SMARTVINO project: when wine can benefit from ICT

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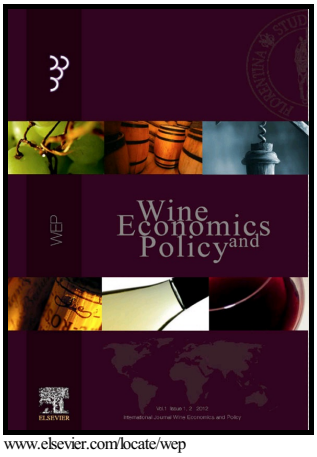

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Title Page

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Running Title: SMARTVINO project: when wine can benefit from ICT

Abstract

SMARTVINO project is devoted to the study and implementation of innovative services able to convey information related to wine and its traceability to costumers and consumers. The basic idea is to realize a simple and user-friendly tool, addressed to all kind of users and therefore immediately effective for everyone. SMARTVINO system allows users to take a photo of the previously marked company logo, depicted on the wine label, by a ordinarily known smartphone and then redirected to lots of detailed information related to the wine they are buying or drinking. Contents can concern the productive process, the vine variety the wine is made by, the geo-spatial localization of the vineyards, recommendations about which course is the most appropriate to be coupled with the wine, etc; in general, all the information or suggestions the producing winery wants to share with its customers. Such information can be in form of text, images, videos and web pages.

The project is still on-going at the date of writing. Next activities will be dedicated to draft a detailed plan for the commercial use of results. This paper is devoted to present the outcomes of the project and how these can be exploited in wine scenario.

Keywords: ICT, wine, smartphone

1. Introduction

Technology has transformed our lives in almost all the aspects of our beings: just think about the pre-internet era and you will feel like it is part of ancient history, or about mobile phones, in the absence of which life seems now to be unfathomable. Nowadays, information is instantly available and sharable with virtually anyone on the planet. But the question by anyone in the marketing business, also and especially for wine, is if instincts and desires have been reshaped.

In [Halstead (2013)], the author tries to give an answer, also exploring the connection of social media with wine and wine-consumers: it is a widespread opinion that wine producers have unprecedented opportunities to expand their markets.

The current technological disruption in the wine industry and the impact of technologies on wine purchases has been also inquired in [Higgins et al. (2014)], with particular attention to mobile wine applications (apps) and QR codes. Results demonstrate that wine connoisseurs or experts are

[1]SMARTVINO website: http://smartvino.it/

more likely to employ technology when they are going to purchase some wine. Moreover, the adoption of QR codes and applications into the wine purchase decision is dependent on the ease of use and on the perceived usefulness of technology, while less involved wine consumers are harder to find the value and usefulness of applications.

In this environment has been conceived the SMARTVINO project[1], which is intended to promote wine and its tight relationship with Tuscany region and its landscape, culture, history and traditions. This is accomplished by the study and the realization of an innovative tool able to convey to a customer information or services which can be specific and differentiated concerning the product he/she is buying or consuming. The same instrument can be at the service of the product traceability, which is an important aspect in all fields, even more in the wine and food ones, where the whole production chain has to be guaranteed for the safeguard of the consumer and his/her health. The main aspect has been considered is the ease-of-use of the proposed tool, being it a way to reach the majority of the whole population and not only a restricted more "technologized" subset of it; no less importance has been posed also on the immediacy information are given to the user.

The simplest choice to fulfill these constraints is the use of a smartphone: this is a well-known device, highly versatile, having own processing capabilities and able to be connected to WiFis and data mobile nets. Smartphones are pervasive among teenagers and young people; elders are less addicted to them, but the most are anyway able to use almost all the functions smartphones put at disposal.

The reference scenario is a customer shooting a photo of the producer's logo, depicted on the wine label, by SMARTVINO app previously installed on its own smartphone; after that, the user is redirected to the various multimedia contents the producer has chosen to share, such as images, texts, web pages, videos. The app has been tested giving information related to wine and to its relationship with the Tuscany Region, its culture and traditions, but they can be whichever; SMARTVINO could be even devoted to wine traceability by linking consumers to trusted authorities guaranteeing the productive chain.

Generally speaking, users can benefit from ICT, throughout SMARTVINO app, both before and after the purchase of a wine bottle. In the pre-purchase stage, as well as in the pre-drinking stage, users can check the trustworthiness of the producing farm, can comment on the wine, can verify the correct match with food they are going (or would like) to eat, can be ensured about the provenance by a trusted traceability system. In the post-purchase (drink) stage, they can comment about the wine, find where to buy, send questions to the farm.

