Geographic, Weather, Geological, and Edaphological Data for Vineyards in the State of Guanajuato

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***Abstract*— Geographic, geological, edaphological, and weather conditions are key factors for grape and wine quality. In Mexico, the state of Guanajuato, situated in the central part of the country, is becoming one of the fast wine industry growing regions thanks to its climate conditions. In this work, sources of information for the vineyards in the state of Guanajuato are investigated. Furthermore, a data model for this scenario is proposed. Finally, proof of concept of a web application to gather weather data from online sources is presented. The outcomes of this work will support the activities of a research project aimed at characterizing grape, must, and wine samples from vineyards located in this state.**

Keywords—vineyards; Geographic Information System; weather; geology.

I. Introduction

Geographic and climate conditions of the region where wine is produced such as temperature, rainfall, hours of sunshine, etc. are important and impact the quality of the product[1], [2]. Geologic and edaphological data are also reported to be important to consider when finding suitable farming places for grape wine [3]. Therefore, it is important to record data about these conditions at the grape harvest stage to correlate with the characteristics of the wine produced in a specific region.

Information Systems (IS) are designed to collect, store, process, and visualize data from different sources to support organizational decision making. A key element of an IS is its database, where all the collected and processed data is stored in a structured way. The implementation of a database starts with the design of a data model that includes all the concepts defined in the information scenario and their relationships.

There are various types of data models that correspond to different levels of abstraction: conceptual, logical, and physical. A conceptual data model includes the definition of the entities (concepts) and their relationships. A logical model defines attributes or characteristics that define an entity. Finally, a physical data model includes implementation details of the data model in a specific database manager system.

In this work, first, sources of geographic, geological, edaphological, and weather data of vineyards of the state of Guanajuato are identified. The search focuses on online data services that could be accessed on the go. Then, a data model for collecting and analyzing the collected data is proposed. Finally, proof of concept of a web application that gathers data from the online sources identified is presented.

The outcomes reported in this work will be considered in the development of a Research Information System to support the activities and processes carried out by researchers working in the project “Correlation of physicochemical and sensory properties to the response of nano-functionalized fiber optic sensors in wines produced in Guanajuato”, from now on referenced as “Wine-project”. This project, previously mentioned in [4], is an international collaboration of 3 research groups of the University of Guanajuato in Mexico and one research group of the National Research Council (CNR) in Bologna Italy. This work has impact on the research activities conducted by 2 groups:

a) The Physicochemical and sensory analysis (PSA) research group, based in Irapuato, Guanajuato, Mexico). This group coordinates the collection and analysis of the grape, must, and wine samples of the project.

b) The Software Engineering (SE) research group based in Yuriria, Guanajuato, Mexico. This group aims to develop a research information system to collect, store, preserve, and access project data.

The structure of this paper is defined as follows. First a review of the state of the art on the use and impact of Geographic Information Systems (GIS) in the viticulture sector is presented. Then, the methodology to develop this work is presented and described. Finally, the conclusions and future work are presented.

II. WINE INDUSTRY IN GUANAJUATO

Wine history in Mexico goes back to the Spanish Conquest when Hernán Cortes ordered planting grape vines [5]. According to [6] in Mexico there are 14 wine-producing states such as Aguascalientes, Baja California Sur, Chihuahua, Coahuila, Durango, Guanajuato, Jalisco, Nuevo León, Querétaro, Puebla, San Luis Potosí, Sonora, and Zacatecas.

As reported by [7] Guanajuato ranks fourth nationally with the highest wine production just below Baja California, Coahuila, and Querétaro. Furthermore, its participation within the national industry is 5.2% with 400 hectares planted and a potential 100,000 hectares suitable for grape wine farming according to a study carried out by the National Institute of Forestry, Agricultural and Livestock Research (INIFAP), together with the National Council of Science and Technology (CONACYT).

In Guanajuato state, wine production activity extends various municipalities including: Dolores Hidalgo, San Miguel Allende, Comonfort, San Felipe, León, San Francisco del Rincón, and Guanajuato with 43 vineyards in different stages of maturation in terms of wine tourism activity [8]. Figure 1 shows a map of the state of Guanajuato and its municipalities obtained from [9].

Fig. 1. Map of the state of Guanajuato and its municipalities [9].

III. STATE OF THE ART

Geographic Information Systems have been reported within the viticulture sector. Some of these works aim to find suitable farming places for grape wine. For instance, in [10] the authors reported the use of the GIS to determine the suitable farming places in Nepal for grapes for wine production. The authors collected data from the NASA's Shuttle Radar Topography Mission (SRTM), the GlobCover, and the Soil and Terrain database for Nepal. The suitability analysis was carried out considering characteristics such as slope, aspect, soil, landcover, and phisiography. Authors conclude that a large-scale study with more parameters could help reassure farmers and the wine industry. According to [11] the availability of light is a critical factor to be considered in evaluating the suitability of the site for viticulture. The authors use a GIS and digital elevation models to integrate a Photovoltaic Geographic Information System, Excel spreadsheets and Visual Basic macros to calculate both sunrise and sunset and potential maximum day length.

