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Transactional Information System to Support Wine Quality Research at the State of Guanajuato in Mexico

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***Abstract*— Research Information Systems assist data collection, storage, processing, and retrieval for carrying out research processes supporting collaborative work. In this work the software engineering process to produce the first prototype of a data sample collection module is described. The prototype includes a mobile application to collect grape, must, and wine sample data from vineyards and a web information system to visualize and retrieve the data. This is a work in progress that contributes to the design of fibre optic sensors and machine learning algorithms for wine quality research using physicochemical and sensory data.**

***Keywords*— grape; must; wine; fiber optic research; vineyard; research information system.**

I. INTRODUCTION

Research Information Systems (RIS) support the activities and processes carried out by researchers at both wet and dry labs. This support can range from a transactional level, through a decision making level, and research and scientific data processing. These systems aim to enhance collaboration among team members and research groups, to accelerate research processes by providing effective research data management, and to provide tools and mechanisms to reproduce research results and findings.

Adoption of RISs by the research community is an important challenge to address. Therefore, it is important to follow up software development methodologies and practices that keep users engaged and willing to participate in the software development process to own it.

This work aims to support the activities of the research 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 is an international, collaborative, and multidisciplinary project with the participation of 3 research groups of the University of Guanajuato in Mexico and one research group of the National Research Council (CNR) in Bologna Italy. In specific this work has impact on the research activities conducted by 2 groups:

a) Physicochemical and sensory analysis (PSA) research group, located in Guanajuato (Irapuato). This group aims to coordinate the collection of the grape, must, and wine samples as well as analysing them. And,

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

The RIS prototype presented in this work is the first approach to develop a transactional information system to collect, store, and access data for grape, must, and wine samples.

The paper is organized as follows: first a brief description of the state of the art in research information systems is presented. Next, the data collection case study is described, followed by a description of the methodology for the development of the prototype. Finally, conclusions and future work are discussed.

II. RELATED WORK

According to [1], Research Information Management Systems (RIMS) facilitate the centralized storage of research related data for analysis, reporting, and dissemination activities. RIMS offer institutions benefits as described in [1]. These include:

- to facilitate national and international collaboration, increasing the visibility of researchers’ profiles, their research outcomes, the available infrastructure, etc.
- to increase the impact of research by providing efficient access to information, resources, and analysis tools, etc.

The international organization for research information euro CRIS designed the Common European Research Information Format (CERIF), a data model for the scientific research domain. This model is provided as a service aiming to foster international cooperation for the RIS community [2],

[3]. The term CRIS, Current Research Information System, is a term that is used interchangeably with RIMS by this community. An example of the adoption of the CERIF model to create modules for publications and project information for a RIS at the Karlsruhe Institute of Technology was described in [4].

While previous examples focus on the research outcomes, other information systems provide support through all the research pipelines. For instance, NeuroHub, as reported in [5], provides a platform to assist and facilitate the research activities carried out by neuroscientists at three different institutions: the Center for Integrative Neuroscience and Neurodynamics (CINN) at Reading, the University of Oxford, and the University of Southampton. The system provides support for the entire research process, including management of research data throughout the experimental process and management of laboratory equipment. The NeuroHub system was developed using open-source technologies such as Drupal and Alfresco. At the time of reporting, the system was in production with a user community of 74 researchers. The reported results included a growing user community and increased efficiency in research data management.

Another example of information systems as a tool in wine production is found in the work [7], in which the authors describe the factors of the TOE (Technological Organization Environment) model, so that small and medium-sized wine companies in the Guadalupe Valley use information systems to increase their productivity and competitiveness. It should be noted that data collection using information systems can be of practical value to the wine industry.

An important aspect for Wine-project researchers is traceability, which is defined by the ability to track and follow the path of a product, process, or information throughout its life cycle [8]. In works like [9,10], systems have been developed where mobile devices are mostly used to carry out supply chain traceability. As part of the results, the authors in [9] show a system for the identification of vineyards and the origin of the grapes based on a QR code printed on the container where the grape stock is transported. Using a cell phone with internet access, the user can read the QR code and obtain data on field conditions during grape growth, climate, and grape origin.