The proposed tool is based on digital watermarking: by means of it, it is possible to insert an information (*watermark* or *code*) in an image or in a part of it, such as the logo of the producing farm; the introduced alterations are not perceivable by the human eye, thus the watermark turns out to be invisible. The code can be subsequently recovered by shooting a photo via one's own

smartphone. The code has been previously associated to an external link, thus lots of chosen information can be displayed on the smartphone screen; the same code can be also used to launch services onboard the smartphone.

The proposed approach is intentionally simple and immediate; nonetheless, on the opposite side, it faces with some major issues due to the physical print and location of the label on the curve surface of the wine container. In particular, after the digitally watermarked label is printed and stuck on the wine bottle, it has to be acquired by the smartphone camera: it is possible to argue that all these processes introduce severe distortions that make the code to be barely recovered. A note has to be posed also on the position of the camera with respect to the label: the geometrical distortion induced is in the 3D space, inducing in turn several degrees of freedom that reduce the ease of code recovery.

The paper is organized as follows: some existing techniques to retrieve information from images are presented in section 2, while in section 3 a particular attention is devoted to the watermarking scheme; some specific requirements and the final chosen architecture are presented in section 4. Conclusions and ideas for future works close the dissertation.

2. Information coding technologies

Information theory studies the transmission, processing, utilization, and extraction of information; such information can be thought of as a possible message which has to be delivered from the source to the receiver. Information theory is closely associated with the so-called *coding theory*, wherein messages are modified following explicit methods to became *codes*, to increase their efficiency and reduce error in communications. Information theory is also used in intelligence gathering, gambling, statistics, and even in musical composition; for what concerning to our framework, information theory is used for information retrieval, that is to retrieve information from a particular medium.

For the needs of SMARTVINO framework, several information coding techniques have been inquired and the most relevant ones are recalled in this section: all of them could be applied to SMARTVINO needs, though each of them presents different limitations that will be discussed hereafter.

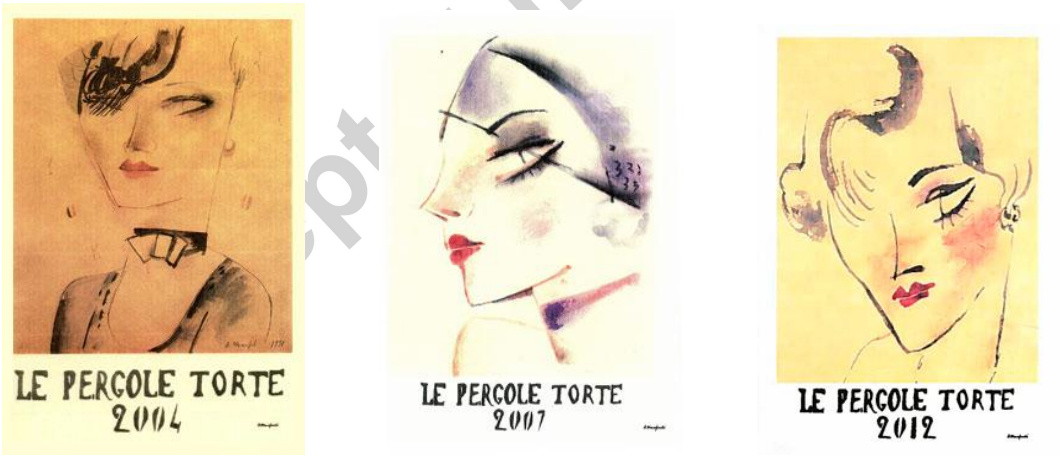
2.1. QR code

QR-code can be regarded as the evolution of the bar-code and can be seen in Figure 1. It is composed by a number of black or white little squares composing a code able to store a great number of information (7.089 characters).

Figure 1: Example of a QR-code.

QR-codes are very popular and well-known by a large amount of population, letting them be highly recognizable and tested from lots of people. They were born in 1994 for internal use of Toyota group; since 2000, they became more and more popular and are now applied in several fields.

The use of QR-codes for SMARTVINO project is recommended because of a lot of pros. First of all, QR-codes are very popular, thus the presence of one of them on the wine label immediately suggests that it is possible to gain several additional information; users can thus obtain these multimedia contents very easily, since they are very used to QR-codes. This is an interesting and important adds-on, being responsible of some sort of automatic and low-cost advertisement.



(a) 2004 (b) 2007 (c) 2012

Figure 2: Three of Montevertine's Pergole Torte artistic labels.

QR-codes also present a high robustness to several modifications, due to the use of the Reed-Solomon error correction code, able to reconstruct up to 30% of information if it has been lost. This one, joint to the great capacity of QR-codes, meaning they are able to store a huge amount of characters, is another benefit QR-codes can show.

Nevertheless, as a counterweight to these pros, it is possible to tell that the presence of a QR-code over artistic and designed labels is not tolerated by producers at all: think about, for example, some artistic labels such as Montevertine's ones in Figure 2, where a QR-code has to be stitched. Usually, producers prefer to give up multimedia contents rather than tolerate a similar solution.

