José Fernando Navacerrada Santiago
Lieutenant Guardia Civil
Deputy General Directorate of Information and Communication Systems for Security (SGSICS)

INTEGRATING OCR SENSORS FOR CRIME PREVENTION AND INVESTIGATION

INTEGRATING OCR SENSORS FOR CRIME PREVENTION AND INVESTIGATION

Summary: 1.- INTRODUCTION 2.- TECHNOLOGICAL FRAMEWORK 2.1.- OCR Technology 2.2.- Automatic license plate recognition. 2.3.- WEB services. 2.4.- Databases. 3.- PRACTICAL DESIGN AND IMPLEMENTATION. 3.1.- Design. 3.2.- Practical implementation. 4.- TESTS AND RESULTS. 5.- CONCLUSIONS AND FUTURE LINES OF RESEARCH. BIBLIOGRAPHY.

Abstract: It is completely unthinkable that the free exercise of rights and freedoms as citizens within a society can be achieved outside of a security environment. Citizen security, therefore, is constituted as the backbone of the work of all Police Corps. The Guardia Civil, not in vain, allocates a large part of its human and material resources to achieve this goal.

The purpose of this work is none other than to provide a solution in which to put, once again, technology at the service of citizens, more specifically that of their security, so that from different angles provide solutions that complement the human potential of the Guardia Civil and consequently increase its effectiveness and efficiency.

The proposed system will deal with the use of different technologies to capture, transmission, storage and exploitation of vehicle license plate data for the generation of alerts. These alerts are intended to facilitate decision making and, therefore, achieve a direct impact on the optimization of police work regarding the prevention and investigation of crimes.

Resumen: Se hace, de todo punto, impensable, que el libre ejercicio de los derechos y libertades como ciudadanos dentro de una sociedad, pueda lograrse fuera de un ámbito de seguridad. La seguridad ciudadana, por tanto, se constituye como elemento vertebrador de la labor de todo Cuerpo Policial. La Guardia Civil, no en vano, destina gran parte de sus recursos tanto humanos como materiales a la consecución de este fin.

El propósito de este trabajo no es otro sino el de aportar una solución en la que poner, de nuevo, la tecnología al servicio de la ciudadanía, más concretamente al de su seguridad, para que desde diferentes ángulos aportar soluciones que complementen el potencial humano de la Guardia Civil y que en consecuencia aumenten su efectividad y eficiencia.

El sistema que se propone, tratará mediante la utilización de diferentes tecnologías, la captación, transmisión, almacenamiento y explotación de los datos de las matrículas de vehículos para la generación de alertas. Estas alertas tienen la finalidad de facilitar la toma de decisiones y, por tanto, conseguir una repercusión directa en la optimización del trabajo policial referente a la prevención e investigación de delitos.

Keywords: Optical Character Recognition, Automatic Licence Plate Recognition, Crime prevention and investigation, Public Security, System Integration.

Palabras clave: Reconocimiento Óptico de Caracteres, Reconocimiento Automático de Matrículas, Prevención e investigación de delitos, Seguridad Ciudadana, Integración de Sistemas.

1.- INTRODUCTION

Throughout history, human beings have used their intelligence to discover new methods, processes, and ways of acting. Changes which have meant a step forward for the society of the time. The need for improvement, together with the non-conformity of human nature, have been the driving force capable of projecting continuous evolution and which, to this day, shows no signs of stopping.

The most basic needs which have made humankind strive for continuous improvement have hardly changed much since the first humans inhabited the earth. The need for relationships and communication, to secure and facilitate supplies of food, for intimacy, protection, and shelter from external agents, for reproduction to perpetuate the species, to be safe in order to develop their personality freely. They have all be linchpins on which to build new forms of prosperity. Methods and processes to gain more benefits, more durability, less effort, greater efficiency, etc. In short, all of them manifestations of evolution.

This extraordinary exponential development, especially in recent decades, in disciplines such as electronics and information technology has had a significant impact on people's quality of life. They have provided new ways of relating to each other, of managing resources, of entertainment, etc. Conversely, this "New World" has revealed an alternative spectrum for engaging in new types of crime, further compromising people's freedom and security.

Security, or rather the lack of it, has been, is and will be a constant concern for citizens. A person who is not safe in the environment in which he or she operates is a person subject to the fear of being attacked by any external agent.