In this work, a research information system to support fiber optics and machine learning research is being developed. In the specific context of the state of Guanajuato, an information system that adapts to the needs of the region and the characteristics of the wines produced there is still not reported.

This highlights the opportunity to develop a proprietary information system to help promote the management and analysis of wine research data in the Guanajuato region.

III. GRAPE, MUST, AND WINE SAMPLE DATA COLLECTION

This work focuses on the first stage of the research process of the Wine-Project: sample data collection from vineyards in the state of Guanajuato.

Figure 1 shows a simplified illustration of the wine process stages from grape to bottled wine samples. First, grape samples are collected from the vineyards either by technicians of the Grape and Wine Association of the State of Guanajuato or by university students and researchers. The samples are collected, and sample data is recorded using the paper-based form designed by the PSA research team, see in Figure 2. Samples need to be packed and delivered following the indications described in the same form. These forms are then delivered along with the samples to the physicochemical analysis lab. Then the samples are stored in fridges to then be analyzed by both the PSA and the FOS research teams.

From the description above, it is possible to identify the stakeholders involved in this part of the project:

- Technicians of the Grape and Wine Association of the State of Guanajuato.
- Researchers and students at the PSA analysis laboratory.
- Researchers and students at the FOS laboratory.
- Researchers and students at the SE group.
- Members from IDEA Guanajuato, the funding agency supporting the development of this project.

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.

Figure 3 shows the use case diagram for this module.

Fig. 1. Wine process stages from grape to bottled wine.

IDEA-GTO PROJECT STAGE 1: PHYSICAL AND SENSORY PROPERTIES OF WINES FROM GUANAJUATO			
Sample Data Collection Form			
Vineyard:		Municipality:	
Vineyard first year:		Vineyard first harvest year:	
Sample Delivery Date			
Type of sample:	○ Grape ○ Must	○ Freshly made Wine	○ Stored Wine. Time:
Grape variety:		Temperature at Delivery:	
If GRAPE	Please provide 100-200grs of grape in a plastic bag.	Harvest date:	
If MUST	Please provide 100mL in a sterile plastic bag.	Start date of the must:	
If WINE	Please provide 1 closed bottle.	Packaging date:	Time in barrel:
Name of the person taking the sample:			
Name and signature of the person delivering the sample:			
Name and signature of the person receiving the sample:			

Fig. 2. Sample data collection form designed by the PSA Research Group.

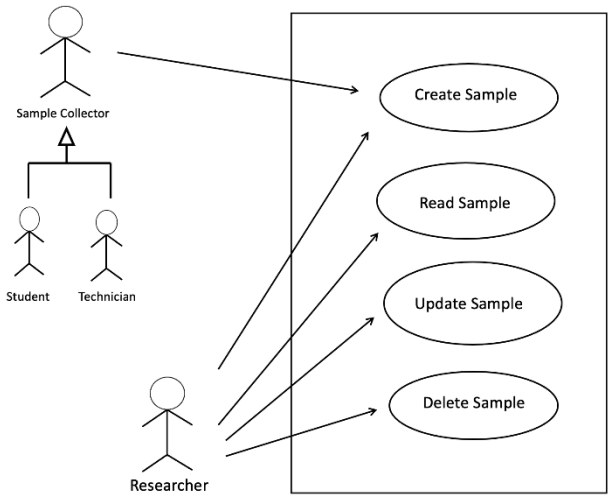


Fig. 3. Use case diagram for the sample data collection app.

IV. METHODOLOGY

A first working prototype was developed following the SCRUM project development methodology [7].

A. Software Requirements

Software requirements elicitation was carried out interviewing users engaged with the project. The prototype presented in this work was developed in 3 sprints. In Table 1 a list of the high priority user stories is presented. Acceptance tests were designed for each user story and close communication was conducted with the PSA team to ensure their involvement in the development.