2.2. RFID

RFID stands for *Radio-Frequency IDentification*; it identifies a technology able to automatically exchange information between a transmitter and a receiver. The great potentiality of this technology is due to the fact that the transmitter is an electronic label, called *tag* or *transponder*, that is very thin and can be molded in whichever shape: the most popular use of RFID is their insertion in dress labels, with anti-shoplifting aims. The reading of RFID is accomplished by a suitable device.

We review here some major advantages of RFID:

- no need of optical visibility between the transmitter and the receiver: it is sufficient that they are sufficiently close (8-10 meters or even more) to accomplish the transmission;
- transmissions are very fast and reliable and several RFIDs can be managed at the same time or, more correctly, in a time lapse of few seconds (identification and reading of a single tag in approximatively 1/10 sec);
- RFIDs can be inserted in suitable not-metallic containers to resist to chemical attacks or to operate plunged in a fluid;
- information can be easily updated on demand;
- can be joined to suitable sensors to give information also concerning the environmental condition.

The major drawback for the application under study is that RFIDs represent an additional cost weighing on the proper label one, even if RFID price influences very low the final label cost. In fact, what is expensive is the re-planning of the whole labeling process: even if the printing process can be left unaltered, there arises the need of the application of RFID to the label itself. This in turn implies the purchase of new machinery, which weighs a lot on the final label expenses.

2.3. NFC

NFC stands for *Near Field Communication*; this technology was born in 2004 to provide wireless bi-directional connectivity in short range (up to 10 cm) between a *initiator* and a *target* device. The NFC tags are used as read-only data stores, but they can be re-written by another NFC device; they are able to save up to 8.192 bytes.

RFID and NFC exhibits very similar behaviors, as well as similar pros and cons: it is possible to assess that their use is not advised for our project framework, mostly due to costs and efforts farms should suffer by the higher label expenses.

2.4. Beacons and iBeacons

Beacons technology is referred to devices and applications able to interact via BLE (Bluetooth Low Energy) standards; iBeacons is the Beacons Apple's iOS standard.

In other words, beacons devices can receive and transmit signals to other similar devices in the neighborhood. They can be labeled by a unique identifier and they can share hypertextual messages, as well as an estimation of the distance between the transmitter and the receiver. If suitably positioned, beacons are also used to perform a micro-local localization in indoor contexts (e.g.: shops, museums). Many commercial smartphones (both iOS and Android based) are born with this native technology onboard, thus the way is paved for the development of customized mobile applications. Moreover, the BLE communication standard, used for sharing data in a short range, has been developed with particular attention to the low power consumption, therefore Beacons devices' battery can last up to 3 years with no need of maintenance.

Generally, Beacons' main behavior is some sort of advertisement: they transmit small data packets in broadcast at predefined time intervals; the device receiving these packets can react by starting some applications (or displaying information, or whatever else), or it can start a further communication with the emitting Beacon. A time interval is on average 100 ms, but this value can be reduced to be found more quickly, or it can be increased to save more battery.

Concerning the project framework, it is necessary to put attention on the physical dimensions of a Beacon, that is too thick to be hidden in a wine label, thus preventing the Beacons' use in this framework. The reference to this technology and devices was anyway due for a complete overview of what actually is available in this field.

2.5. Image recognition

Image recognition is a branch of Computer Vision, specialized in the study and development of algorithms aiming at the reproduction of human visual system for the identification of objects or faces depicted in an image. Image recognition systems receive an image as input and output a set of information concerning its contents; the kind of the given back information are used to classify the various algorithms on several levels, starting from a low level (statistical data on grey levels or on luminance) to a high level (semantic information).

The mentioned methods are actually effective in the field of face recognition and are based on different approaches, but a comprehensive review of all of them is out of the scope of this paper; we only mention that they can be based on a *supervised learning* or on an *unsupervised one*.

In the supervised learning approach the recognition is performed by comparison between the under-test image and a set of known shapes or faces: this imply a previous training stage,

where as much as possible elements are given to the algorithm in order to teach it. This approach is generally more precise and effective, but it is also more time consuming. Conversely, the unsupervised approach is not based on any sort of previous knowledge: it is faster, especially if thinking it doesn't need the training phase, but generally presents a higher error rate.

Among the other, a special mention is deserved to SIFT based methods: the SIFT (Scale-Invariant Feature Transform) algorithm was born in the field of Computer Vision, primarily in 1999 [Lowe (1999), Lowe (2004)]; subsequently, it has proved to be a robust approach in several sectors. By SIFT it is possible to extract a description of one image's contents, whose feature elements are invariant to a lot of geometrical transformation, being thus able to identify similar patterns despite different orientations, zoom factors, translations. SIFTs are highly powerful describers that could be good candidates to be applied in the project framework.