The fact that we normally live in a society makes it essential to determine the values based on which people organise and relate to each other. Article 1(1) of the Spanish constitution "upholds freedom, justice, equality and political pluralism as the highest values of its legal system" (Spanish Constitution, 1978). Similarly, in Article 17(1), considering it a fundamental right, it states that: "Every person has a right to freedom and security". (Spanish Constitution, 1978). Finally, Article 104(1) establishes who is the guarantor of this freedom and security by stating that: "The Security Forces and Corps serving under the Government shall have as their mission the protection of the free exercise of rights and liberties and the guaranteeing of the safety of citizens". (Spanish Constitution, 1978).

The values of freedom and security have historically gone hand in hand and according to the majority doctrine, the enhancement of either is directly related to the

detriment of the other and vice versa. The background of this issue seems to be mostly in connection with the necessary and unavoidable interrelation between individual and community interests. While in a society where individual interests predominate, the value of freedom is given more importance, in a society where the interests of the many are more important, the security of the community will be more important than the freedom of the individual. According to legislation, the solution lies in the coexistence of both values within society and in the need not to conceptualise them as unlimited rights, even in the case of fundamental rights. It is therefore essential to specify how this limitation is to be determined.

According to STC 37/1998, when restricting any of the fundamental rights, a prior judgement of proportionality is necessary, as stated in the text:

In order to check whether a measure restricting a fundamental right passes the proportionality test, it is necessary to ascertain whether it meets the following three requirements or conditions: whether the measure is likely to achieve the proposed objective (suitability test); whether it is also necessary, in the sense that there is no other more moderate measure available to achieve that purpose with equal effectiveness (necessity test); and, finally, whether it is weighted or balanced, as it derives more benefits or advantages for the general interest than harm to other conflicting goods or values (proportionality test in the strict sense).

In the field of the protection of public safety, both Spanish Parliament with the enactment of laws, and the courts through the corresponding jurisprudence, seek this proportionality between public security and guaranteeing the protection of individual rights. Although this proposal is a guarantee in terms of encouraging the full development of the individual in the society in which he or she lives, it reveals circumstances where an abuse these freedoms hinders the protection of society as a whole.

In the case of the Guardia Civil, this has led to operational and organisational changes, such as the new territorial distribution. These modifications aim to increase a service potential, which has already diminished due to a shortage of personnel, a circumstance that has been aggravated by the latest amendment to the General Order on the provision of service, timetables and working hours of Civil Guard personnel.

Considering this approach, it is pertinent to make use of other types of solutions, such as technological solutions, to make police work significantly more effective.

In this case, the proposal consists of reading of registration plates by cameras with Optical Character Recognition (OCR) technology installed in certain municipalities. Obtaining this data coupled with other types of technology already used by the Guardia Civil, will make it possible to implement a real-time alert system that will facilitate decision-making and, therefore, optimise police work to prevent and investigate crime.

2.- TECHNOLOGICAL FRAMEWORK

2.1.- OCR Technology

Optical Character Recognition (OCR) is a software that digitises characters contained in handwritten, typed or image-embedded text. A preliminary step to using this technique will therefore be to provide a digital image in which the information is contained in a series of pixels. Having done this, roughly speaking, the software will search for patterns among this set of pixels that determine the identification of the characters. There are different variants of the process to be followed for this identification. The process followed on this occasion is the one described in (Sánchez & Sandonís, 2015), which consists of the following phases:

a) Image adaptation (Preprocessing)

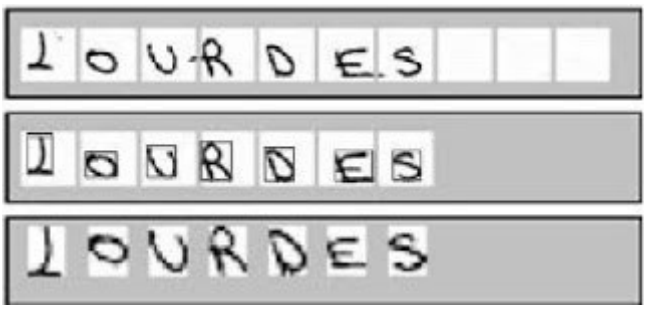
During this phase, the image is prepared for processing. All the imperfections in the document that are not characters are removed, the character size is normalised and finally a binarised image is obtained. The binarised or binary image is obtained by reducing the colour spectrum of an image to two colours only, which are digitally represented with zeros and ones. Normally, the colours chosen are black and white. One of them is used to represent the objects appearing in the image and the other one will represent the background.

b) Selection of the area of interest (Segmentation)

In this phase, the image is divided in such a way that there is an entity to be recognised in each of these divisions. A first division is made by horizontal segmentation with two transitions: one from white to black and one successively from black to white. The content in both corresponds to one line. All these rows are stored in a one-dimensional array.