Another work using GIS to explore the suitability of wine cultivation sites is reported in [12]. The authors use a multi-criteria analysis Boolean overlay, a combination or weighted linear sum (WLC or WLS), a ranking or precedence method, ordered weighted average (OWA) techniques for land suitability analysis.

Previous case studies have been reported for vineyards in Romania. For instance, authors in [13] reported a case study in which a GIS is used to determine the geomorphological characteristics of the vine growing center of the Husi vineyard. The focus of that work was on the spatial distribution of exposure and slope inclination to determine the ecological suitability of grape growth in this vineyard. Four areas with different geomorphologic characteristics were identified in this region. In [14] the authors reported an analysis of the suitability of land use in the Prahova area in the Southern Carpathians in the Dealu Mare Vineyards in Romania. The authors created maps using the ArcGIS 10.5 program using a soil map of Romania and a digital elevation model research focusing on hypsometric, slope, geological, land use, and soil maps. Authors conclude that the morphometric characteristic was represented by the slope, which is the most important requirement in the geomorphological evaluation of the analyzed area.

In [3] the authors reported the characterization of 4 wine growing regions in Texas, US. The characterization focused on climatic, geologic and edaphic conditions of the viticultural areas. In [15] the authors reported the development of an integrated information system to monitor the effects of climate change in the Hungarian wine grape industry.

The authors of [4] reported a transactional information system to support wine quality research in the state of Guanajuato. A mobile and a web application was developed to support the registration in situ of grape, must, and wine samples collected for the project.

The aim of this work is to identify and model geographic, geological, edaphological, and weather data that will be important to consider for the analysis of grape, must, and wine samples collected for the wine project. The outcomes of this work will impact specifically in the sample collection activities reported in [4].

IV. METHODOLOGY

In this section the steps to carry out this work are presented. First, stakeholders of this work are identified. Second, a requirement analysis is presented and discussed. Third, online data source services are described and discussed. Fourth, the design process of a conceptual data model for the geographic and climatological data of vineyards of the state of Guanajuato is proposed. Finally, the design and development of proof of concept of a web application to collect data from online sources is described.

A. *Stakeholder Identification*

The stakeholders involved in this part of the project are:

- Researchers and students at the PSA analysis laboratory to monitor sample collection.
- Researchers and students at the SE group.

Two roles are identified within this scenario:

- Sample Collector. Technicians of the Grape and Wine Association of the State of Guanajuato and Students from the PSA Laboratory share this role, which in turn can create samples in the system.
- Researcher. Researchers at different laboratories and groups share this role which can conduct CRUD activities in the system.

B. *Requirement Analysis*

Figure 2 shows the use case diagram for the data collection app as reported in [4] with an additional actor and use case. The use case is extended as in the sample collection workflow it is considered that when users create the sample weather conditions will be added to it. The present work will impact specifically on the use case for searching geographic and weather conditions included in this diagram. Furthermore, the additional actor is a geographic and weather online system.

C. *Weather Data Sources for Vineyars in the State of Guanajuato*

In order to select the weather online data service it was necessary to investigate the API that offers the necessary information for this project. The online services that were investigated are listed in Table I and II. The criteria defined to select the online service included: a) must provide access to data from a specific geographic location, and b) must provide access to historical data.

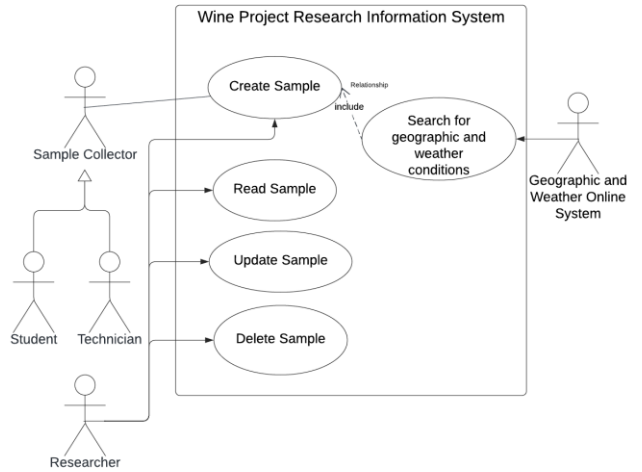


Fig. 2. Use case diagram for the sample data collection app. The use case diagram is an extension of [4]where the use case“Search for geographic and weather conditions”, focus of this work, is included.