Nonetheless, using image recognition approaches implies a severe limitation: the recognition, and the subsequent differentiation, is made at label level, that is it is impossible to join a different code to each wine bottle, but this can be made only for each wine typology or each year (identical labels). On the basis of these considerations it is necessary to conclude that this approach is not so satisfactory to be applied.

3. Existing watermarking techniques

Digital watermarking [Barni and Bartolini (2004)] deals with the insertion of an invisible mark in an image, so that it is completely hidden in the host document in an invisible manner. There are some characteristics of the algorithm, which have to be more or less satisfied on the basis of the final application they have been designed for: some of them are recalled in the following. Watermarking is generally used to guarantee for the originality of a document, proving it has not been altered in any way; it is used also for the identification of the legal rights owner and for other applications. It is easy to argue that digital watermarking has proved to be a versatile technology, able to conform to lots of fields and issues [Caldelli et al. (2006)].

The principal features of a digital watermarking system can be recalled in here, keeping in mind that each of them will have a diverse weight depending on each specific application field:

Privateness: the mark can be extracted by users knowing a specific password, or conversely by everyone is interested in it. The choice in this case is up to the application in use and to the kind (or meaning) of the mark itself;

Blindness: such characteristic deals with how the mark is extracted: not-blind methods needs the presence of the not watermarked image's version for comparison, while blind ones deal only with the watermarked image;

Visibility: generally, the inserted mark has to be invisible to users. We mean invisible as *not visible to the human eye*, that is modifications are applied in part of the image the human eye cannot perceive (e.g. high frequencies of a suitable image transform); masking algorithms

are also employed. This characteristic can also be more or less stressed on the basis of the image and the application;

Robustness: states how the mark is still extractable despite severe alterations are applied to the host image. Generally, the request is for a highly robust mark, that means that it is hard to remove; anyway, other applications can request for a weak mark, that, if recognizable, states that the image has not suffered any kind of alterations.

In the framework of SMARTVINO project, the watermarking scenario seems to be the most performing one. It does not imply any modification to the graphical appearance of the label, that can be designed without any restriction or left unaltered with respect to the layout already chosen by the farm. Note also that the watermark is inserted in the digital version of the label, thus the printing process is left completely unaltered and labels can be printed as usual. All of this in turn implies that no additional costs are forced for the farm to use high-priced specific printers (both bought actually or as a service) or to re-design the label; the only expenditure for it would be due to the whole SMARTVINO service, including logo watermarking and the proper content management.

Concerning the data to be inserted, it is sufficient that the mark is a code, which could be different for each wine bottle. The back-office service will provide the correct assignment between codes (or selected groups of them) and digital contents to be conveyed. Moreover, this link can be modified easily each time the farm requests it with no need of physical contact with the label; this is also true for the wine bottles already marketed, representing a great opportunity, for the producing farms, for sending up-to-date advertising messages to consumers.

Watermarking approach has some hurdles to cope: firstly, due to the physical shape of the bottle (the watermarked label is not lying on a plane but on a cylinder) and secondly due to the fact that the label has to be printed and acquired back. This last operation can be modeled as a chain where the mentioned operations imply severe distortions on the image, able to make the hidden mark impossible to be read. This complexity deserves a particular attention and some details are given in the following subsection 3.1.

3.1. Print-Scan watermarking techniques

Print-scan process depicts the chain when a watermarked image is printed and subsequently scanned back; the watermark is searched downline of the scanning process. This imply that the mark has to resist to digital-analog and analog-digital conversions, as well as to noise that will be added during the chain, for several reasons. Since it is impossible to ensure the alignment of the image during the scanning, the mark has to resist also to geometrical transformations, such as rotation, scale, translation.

Several studies have been accomplished and several approaches have been proposed in literature, encompassing a detailed modeling of the whole process and the exploitation of printer's behavior ([Solanki et al. (2004), Solanki et al. (2006)]), the insertion of a leading signal to face geometrical problems ([Zhang et al. (2009)]), the exploitation of different image transform

domains ([Kang et al. (2010)]), the insertion of multiple watermarks ([Pramila et al. (2008a)]) or the introduction of a synchronization pattern ([Caldelli et al. (2000)]) to strengthen the robustness to geometrical transformations.

It is worth to notice that the previously mentioned methods are referred to simplified theoretical conditions, to ease the study; when the print-scan methods are practically applied, some additional details became more and more important, such as luminance conditions, printing resolution and type of paper, and they have to be kept in appropriate consideration.

