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Knowledge engineering approach for the analysis of viticulture

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ABSTRACT

The sustainable development of agricultural regions requires a methodical approach that will make a viable land management system policy in practice. In this regard, distinctive contextual characteristics of a country (remarkable areas for raising the regional products) could be taken into account in order to promote the good character of agricultural outputs and to increase the added value of considered lands. The manuscript primarily describes in qualitative and quantitative terms a mechanism for synthesizing information about wine production characteristics and therefore provides sufficient substantive treatment of agricultural or other system interactions. Firstly, the manuscript presents a discussion about many factors that affect wine production, and secondly, the focus is more on the development of an integrated approach using numerical and symbolic reasoning. The Geoviticulture Multicriteria Climatic Classification (MCC) System is engaged with a methodology comprising three viticultural climatic indexes of different natures: hydric type (dryness index), heliothermal type (Huglin index), and Nictothermal type (Cold Night Index). The knowledge representation is symbolized with the conceptual graphs formalism and the reasoning mechanisms are based on graph operations. A visual reasoning development focuses more on the decision process that would seem more appropriate for a practice on decision support. In addition, the Decision Support System (DSS) component is illustrated with a case study of Croatia republic in very broad characterizations of its main regional grape varieties.

1. Introduction

With the collapse of the Berlin Wall in November 1989, the land policies and land market in Central and Eastern European countries have been evolved through the land reform and the self-regulation of the free market (Bojnec, 2011; Lerman et al., 2002). Furthermore, in July 2013, the accession of Croatia as new member state of the European Union has made it possible to be eligible for assistance of Common Agricultural Policies. Under these circumstances, the European agricultural policies may encourage the development of intensive production practices in fertile regions and extensive farming situations (i.e. abandoned or marginalized farming areas) in regions with limited environmental conditions (e.g. mountainous and isolated areas). This underscores the need of targeting policies in these agricultural landscapes and the importance to highlight the principles and measures that preserve the integrated development with local, regional and national characteristics (Kanianska et al., 2006).

Croatia is a young country; it declared independence in June 1991 and 6 months later obtained diplomatic recognition by the European Economic Community members, and subsequently, the United Nations. However, it is a very old wine country. The country enjoyed a huge renaissance which allowed a new generation of winemakers to revive an ancient tradition. The vines have grown there since ancient times (Jackson, 2000). It was introduced about five centuries before Christ by the Greeks who planted the first vines in the south of Dalmatia, particularly in the islands of Vis, Hvar, and Korcula. The first experiences were not conducive to any form of culture with their rocky slopes tumbling steeply to an indigo sea and azure sky. In terms of production, with an average overall annual quantity of 1.5 million hectoliters, it arrives at the 21st largest in the world. With over 100 traditional varieties of local grapes listed in a small area, Croatia has a very promising future, especially as the young winemakers are determined to highlight this feature. The strong wine identity of Croatia is a major asset in a market increasingly globalized. Croatia has recently tried to build a strategy and to adapt his business in the field of viticulture and marked the first major breakthrough of Croatian wines on the international scene. This is not surprising, given its extraordinary climatic predispositions and in light of the fact that the Croatia has two great traditional varieties of local grapes, Plavac Mali grape and Malvasia Istarska grape, which have become an essential part of the Istrian peninsula's tourism offerings.

The aim of this paper is to study the Croatian vineyard as a whole and to shed light on its characteristics. Local types of grape varieties are numerous, their characteristics are part of Croatian heritage, but the best known/common varieties are also present in some vineyards. As a first step, we describe the Croatian regions and identify its main

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varieties. Secondly, using Conceptual Graph user interface (CoGui), we will study the different possible combinations of key parameters (soil/climate/varieties) to determine whether the current varieties are the best. We will need accurate data and comparators to know precisely if the conditions are optimal for obtaining a quality of bunch of grapes (Fernández-Mar et al., 2012). Using the business rules, once the procedures are integrated in the CoGui software, we can analyze the choices made by Croatia. As a result, our proposal benefits from a thoughtful combination of thoroughly scheduled sequences of activities and integrated approaches that occur throughout the reasoning process (see Fig. 1). The combination of ontology-aware and applicable data-driven models is an interesting approach to model the domain knowledge and to build the interpretable models (Thomopoulos et al., 2013).

The development of a hybrid numerical–symbolic approach to crop modeling is useful for knowledge specification and reasoning about locations having similar meteorological and agricultural conditions (Russell et al., 1999). Using meteorological data and soil characteristics, it is possible to deduce some properties from contextual information and domain knowledge about the main crop cycles and traditional winemaking present in worldwide with associated specified requirements (Pinney, 2012). In that case, we will develop hypotheses grouping designation, which will enlighten Croatia in their communication to increase their international recognition. The global market is difficult to penetrate; the characteristics of the "Old World" wines and traditions have a leading market share in the key sectors of the international wine economy (Charters, 2006). Given its rich history, varied geography, and diverse culture, Croatia has been mainly influenced by viticulture and winemaking. Some of these characteristics of the country will determine whether its export potential is opened or closed to the current standards of winery business models and marketing practices. Using these results, it is possible to propose appropriate sustainable improvements to access the market without distorting the assets of this country.

