A WEB SERVICE FOR GRAPEVINE MONITORING AND FORECASTING A DISEASE

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Abstract: A web-based expert system for the grapevine monitoring and forecasting the appearance of downy mildew, which is a common disease of grapevine in Montenegro, is presented in the paper. The system is based on the 3 10 rule, customized for the south Montenegro region. The proposed web-based expert system is user-friendly, requiring minimal user-input data. In addition to several locations and weather stations which are initially embedded into the system, new locations can be easily added, and each location may use an arbitrary weather station. Moreover, the system is implemented with a multi-user structure, providing two types of predefined users: the administrator and the farmer. The priority levels and privileges depend on the active type of user. The purpose of the system is to predict the grapevine disease appearance based on the live data collected from weather stations in the field, combined with the expert knowledge implemented into the system. The proposed system provides the live monitoring of several relevant parameters, and alerts the user when a risk of infection is detected.

1. INTRODUCTION

Many scientific areas have been affected by rapid development of information and communication technologies (ICT) [1]-[11]. Biosciences, including the agriculture, are also in the line with this trend [4]-[7]. During the agricultural history, the monitoring of fields primarily depended on the knowledge of the farmers. Nowadays, the farmers are much more aware of the importance of science, which results in the growth of their interest in the

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expert opinion about the needed actions in their fields. However, the communication between a large number of farmers on the one side and a relatively small number of experts on the other side can be a problem. ICT has been recognized as a powerful tool to overcome this problem [4], [5], [7]-[11]. A number of expert system that can improve productivity has been developed [4]-[7]. All developed systems share the common goals: to maximize productivity, minimize investment, and to produce better and healthier products.

Grape is a widely grew fruit and a raw material for many different products. This is the reason why it attracts interest of many researchers. As many other plants, the grapes is very susceptible to a number of diseases. Prevention and anticipation of these diseases has always attracted a significant research interest. Downy mildew is one of the most widespread vine diseases that affects the yield each year, both in quantity and quality [11]-[14],[18]-[21].

The smart spraying expert system aims to automatically predict the appearance and development of this disease and to alert producers using a highly intuitive user interface. The intensity and the timing of the attack of downy mildew depend on several factors, among which the most important are meteorological factors and growth stages of the plant [11]-[14]. The main objective of the smart spraying expert system is to reduce the human involvement in the process of prediction and detection of downy mildew. To this end, a web-oriented expert system for the detection of disease, that uses information about temperature, precipitation, relative humidity, duration of leaf wetness and growth stage of grapevine is developed. All the data needed by the system are obtained from a database containing also the meteorological information from weather stations, stored on hourly basis. The only data that should be entered by user is the growth stage in vineyard. When all conditions for the occurrence of infections are met, the user is alerted through a very intuitive graphical interface. The development of the software solutions for forecasting the occurrence of downy mildew will contribute to reducing the number of treatments against this disease, and will thus reduce the cost of protecting vines in the production process. In addition, it is of a particular importance for reducing the potential risk in the use of plant protection products on humans and the environment. The advantage of this system compared to the existing ones [6] is the ability to monitor a sophisticated influence of microclimate on the appearance of the infection, and a rapid implementation of the countermeasures. Moreover, it is important to emphasize that the anticipation mechanism embedded in the proposed solution is the result of the previously published research [23].

The rest of the paper is organized as follows. Section 2 contains brief background remarks concerning the expert systems in general along with their applications in the agriculture, as well as some background details about the proposed expert system. Herein, the 3 10 rule which is implemented in the proposed solution is also described. Section 3 contains the description of the main modules of the developed system, including the respective illustrative screenshots. Section 4 concludes the paper and outlines the direction of the further development of the presented system.

2. BACKGROUND

A. Global outline of the system

Expert systems, which arise in the area of Artificial intelligence, are representative examples of knowledge-based computer systems which emulate the human expert ability to make decisions [1]-[3]. This kind of software uses sophisticated methods and algorithms for the analysis and interpretation of the data provided by users and/or other systems.

Expert systems have been extensively used in agriculture. Examples are numerous, and include: smart fertilization, smart irrigation, decision making/supporting systems adapted for the specific plants etc. A more detailed overview including examples of applications based on the expert systems can be found in [4] and [5].