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

Sprint	ID	User story
1	US-01	As a USER of the information system, I WANT to use a form on my mobile device, SO I CAN register the data of the samples that I am going to collect.
2	US-06	As a USER of the information system, I WANT to select a vineyard name from a drop-down list, SO I DON'T HAVE to type the vineyard name manually every time I have to register a sample.
	US-07	As a USER of the information system, I WANT to select the sample type from a drop-down list, SO I DON'T HAVE to type the sample type manually each time I need to record a sample.
3	US-08	As a USER of the mobile app, I WANT to take pictures of the data collection forms SO I CAN verify that the information captured through the mobile app is correct and complete.
	US-09	As a USER of the information system, I WANT to use a web form in my preferred browser, SO I CAN see the details of the samples that have been registered in the Database.
	US-10	As a USER of the information system, I WANT the data to be hosted in a server provided by the UG, SO I CAN have the project resources centralized under a single access point.
	US-11	As a USER of the information system, I WANT all services used by the mobile application to be hosted in a server provided by the UG, SO I CAN have the project resources centralized under a single access point.

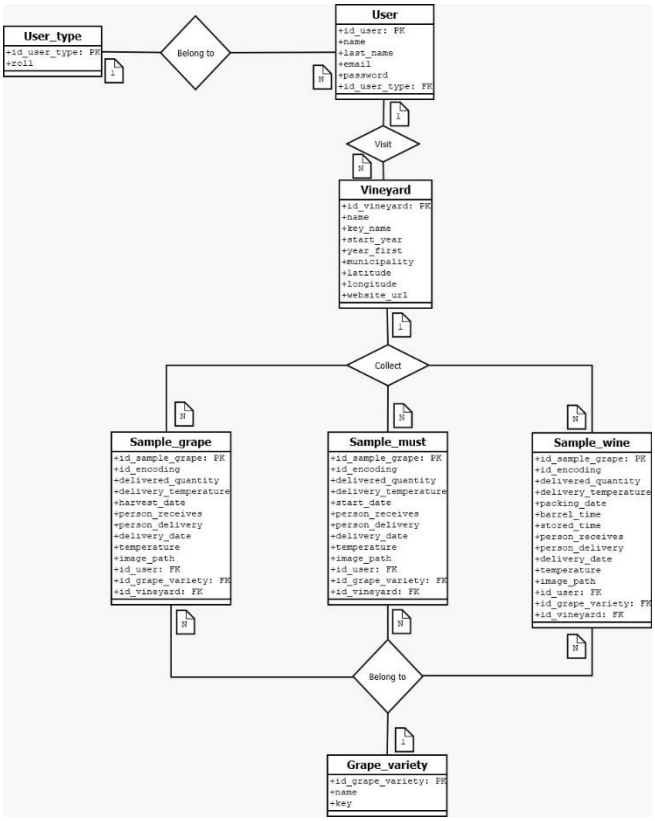


Fig. 4. Data model of the system.

B. Software Design

The design of the data model, presented in Figure 4, was implemented in MySQL. In this model, entities for the vineyards, samples, and users are considered. The database is hosted on a server within the University's domain. The mobile app will be used by Sample Collectors to save the sample collection data, while Researchers will use the web application to access the collected data.

C. Software Development

The mobile app was developed using java and Android Studio, while the web information system was developed using PHP and web services.

V. RESULTS

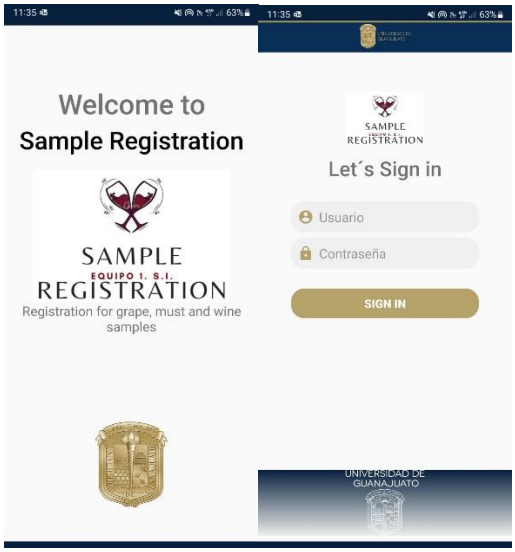
A first prototype of the mobile application and the web information system was developed.