In order to make the reading easier, the rest of the document is divided into three sections. Section 2 presents a numerical reasoning with the Geoviticulture Multicriteria Climatic Classification (MCC) System. Section 3 describes a symbolic reasoning with conceptual graphs for formal knowledge representation and visual reasoning (rules and queries). Section 4 provides the conclusion of the hybrid approach combining data-driven models and ontology-based reasoning for the development of sustainable systems, especially for the improvement of viticulture.

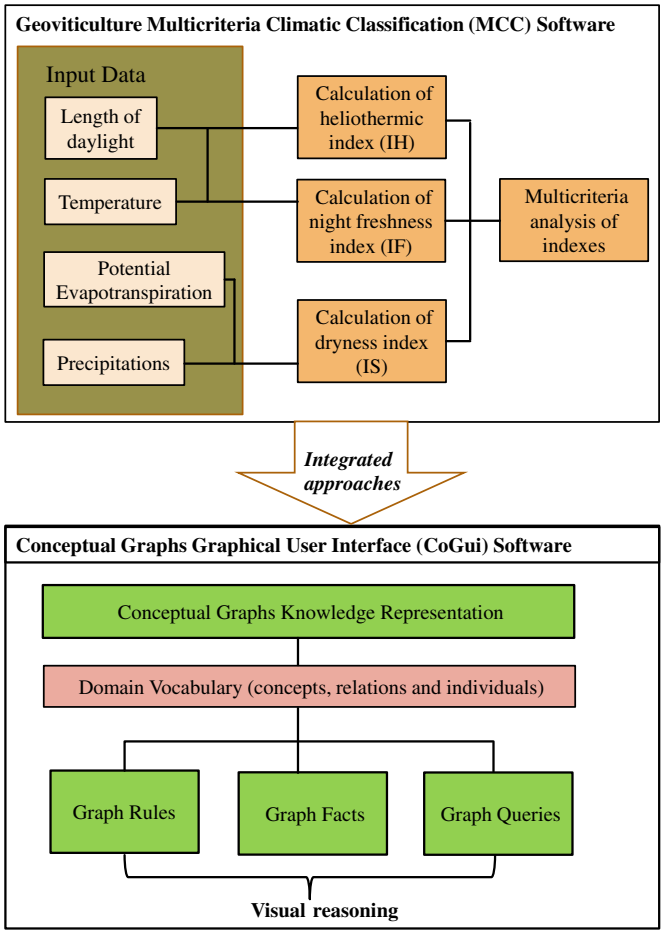

Fig. 1. General scheme of the proposal.

2. Numerical reasoning with MCC system

2.1. Geoviticulture Multicriteria Climatic Classification System

The Geoviticulture Multicriteria Climatic Classification (MCC) System proposes a methodology comprising three viticultural climatic indexes of different natures: hydric type (dryness index) (Deloire et al., 2004), heliothermal type (Huglin index) (Huglin, 1978), and Nictothermal type (Cold Night Index). Each of these indexes is complementary to each other (see Table 1) (Tonietto, 1999). From these clues, classes were created with value intervals or groups for a characteristic. These classes will help consolidate the regions in the world according to some similarities and to provide guidance on places, grape varieties, or numbers of harvests per year. In this case, it is suggested that similar wine production processes be grouped together under the same trading designations. Assessments are based on several climatic variables and agro-climatic indexes (Ruml et al., 2012).

Particularly, each region has been analyzed with a combination of these three major indexes. It is a multicriteria analysis of these three indexes which suggests if a vineyard produces a good wine or not. Of course, we cannot say that a wine is good or not by just these three indexes. There are plenty of other parameters that affect its quality. We have other factors such as the winemaking, wind, maintenance of the vineyard, wine maturation, compliance dates, or the influence of the wine critics or gastronomy critics (Sablayrolles, 2009).

2.2. Numerical reasoning with the processing of climatic indexes

For the numerical reasoning (see Fig. 2), we use the procedures implemented in the MCC system available online in the website "cnpuv.embrapa.br" that allows us to directly calculate (see Fig. 3) the useful indexes (Torres et al., 2011). From the point of view of numerical reasoning (Kamsu-Foguem et al., 2013b, 2014c), it is required to find

Table 1
Viticultural climatic indexes of MCC system with their respective classes (Tonietto and Carbonneau, 2004).

Viticulural climatic indexes	Climate classes	Acronym	Class interval
Dryness Index (SI, mm)	Humid	SI-2	150 < SI
	Sub-humid	SI-1	50 < SI ≤ 150
	Moderate dry	SI + 1	−100 < SI ≤ 50
	Very dry	SI + 2	SI ≤ -100
Huglin Index (HI)	Very cold	HI-3	HI ≤ 1500
	Cold	HI-2	1500 < HI ≤ 1800
	Cool	HI-1	1800 < HI ≤ 2100
	Warm	HI + 1	2100 < HI ≤ 2400
	Hot	HI + 2	2400 < HI ≤ 3000
	Very hot	HI + 3	3000 < HI
Cold Night Index (CI, °C)	Hot nights	CI-2	18 < CI
	Warm nights	CI-1	14 < CI ≤ 18
	Cool nights	CI + 1	12 < CI ≤ 14
	Cold nights	CI + 2	CI ≤ 12