.

4.3 Disease Prevention Service (DPS)

The job of this service is to calculate the risk index of occurrence of certain implemented diseases, using the stored data from the DCS service, and to provide the user with an alert in order to respond accordingly. This service has an API through which we can extract these indexes. Moreover, there is a notification service if there is a high risk index for any disease.

4.4 Pest Identification Service (PIS)

A pheromone trap is an insect trap that uses pheromones to attract certain insects. Pheromones are chemical substances needed for living beings to communicate with each other. Insects send these breeding signals to warn others of their kind about a predator in the area, or to find food. Using specific pheromones, traps can be placed to monitor pests in the vineyards. By constantly monitoring the number of specific insects, a pest infestation can be detected before it can occur. Early detection of insects using pheromone traps can reduce the damage in agriculture. The Eco-Informatics Lab has set up pheromone traps in Kamnik Winery that looks as shown on Figure 4.

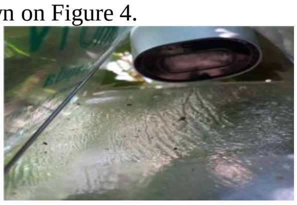

Fig4: *Camera mounted over the pheromone trap*

This type of trap is used when the aim is to detect the emergence of pests as early as possible. When a greater number of pests that attacked the vineyard are detected, the vineyards should be sprayed with insecticides. Using this approach, the yearly number of sprays are potentially reduced, which reduces the costs of the farmer, and at the same time protects the environment. The detection of trapped insects is done using a real-time camera images and by executing a code script. That service was developed at the Eco-Informatics Laboratory. The ultimate goal is to eliminate the need to physically walk and manually count all the insects caught on each trap. This should be replaced by automatic recognition of the number of insects in the image.

5. Models used for vineyard disease forecast

he disease prevention service will implement models for diseases that are most prevalent in our country. The disease prevention model [5] uses soil temperature data at different depths and locations, soil moisture content at the same locations, and the date of bud burst. It uses linear regression, source and recurrent neural networks as prediction algorithms. The study was conducted with a relatively small data set, but still indicates the potential of machine learning for disease prevention. The paper [6] predicts diseases of vineyards using the CNN (Convolutional Neural Network) approach and collected real-time data (humidity, temperature and soil moisture). The CNN approach is used to predict the likelihood of a disease, and sensor values are used in a trained linear regression model to predict the disease appearance percentage.

The study [7] performed a quantitative analysis of the relationship between weather conditions and the risk of seasonal vineyard diseases. Epidemiology, management and modeling of the most common diseases of the vineyards are given. The limitation factors in the prediction modeling of this study is the limited projection data (daily maximum temperature, daily minimum temperature and daily rainfall). The data we will use in our research on prediction disease modeling in vineyards are gathered on a daily basis with a resolution of 10 minutes. Having that, the dataset will be quite large and the possibility of predictive modeling of all diseases will be increased.

6. Conclusion

In this paper is devoted to the part of the research where the initial data identification is performed. In that context, a comprehensive analysis of the dataset used to test the model was performed. However, in order to identify the necessary dataset, in conversation with agronomists from the Institute of Viticulture at UKIM and using the available literature, an analysis of existing diseases that attack the vineyards in our country has been made. After differentiating the important dataset, it was agreed with a larger number of wineries to collect their datasets measured by the sensors of the measuring stations from different vineyard plantations.

In addition, the services needed for the collection, analysis and prevention of diseases in the vineyard will be used. The disease prevention service will be upgraded daily. The service will use the well-known classic models for disease prognosis (prediction) of vineyards, but also original models for disease prediction using machine learning algorithms. It is planned to use the data collected from drones and satellite imagery in order to obtain NDVI indices, which would give us an additional picture of the condition of the vineyard.

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