D. *Geographic, Geological, and Edophological Data Sources for Vineyars in the State of Guanajuato*

The state of Guanajuato offers data about the edaphology and geology in the state through an interactive map web application available at [16]. Figures 3 and 4 show a map of edaphologic and geological zones in the state respectively. In order to get edaphology and geology data from a specific geographic location it is necessary to convert the corresponding latitude and longitude coordinates into EPSG:3857 also called Web Mercator coordinate system used by the maps provided in [16]. The map legends in Figures 3 and 4 show the data to be stored in the edaphology and geology attributes of each vineyard.

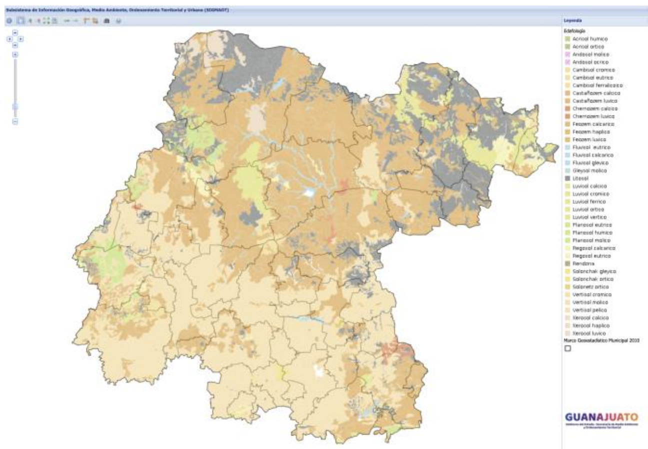


Fig. 3. Map of edaphologic zones in the state of Guanajuato . Edaphologic zones. Source [16]

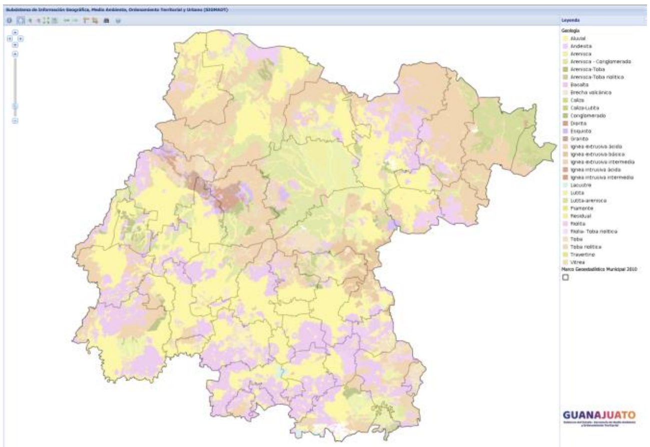


Fig. 4. Map of geologic zones in the state of Guanajuato. Source [16]

TABLE I. PRODUCT BACKLOG SHOWING SOME OF THE HIGH PRIORITY USER STORIES DEFINED IN THE PROJECT.

Service	Provider	URL	Historic Data?	Day	Hour	Geographic location	Has API?
Sistema Meteorológico Nacional	CONAGUA	https://smn.conagua.gob.mx/	1986-2018	Yes	Yes	No	Yes
Meteored		https://www.meteored.mx/	No	Yes	Yes	No	Yes
The Weather Channel	IBM	https://weather.com/	No	Yes	Yes	No	Yes
Accuweather	Accuweather	https://www.accuweather.com/	-2021	Yes	Yes	No	Yes
OpenWeather	OpenWeather	https://openweathermap.org/	Yes	Yes	Yes	No	Yes
Weatherbit.io	Waetherbit	https://www.weatherbit.io/	3-20 years	Yes	Yes	Beta	Yes
Weatherspark	Cedar Lake Ventures, Inc	https://weatherspark.com/	Yes	Yes	Yes	No	NA
Ventusy	Ventusy	https://www.ventusky.com/	Yes	Yes	Yes	Yes	No

TABLE II. PRODUCT BACKLOG SHOWING SOME OF THE HIGH PRIORITY USER STORIES DEFINED IN THE PROJECT.

Service	Temperature	Precipitation	Wind Speed	Wind Direction	Relative Humidity	Wind Gusts	Dew Point	Free access
Sistema Meteorológico Nacional	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Meteored	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
The Weather Channel	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Accuweather	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OpenWeather	Yes	Yes	Yes	Yes	Yes	No	No	Limited
Weatherbit.io	Yes	Yes	Yes	Yes	Yes	No	Yes	Limited
Weatherspark	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ventusy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

E. Data Model

Conceptual and logical data models for the use case were designed. The conceptual data model for this work is presented in Figure 5. The entity “Section” is defined in this data model as it considers that in a given vineyard there might be different sections of land with different characteristics. Figure 6 shows the logical data model. This model differs from that reported in [4] as this includes attributes for storing geographic and weather data in the section entity for longitude, latitude, edaphology, and geology. The attributes added are: precipitation, wind_speed, wind_direction, and dew_point.