A second division is created via vertical segmentation to isolate characteristics. This time we are looking for the spaces between characters that determine the spacing between them. As with horizontal segmentation, the same two transitions are obtained. Gaps between words are identified because there is a larger distance between the characters than the distance between the individual characters in the same word. Once the character has been separated, an operation is carried out to determine the minimum continent. The following figure shows the process and outcome of the segmentation phase.

Figure 1: Segmentation process in OCR



Source: Sánchez & Sandonís, 2015

c) Digital Image Representation (Feature Extraction)

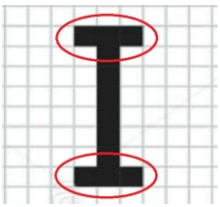
The purpose of this phase is to find characteristic characters that define and discriminate some characters from others. This will facilitate subsequent recognition.

Examples of these peculiarities include:

1 Transitions between the abscissa axis and the ordinate axis

A factor to consider in the figure below is the number of transitions from the horizontal to the vertical axis or vice versa, as well as the situation in which they occur.

Figure 2. Transitions from horizontal to vertical or vice-versa

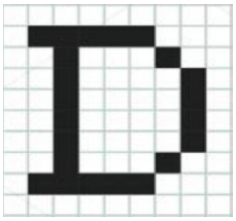


Source: Prepared internally

2. Determination of closed surfaces

The discovery of closed surfaces within a character, as shown in the figure below, is a very characteristic factor of a limited number of characters.

Figure 3. Determination of closed surfaces in characters

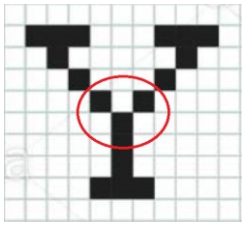


Source: Prepared internally

3. Determination of bifurcations

Another determining factor that helps character recognition, as shown in the figure below, is the identification of bifurcations in the letters. Once you have the character arranged in pixels, it is easy to identify the location of the fork with respect to the character, as well as its orientation.

Figure 4. Determination of character bifurcations



Source: Prepared internally

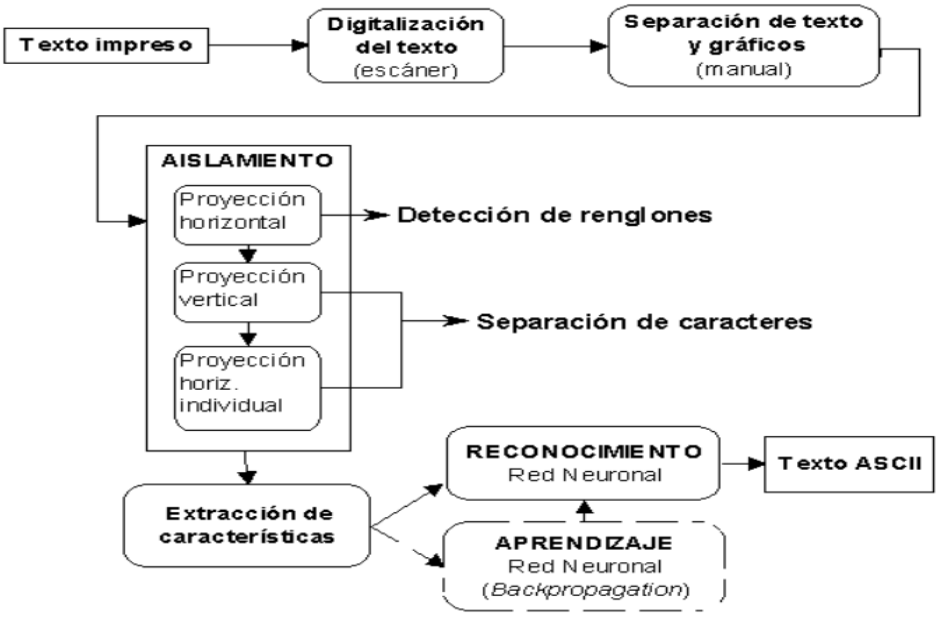
d) Distinguishing the character in the image (Recognition)

At this stage it is possible to process the text character by character to achieve recognition. There are different types of data mining algorithms that can be used for this purpose, including: K-NN algorithm, decision trees and neural networks.