The mobile application was developed in the Android Studio development environment, using the Java programming language. The app collects in situ data of the grape, must, and wine samples collected from the vineyards in the state of Guanajuato and

registered in the project. As shown in Figure 6 and Figure 7, the app has a welcome interface screen where an institutional image is shown. Tapping on this screen the login interface is shown Figure 6b. This application is linked to a database hosted on a server of the University of Guanajuato. By entering the user data and password previously registered by an administrator, the user will be able to access the sample collection functionality shown in Figure 7. This screen allows the user not only to capture the data elements considered in the paper-based form but also to upload pictures of the samples and the forms for further reference. Data access and registration was carried out using webservices.

The web application was developed using PHP. Access and visualization of sample collected data is carried out through this application. The web app has a responsive design that adapts to browsers on mobile devices. After logging in the system, the user visualizes the cards with the available samples, as shown in Figure 8. If the user needs to see more information of a specific sample the system will show the screen as shown in Figure 9.

The mobile and web applications were evaluated by users involved in their development. All acceptance tests designed for each user story were passed and the prototype is ready for a real scenario evaluation for the next sample collection period. Grape harvest in Guanajuato is carried out in August and September.



a) b)

Fig. 5. Mobile application. a) Welcome and b) Login screens.

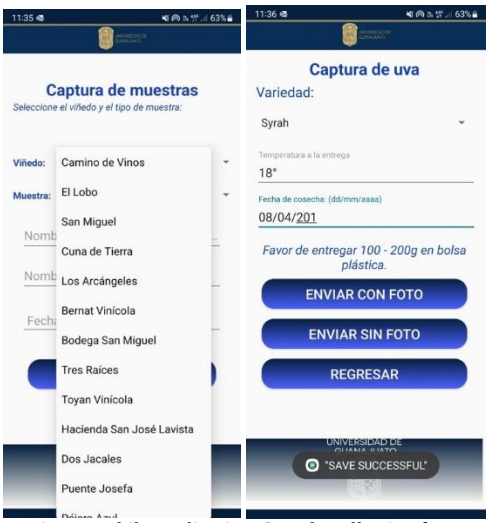


Fig. 6. Mobile application. Sample collection form.

Fig. 7. Web Application Interface.

Fig. 8.Web Application Interface – Sample information visualisation.

VI. Conclusions and Future Work

The aim of this work was to design and develop a prototype of a transactional information system for sample collection of the wines produced in Guanajuato. The prototype provides an alternative to the paper-based data collection form that was initially considered.

The system was designed with two interfaces: mobile and web to assist the data sample collection in vineyards and visualization, respectively. The use of a mobile application compared to other interfaces provides the possibility for sample collectors to use their own devices with no need to invest in or carry other equipment that may difficult the physical task of the sample collection and data registration.

In comparison with the work presented in [11], both projects share the objective of improving traceability in wine production using information and communication technologies. While [11] proposes a data model and prototype based on web and mobile applications with encrypted QR codes for wineries in Albania, the system reported in our work focuses on the collection of must, grape, and wine samples through a prototype transactional information system.

Both projects developed unique software architectures with specific databases. The key difference lies in the data entry structure: while the system reported in [11] uses a mobile application for grapes and QR codes, the approach of our work allows for the gradual upload of data through a mobile application connected to a web service, including grape, must, and wine information. While both share the vision of improving traceability, the singularities in the data structure and the inclusion of additional information in our system highlight the strengths of each approach. The future possibility of implementing QR code generation could further enhance traceability in the proposed system in Guanajuato.

The use of the scrum methodology in this type of development where the teams are small helped to comply with the user stories, since it favors communication between the members of the development team and the stakeholders.

As part of the future work, a further evaluation of the prototype is being considered. While the prototype has been evaluated by users involved in the project, it is necessary to evaluate it with new users in the wild. Poor internet connectivity can be a limitation for the sample collection system given that some of the sample collections are conducted in the vineyard fields. This will help to gather feedback from the different user roles to improve its functionality and user experience. The evaluation will help to identify how the system can be adapted to implement features that reduce the data capture using computer vision techniques that would help to avoid errors and speed the data collection process.

This development will be integrated as a module in a research information system to support activities carried out by the Wine project. Furthermore, given that sample collectors work for government offices a more extensive analysis of how this solution can be used in other scenarios in the agricultural and food area must be carried out.

Finally, students of the master's in technology management conducted the development of the system and additional aspects were considered to ensure the sustainability of the solution provided. This will be analyzed and addressed as part of the future activities of this work.

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