3.2. Print-Cam watermarking techniques

These methods are devoted to the reading of the watermark by analyzing images that are printed and acquired by a camera, for example the one smartphones are equipped with. In this case, distortions are introduced mainly due to the shot, and only to a lower extent by the printing process. The most important difference with methods mentioned in section 3.1 is that the complexity of the problem increases due to the degrees of freedom of the geometrical transformation, moving from a 2-dimensional space for the scanner acquisition (the printed image is laid flat on the scanner bed), to a 3-dimensional space of the image acquired by a camera.

Studies on these items covers several approaches. The whole print/acquisition chain is inquired, giving particular attention to the optical axes inclination as well as to the print quality, inks and heads alignment ([Pramila et al. (2007)]); robustness of the watermark is increased covering its visibility by suitable masks ([Pramila et al. (2012)]). Moreover, transformation parameters are estimated to correct it ([Katayama et al. (2004)]), or a template is used to mark the image in order to nullify the geometrical distortions ([Pramila et al. (2008b)]).

Such as what said for print-scan methods, works presented in literature are often tested in friendly conditions, thus don't present comparison between different luminance conditions, different paper sheets, different print resolutions, while they can be very discriminant in practical conditions. Moreover, tests accomplished in these works are performed when the image is posed on a white background, which facilitates the discrimination of the image from the rest. This is also a great benefit that is not present in practical applications, where it is necessary to perform a more detailed study.

4. SMARTVINO architecture

The analysis of the techniques mentioned in the previous sections has defined that the most suitable one to be used in the project context is digital watermarking, mainly because of its flexibility. Moreover, digital watermarking ensures the smaller impact on wine labels and on the related printing process: in fact, changes are accomplished on the digital version of the label, while the printing process is left as-it-is, with no further costs for the producing farm and, more relevant, with no impact on the label's design.

4.1. Requirements

Once digital watermarking has been chosen as the most suitable technology to be used, it is necessary to give attention to some major requirements for the application that have to be satisfied.

First of all, the *invisibility* requirement for the watermark to be inserted in a label has to be severely considered. In facts, nowadays wine field is not limited to the quality of the product, but it involves also several marketing issues such as the label choice. The importance of the wine label is also demonstrated by the birth of a new professional business, the *wine label designer*, that is the art of create a successful wine label, able to contribute to the success and reputation of the wine. Labels are no more used just to present the wine, but also to instill virtue and integrity of the producing farm: many firms choose to join their products, or few core ones, to valuable hardly studied labels that can impress consumers with their design.

This is also the choice made by Montevertine farm, partner of SMARTVINO project: the label of its core product (the *Pergole Torte* wine) is a masterpiece of the artist Alberto Manfredi, different each year but with the same distinctive subject, as it is possible to see in Figure 2 (the complete collection can be appreciated on the farm web site[2].

It is simple to argue that the invisibility requirement is extremely important and modifications of the label have to be avoided or severely limited. In particular, a QR-code inserted in the label arrangement is completely un-usable, since it would imply a complete re-design and, in any case, it is something of completely detached from the rest of the label: producers prefer to give up the offer of multimedia contents joint to the label rather than to bear the QR-code.

Among other requirements, the introduced watermark has to be *blind*, that is it does not need the comparison with the same un-marked image to be read, so as to be able to work only by acquiring the wine labels and not depending on the original version of them for the processing, which would imply a big database for the storage.

The *robustness* is also a characteristic hindering the development of SMARTVINO system: please note that the digital version of wine label has to be printed and stitched on the (cylindrical) bottle; after, it has to be acquired by a user through a smartphone, thus causing positioning problems. The watermark has therefore to ensure a sufficiently strong robustness to resist to these modifications, but this has impact on the visibility of the watermark: the more robust a mark, the more visible it is. The following Figure 3 outlines that in a watermarking scheme some requirements are joined together, since the increase of one of them inevitably implies the decrease of one or more of the others.

Leaving out the capacity requirement (for the chosen implementation, the mark has to include a small code, thus it is not in need of a large capacity), Figure 3 shows that it is unavoidably necessary to reach a trade-off able to guarantee a low visibility maintaining a sufficiently large robustness.

[2]Montevertine's website: http://www.montevertine.it/

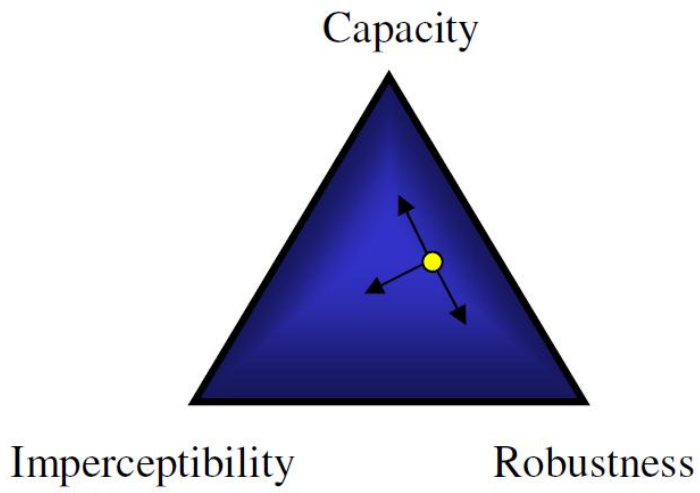


Figure 3: Trade-off diagram of a watermarking scheme. When the white dot (identifying the features of the chosen watermark) is more devoted to a greater robustness, for example, inevitably distances itself from imperceptibility and capacity; the trade-off is made by choosing the best location between what is desired and what we are willing to suffer.