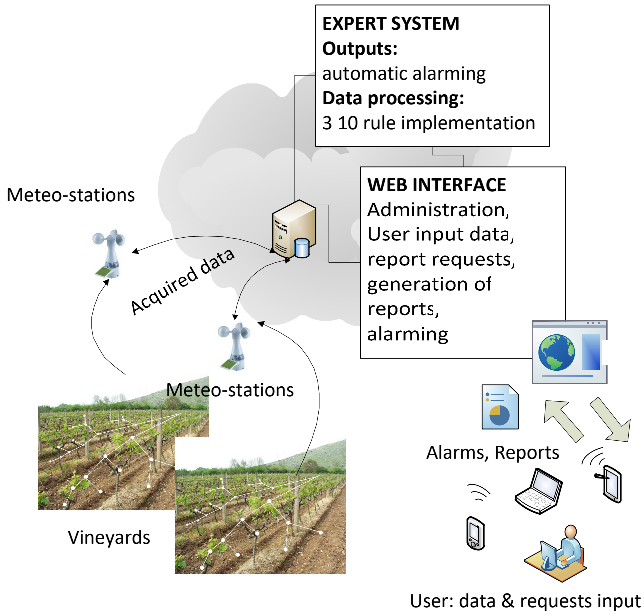

Figure 1. A global outline of the developed system

Two crucial segments of expert systems can be identified: the knowledge base and the inference engine. The knowledge base is consisted of the facts, and the rules. The inference engine applies the rules to the known facts, and enables the deduction of new facts.

The position of the proposed expert system in the global grapevine monitoring system is shown in Fig. 1. The knowledge base of the proposed system contains the rules for predicting the infections of *Plasmopara viticola* based on 3 10 model, and will be explained in details in the following subsection. As it is shown in Fig. 1, besides this internal knowledge base, our expert system uses the data obtained from the meteo-stations, as well as important data provided by users. To make successful decisions, the inference engine combines all the data with the implemented rules, and provides the prediction/alarming of the infection.

B. The 3 10 model

The 3 10 model is one of the simplest and most commonly used models for predicting infections of *Plasmopara viticola*. There are many variations based on this model which vary from region to region. These variations are caused by micro climate characteristic of certain region. Also, there are some other models which are used for this purpose [11].