V. RESULTS

Considering the search results, the Weatherbit.io site was selected to be used in this work since its API provided the data required for the project: data of a specific geographic location, in a given date and time, including historical data since 1991, and the required weather data such as average, maximum and minimum temperature, wind speed, dew point, wind direction, and precipitation.

Geographic points (longitude and latitude) for each vineyard were defined using Google Maps application. Furthermore, edaphological and geological data for each vineyard was extracted and stored in the section table.

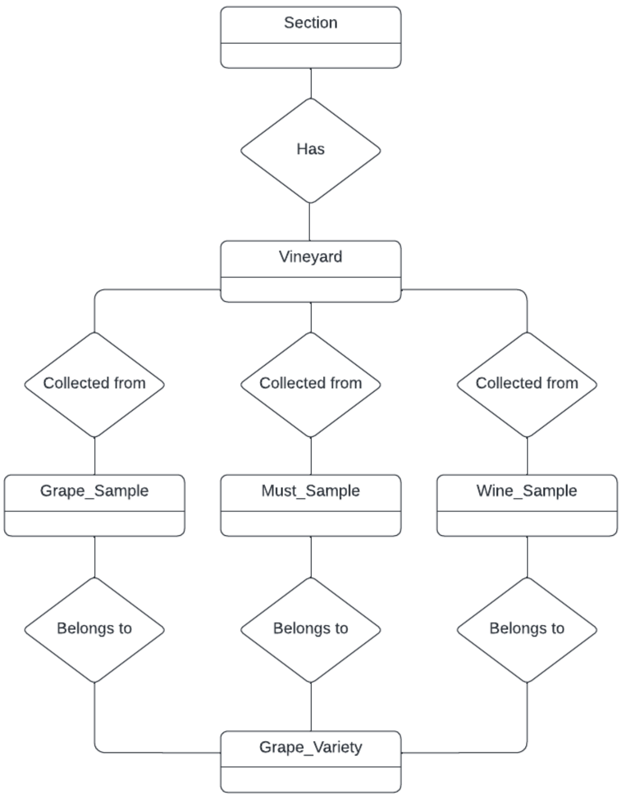


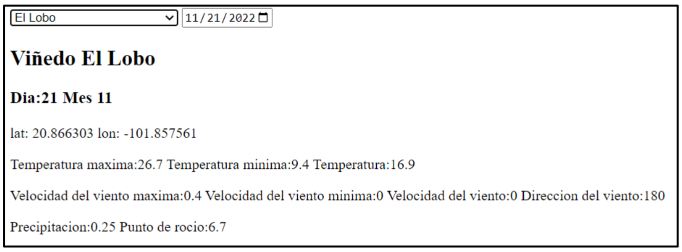
Fig. 5. Conceptual Model for the use case for the “Search for geographic and weather conditions”.

The development of proof of concept for accessing the Weatherbit.io API to get weather data and include this in the data collection workflow. Figure 7 shows a mockup

designed in the MockFlow Wireframepro web application[17] to show how the page for requesting weather information of a specific geographic point could be made. The results are shown in Figure 8, where the answer for the request for a specific vineyard is presented.
Figure 9 shows the page for requesting data for a specific vineyard and date. Figure 10 shows the results of this request.

Fig. 6. Logical Model for the use case for the "Search for geographic and weather conditions".

Fig. 7. Mock up of a webpage to provide weather information for a specific vineyard. Desgined in MockFlow Wireframepro web application [17].


El Lobo 11/21/2022

Viñedo El Lobo

Dia:21 Mes 11

lat: 20.866303 lon: -101.857561

Temperatura maxima:26.7 Temperatura minima:9.4 Temperatura:16.9

Velocidad del viento maxima:0.4 Velocidad del viento minima:0 Velocidad del viento:0 Direccion del viento:180

Precipitacion:0.25 Punto de rocio:6.7

Fig. 8. API response to the query for weather conditions of a particular geographic point.

Fig. 9. Querying vineyard weather data by date.

Fig. 10. Query results of vineyard weather data by date.

VI. Conclusions and Future Work

The aim of this work was to enrich the grape vine sample data for the Wine Project with weather data at collection point. Therefore, a data model to store this data was proposed. Furthermore, online sources that could be queried on the go. The Weatherbit.io online data service was selected considering it provides access to historic data and allows for request of information on a specific geographic point through its API. Proof of concept for accessing the Weatherbit.io data was developed and presented.

As part of the future work, the outcome of this work will be considered in the design and development of the Wine Project. Although the aim of the Wine Project is to assist its participating researchers, the outcomes of this work have the potential to impact actors in an extended context. The system may be further developed to offer geographic, geological, and edaphological data from vineyards.

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