4.2. Scheme of SMARTVINO architecture

The use of a watermarking scheme for the needs of SMARTVINO leads to the following scheme for the application, as depicted in Figure 4.

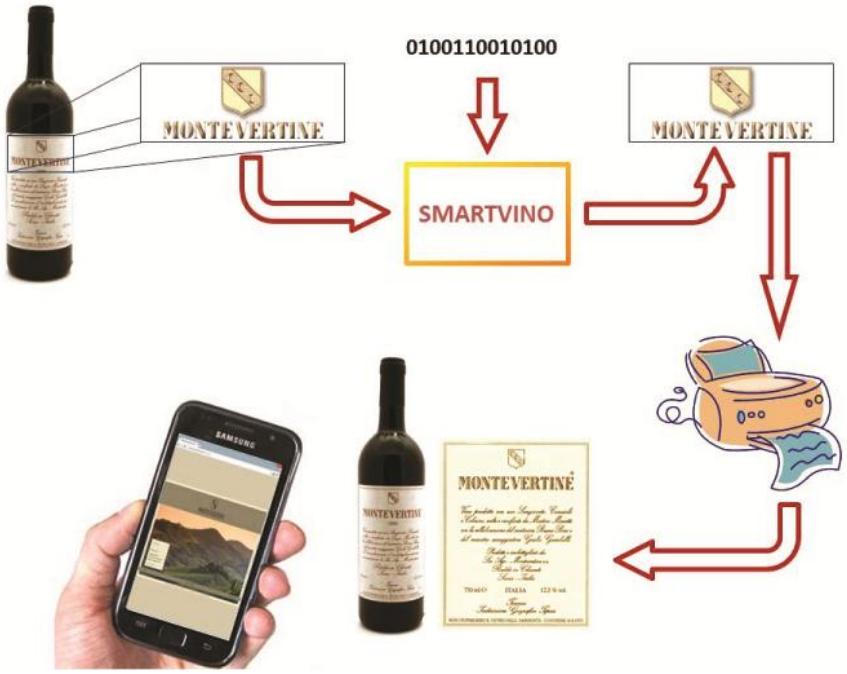


Figure 4: Scheme of the proposed SMARTVINO system.

The adopted algorithm works in the image transform domain, which allows to implement a trade-off between robustness and invisibility. In fact, it is proved that human eye is more sensitive to low frequencies with respect to high ones, thus working in the image transform domain allows to better hide the watermark to the human perception.

Moreover, the to-be-marked image has to be carefully chosen, since the whole wine label could be too large and can cause an uncomfortable acquisition; thus, Montevertine's logo has been elected as the most suitable one: it is a part very likely present on the sold wine labels and its use can be exploited to reinforce the link between the consumer and the producing farm.

The implemented watermarking scheme is composed by two different modules: a *Maker* module and a *Reader* one. The Maker module is responsible for the insertion of the watermark inside the image; it can be regarded as a back-office service upstream the printing process of the label. The Reader module, instead, is responsible for the reading of the watermark from the image and is embedded within an app for smartphones.

The use of SMARTVINO system is very simple yet effective: a smartphone user is allowed to install SMARTVINO app from the well-known appstores; when he/she launches it, he/she is invited to focus a suitably chosen frame on the watermarked logo present on the label of the wine bottle he/she is buying or consuming. The auto-focus system of the smartphone is responsible for the correct acquisition of the image, while an indicator informs that the processing is acting; once the watermark has been identified, the app-screen is replaced by a page containing the additional information the producing farm has resolved to offer to consumers.

The logo image is chosen to be square with dimensions of 512 x 512 pixels; once it has been watermarked, it can be downsized to fulfill the label dimensions needs. Even if the watermarking scheme is able to insert the mark in an invisible way, so as the watermarked image is left unaltered with respect to its not-watermarked version, a frame is drawn around the logo; technically, this helps the Reader role of the app to discard the background and correctly locate the watermarked area. Anyway, the main purpose of this frame is a call-to-action for customers: if the SMARTVINO wine label was completely unaltered with respect to a not-watermarked one, users would not be able to argue that additional contents are available; the frame around the logo is thus responsible for giving a clear indication that it is possible to focus on some part of the label, what users has to set in the viewfinder and how to correctly locate the watermarked element in it.