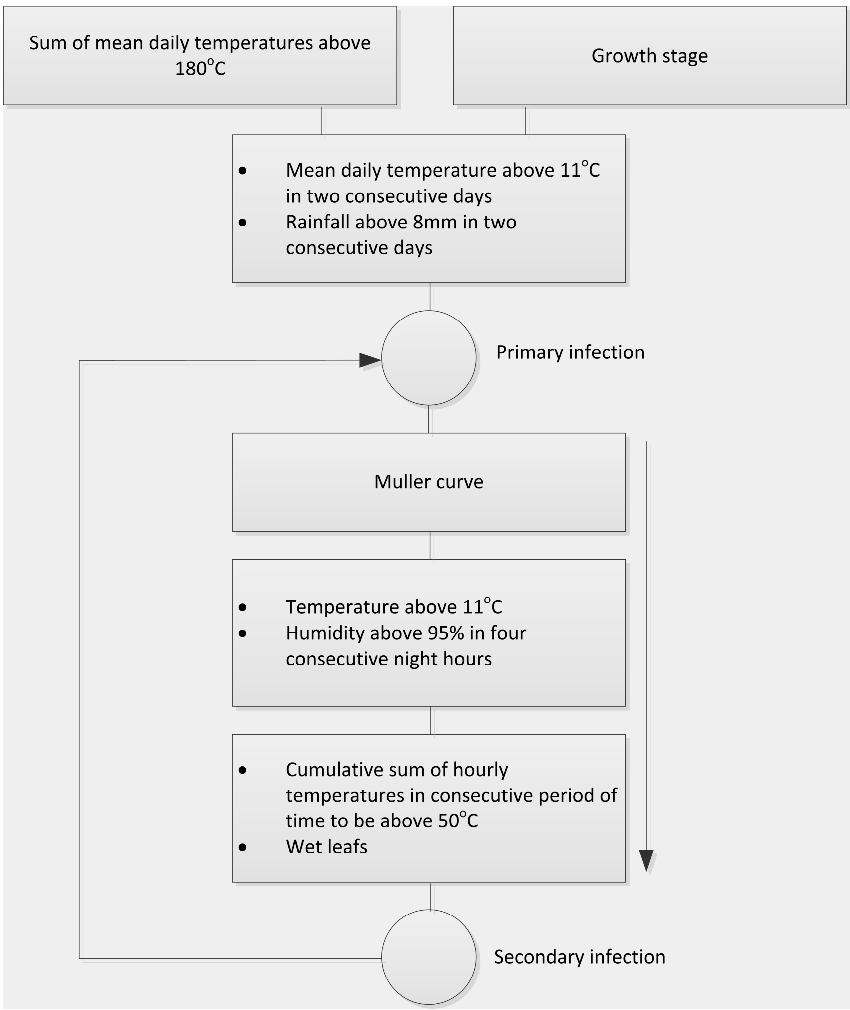

Figure 2. Diagram of the algorithm for monitoring downy mildew

Plasmopara viticola causes primary and secondary infections. Secondary infections can be developed only after primary infection has been achieved. There are several conditions for realization of primary infection:

1) The sum of mean daily temperatures from January 1st should be greater or equal to 160°C. This sum of temperatures is obtained by summing mean daily temperatures strictly greater than 8°C, where part above 8°C is summed.

2) After the sum of 160°C is achieved, the mean daily temperature in two consecutive days must be greater or equal to 11°C.

3) Total volume of rainfall in two consecutive days in which condition 2) is satisfied must be greater or equal to 8mm.

These three conditions reveal the reason why this model is called 3 10. Besides these three conditions, one more condition must be met. It reads that growth stage of grapevine must be on sufficient level. When all these conditions are met, we consider that primary infection has been developed.

There is an incubation period after primary infection before the symptoms of disease become visible, which can be calculated according to Müller curve [17]. After this period, two more special conditions which depend on temperature and humidity must be met in order to achieve secondary infections. After each secondary infection, the process is the same as in the case of primary infection. The diagram of the process is presented in Fig. 2.

3. SYSTEM DESCRIPTION

The web based interface for grapevine monitoring and the disease forecasting is designed as multi-user, where two levels of credentials are available, an administrator and a farmer level. Before any page is opened, a user must log in by providing his/her username and password. Based on the username, the system recognizes its priority level (administrator or farmer), and the corresponding options are available to the logged user. All system options can be categorized in five groups:

- Users;
- Locations;
- Monitoring of the disease;
- Growth stages of grapevine;
- Records of spraying.

All these options are available to administrator, while Users and Locations are disabled for the farmer. Data needed to apply 3 10 rule are stored in a MYSQL database, where the measurements from the vineyard are collected on hourly basis. Also, information about users, vineyards, and credentials are stored in the same database.

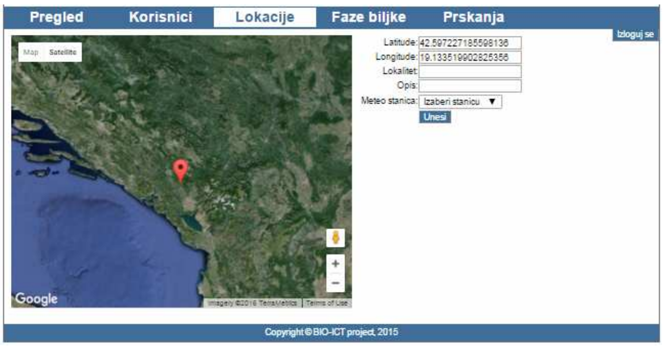

Figure 3. Interface for adding new vineyards to the system

Figure 4. Interface for linking users and vineyards

A. Users and locations

The one of the main functionality enabled only for administrator is adding of a new user. Before a new user is added, there is some elementary information that needs to be provided, like first and last name, username, password, etc. Also, there is a very important option where type of user is selected. In this way the administrator can add new user with administrator credentials or add a farmer.

Administrator has an option to add new field (vineyard) to the system. To do this, some basic information must be provided, like name, description, position on map, etc. When adding a new vineyard, one of three weather stations for collecting data must be selected. In this way, each vineyard is connected with certain weather station. The outlook of this interface is shown in Fig. 3.

In order to link user and vineyard, there is special interface enabled to administrator shown in Fig. 4. On the left side, all existing farmers are listed. By clicking on one of them, all vineyards he is responsible for are shown on the right side. It is very easy to add new vineyard to selected user, or to restrict his responsibility for vineyards he is responsible for. In this way, more than one user can be responsible for one vineyard, and one user can be responsible for more vineyards.