Once the watermarked logo has been re-inserted into the label, this one is directed to the printing process and to the usual supply; please note that the printing process, as well as the distribution process, are the same ones used as usual, thus the exploitation of SMARTVINO system does not imply further costs or re-planning of the producing chain to the farm.

The watermark inserted in a logo image is represented by a code, which can be regarded as an identity ID associated to the label (and consequently to the wine bottle); it is possible to join a single code to a same wine typology, but it is preferable to use different codes for different labels,

so as to insert a distinctive fingerprint to each wine bottle for traceability purposes. The fact remains that codes can be associated to the same information for groups (gathered by wine typology, by year, by selected ID groups, etc.), but this is a choice which can be managed server-side, on the basis of the needs of the farm.

5. Conclusions and feasible exploitation

In this paper, the main results of SMARTVINO project have been presented. SMARTVINO is a Tuscany Region funded project, which aims to exploit the potentiality of ICT and smartphones to promote the high quality of Tuscany products, particularly devoted to wine and its connection to environmental heritage, culture, history and traditions.

The main result of SMARTVINO is a system that allows to insert an invisible watermark inside the winery logo depicted on wine labels; users are able to shoot on it and to be redirected to additional contents the producer wants to share. The shooting has to be performed through their smartphone, via the SMARTVINO app installed on it; the application is available both for Android and iOS based smartphones and employs data connection to lead users to enjoy the additional information shared by the winery.

The proposed system is intended to be a valuable tool aiding consumers both in the pre-purchase, purchasing and consuming stages: they would be able to refer to a great amount of information, not limited to a synthetic text printed on the label which often reports only the reference to the producing farm and the vine variety.

Wineries could also benefit from SMARTVINO app, being able to reach every single consumer and thus enforcing trustworthiness towards them, creating in turn a valuable linkage. Moreover, since the code inserted in the label can be different for each bottle, and due to the easiness of the procedure to modify the linked information, producers would be able to reach all the prospective purchasers even when wine bottles have been already sent on the marketplace or sold.

By now, the app has to be intended as the demo resulting from the project activities; neither a business nor a dissemination plans have been draft for its exploitation. Anyway, a brief analysis of its competitor is summarized in the appendix.

Moreover, some future developments can be foreseen, by connecting the app to social networks: users would be able to share their experience and get network opinions concerning the wine, in a very easy way. Since social networks are pervasive in everyday life, a similar function would be profitably inserted in a commercial version of the app, making it express and improve its great potentiality.

Appendix A. SMARTVINO competitors

Nowadays, smartphones have become pervasive in everyone's daily life; they put at disposal an app for everything and the market is stimulated to release even more ones. The world of wine connoisseurs or experts, or simply consumers, doesn't break this rule: there are several apps

available on the stores mentioned to be a must-have for wine lovers. And in fact, they are so! Just to mention some of them, we report a list of the most famous apps with their main characteristics:

VIVINO This app gives lots of information concerning a chosen wine, for example community comments, tasting suggestions, food pairing, a medium price; a function is also devoted to your personal wine cellar, where you can store the labels one has or want to buy/taste. A link to on-line stores is also available for one-click purchase. The search of the desired wine is made by name or by taking a photo of the label. Users benefit from the community and from its write-ups to accomplish more informed choices concerning the wine to drink, and in turn can be a resource, through their comments, for other users;

VINO - Vini Italiani Online (Online italian wines) It is described as the official app of Vinitaly Wine Club. It allows users to search for specific wines, wineries, regions; users can share their tasting and be informed of the ones coming from the community. Suggestions are also available concerning food pairing, regions, wine awards and latest trends. Wine purchase is also possible by selected on line stores;

VINADVISOR Radically devoted to the social aspect, it benefits from the community to share suggestions, comments, write-ups. It boasts a great number of known wines and wineries; a free personal area is available to store tasted wines and to share comments;

HELLO VINO It is defined as the wine shopping assistant. It's the most popular wine app for recommendations, food pairings, occasions and holidays, based on one's personal taste preferences. It put at disposal the social connection (also with popular social networks as Facebook or Twitter), a label scanner, a personal area where store wine names and label shots (to remember the preferred ones), a powerful search engine (powered by wine-searcher.com), a wine guide, food pairing with a direct linkage to the receipts. In the paid version, a live wine consultant is available for suggestions and help;

WINE SEARCHER wine-searcher.com is the industry's largest and most reliable wine search engine, whose database includes more than 6 million wines; the related app is thus the ideal shortcut to find wines, beers, spirits almost everywhere. The app also provides users with detailed information (users' judgements, experts' score, images of the label, vine variety, wineries). A label scanner is also at disposal for storing the chosen drink; connection with the GPS allows users to easily find the nearest store to buy the selected beverage; one-click call key is also available to directly ring up the store.

Almost all of them allows users to take a photo of the label, mostly with storing aims; some of them go the extra mile performing a label identification, based on powerful technological solutions (text recognition, features extraction, computer vision applications). Acknowledging the value and efficiency of these, the best that they can reach is a discrimination on the winery, year, typology: this is clear, due to the fact that labels are the same for the same wine, of the same year and the same producer. SMARTVINO app is a step above: since the inserted code can be different for each logo depicted on the label, it is possible to group the information to share per wine (year,

typology), per production line batch, even up to per single bottle, depending on the choices of the producer; moreover, due to the easiness of the modification procedure of the linked information, producers would be able to reach all the customers or prospective purchasers singularly, even when wine bottles have been already sent on the marketplace.

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References

Barni, M., Bartolini, F., 2004. Watermarking systems engineering: enabling digital assets security and other applications. CRC Press.

Caldelli, R., Barni, M., Bartolini, F., Piva, A., 2000. Geometric-invariant robust watermarking through constellation matching in the frequency domain. Vol. 2. pp. 65–68, cited By 25.

Caldelli, R., Filippini, F., Barni, M., 2006. Joint near-lossless compression and watermarking of still images for authentication and tamper localization. Signal Processing: Image Communication 21 (10), 890–903, cited By 13.

Halstead, L., January/February 2013. Consumer trends in the wine industry for 2013. Wine & Viticulture Journal 1, 72–73.

Higgins, L. M., Wolf, M. M., Wolf, M. J., 2014. Technological change in the wine market? The role of QR codes and wine apps in consumer wine purchases. Wine Economics and Policy 3 (1), 19 – 27.

Kang, X., Huang, J., Zeng, W., March 2010. Efficient general print-scanning resilient data hiding based on uniform log-polar mapping. IEEE Transactions on Information Forensics and Security 5 (1), 1–12.

Katayama, A., Nakamura, T., Yamamuro, M., Sonehara, N., 2004. New high-speed frame detection method: Side trace algorithm (sta) for i-appli on cellular phones to detect watermarks. In: Proceedings of the 3rd International Conference on Mobile and Ubiquitous Multimedia. MUM '04. ACM, New York, NY, USA, pp. 109–116.

Lowe, D. G., 1999. Object recognition from local scale-invariant features. In: Proceedings of the International Conference on Computer Vision-Volume 2 - Volume 2. Vol. 2 of ICCV '99. IEEE Computer Society, Washington, DC, USA, pp. 1150–1157 vol.2.

Lowe, D. G., Nov 2004. Distinctive image features from scale-invariant keypoints. International Journal of Computer Vision 60 (2), 91–110.

Pramila, A., Keskinarkaus, A., Seppänen, T., August 2007. Camera based watermark extraction - problems and examples. In: Proceedings of the Finnish Signal Processing Symposium - on CD. FinSig2007.

Pramila, A., Keskinarkaus, A., Sepp´anen, T., 2008a. Digital Watermarking: 6th International Workshop, IWDW 2007 Guangzhou, China, December 3-5, 2007 Proceedings. Springer Berlin Heidelberg, Berlin, Heidelberg, Ch. Multiple Domain Watermarking for Print-Scan and JPEG Resilient Data Hiding, pp. 279–293.

Pramila, A., Keskinarkaus, A., Sepp¨anen, T., 2008b. Watermark robustness in the print-cam process. In: Proceedings of the Fifth IASTED International Conference on Signal Processing, Pattern Recognition and Applications. SPPRA '08. ACTA Press, Anaheim, CA, USA, pp. 60–65.

Pramila, A., Keskinarkaus, A., Sepp¨anen, T., 2012. Toward an interactive poster using digital watermarking and a mobile phone camera. Signal, Image and Video Processing 6 (2), 211–222.

Solanki, K., Madhow, U., Manjunath, B. S., Chandrasekaran, S., Oct 2004. Estimating and undoing rotation for print-scan resilient data hiding. In: Image Processing, 2004. ICIP '04. 2004 International Conference on. Vol. 1. pp. 39–42 Vol. 1.

Solanki, K., Madhow, U., Manjunath, B. S., Chandrasekaran, S., El-Khalil, I., Dec 2006. 'print and scan' resilient data hiding in images. IEEE Transactions on Information Forensics and Security 1 (4), 464–478.

Zhang, Y., Kang, X., Zhang, P., 2009. Digital Watermarking: 7th International Workshop, IWDW 2008, Busan, Korea, November 10-12, 2008. Selected Papers. Springer Berlin Heidelberg, Berlin, Heidelberg, Ch. A Practical Print-and-Scan Resilient Watermarking for High Resolution Images, pp. 103–112.