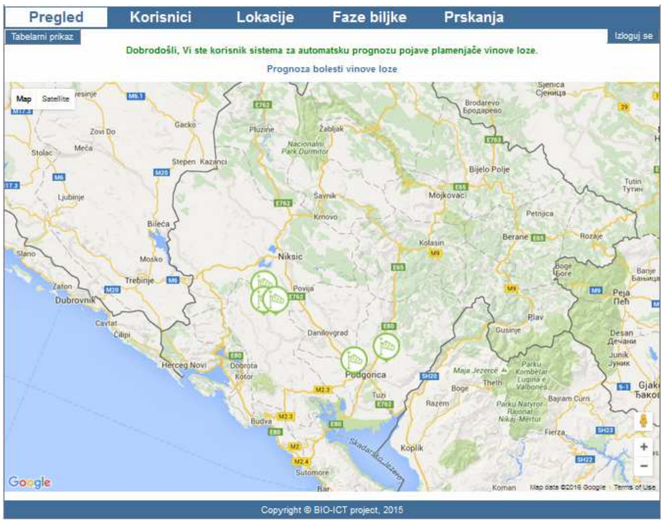

Figure 5. Map preview for monitoring vineyards

Figure 6. Table preview for monitoring vineyards

B. Monitoring of the disease

The part of this expert system by which users can monitor grapevine condition is presented in Fig. 5. This page displays all fields which are assigned to the logged user as the markers on the map. Each marker is positioned on the map at the true location of the vineyard it is representing. Two colors of markers are possible, red and green. Green color indicates that there is no recently occurred infection in vineyard. In other words, there is no need to treat vineyard, while the red color indicates that infections will probably occur in vineyard, and grapevine must be adequately treated. Color of marker is automatically determined based on expert knowledge of the system. Beside this map preview, there is also table preview shown in Fig. 6. From both previews, a page with detailed information providing dates of infections can be reached.

C. Growth stage of grapevine

Very important parameter which affects the disease in vineyards is growth stage of grapevine. This parameter is important for predicting disease since the downy mildew cannot achieve primary infection if leaf is not sufficiently developed. This stage of leaf development is directly related to the growth stages. There are predefined growth stages which are widely used in literature [15]. All of them are implemented in the system and each farmer is responsible to provide information about stages in his vineyards. This is necessary, since this information is used in expert system for predicting disease. There is specially designed interface where user can easily select one of predefined options, also select one of vineyards he is responsible for, and for specified date provide information about vineyard growth stage. This interface is shown in Fig. 7.

Figure 7. Interface for adding growth stage of grapevine

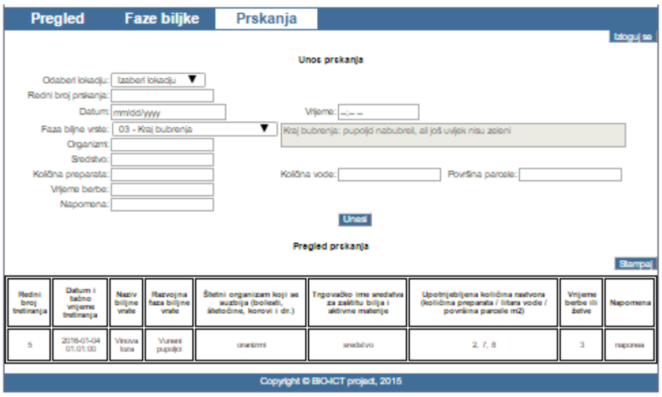

Figure 8. Spraying record interface

D. Records of spraying

The part of system where user can record spraying of vineyards is presented in Fig. 8. There are a lot of entry fields which are required to be filled in, in order to make a valid record. Also, all entered records are displayed above, and a special option to make report about all record is provided. For this purpose, PHP-based software for creating Portable Document Format (PDF) is used [17]. This part of system is not directly related to the expert knowledge, but is very important for each farmer, since according to the Montenegrin legislation spraying records should be made for each vineyard.

4. CONCLUSION

A web based interface for predicting the appearance of downy mildew on grapevine is presented in the paper. The aim is to forecast the appearance of this disease in order to threat grapevine optimally. The multi-user system is implemented and two possible priority levels are provided. Each of them includes certain specific options which are offered after the user logs in. An administrator, as a higher level user, can add new users, both administrators and farmers. New locations can be also embedded, and the farmers which exist in the system can be connected with their locations. Growth stage of grapevine is also a possible input of the system, where each farmer can add a stage for every vineyard. The main part of the system is the automatized interface where vineyards are monitored.

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