Although they are all effective, according to the documentation consulted, neural networks are the ones that offer the highest degree of accuracy and consequently the most widely used today.

Having explained all the phases of an OCR, the following figure shows an example of a possible simplified OCR design.

Figure 5. Simplified OCR design



Source: Sánchez & Sandonís, 2015

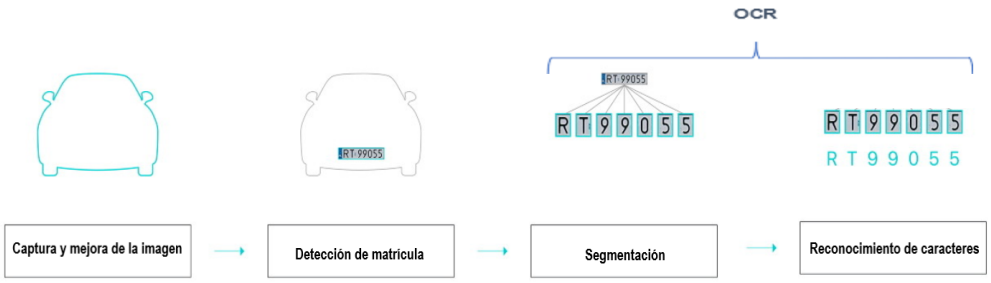
2.2.- Automatic registration plate recognition

Automatic Licence Plate Recognition (ALPR) is technology present in certain cameras and video cameras which is used to do what its name suggests; it recognises vehicle

licence plates in the images captured by these cameras. They can do so whether the vehicle is stationary or in motion. The speed of the camera does not seem to have much influence on the correct functioning of the system, as they work with a shutter speed of around 1/10,000. They are also highly versatile in terms of their use, as they can still be used at night and in adverse weather conditions such as fog, rain, etc. To overcome the types of conditions that make it impossible to obtain a correct result, they can also work with infrared vision.

The process of obtaining registration plates using this type of camera may vary depending on the literature consulted. A standard method, which is the one proposed here, could be made up of the phases shown in the following figure.

Figure 6. Typical phases of an ALRP



Source: Prepared internally

a) Image capture and enhancement

To do a good job in the subsequent stages, it is essential to work on an image of the best possible quality. Nowadays this is not usually a major problem because high-definition cameras are available at affordable prices. Also important at this stage is the angle from which the image is captured, which should ideally be taken perpendicular to the vehicle and at a similar height to that at which the vehicle's registration plate is positioned.

After taking the image, the next step in this phase is to apply a series of processes to present it in the best conditions for the next phase to be applied.

b) Registration plate detection

When the image has been prepared, the registration plate must be placed within the image. The algorithms that perform this task are based on one or, as in most cases, several of the following characteristics:

- The dimensions of the registration plate, such as the one presented in (Hongliang & Changping, 2004) which is based on a statistical study of the edges, also using mathematical morphology techniques to find the horizontal and vertical edges that delimit the registration plate.
- Location of the registration plate on the vehicle
- The background of the registration plate as regards the variation in colour, brightness or texture, an example of which can be found in (Shen-Zheng Wang

& Hsi-Jian Lee, 2003) which is based on the higher brightness that occurs in the background of the registration plates compared to the rest of the image, using this feature for localisation.

- registration plate fixing screws. Some registration plates that are fixed to vehicles by screws. In certain cases, these can be useful as recognition elements.

c) Segmentation

This phase works basically in the same way as the OCR process described above, the only difference being that the developers have adapted the algorithms to the specific characteristics of vehicle registration plates.

d) Character recognition

This phase is fully in line with, and fully applicable to, what is described in the section on OCR technology.

2.3.- WEB Services

Web Services are able to establish a remote communication between two computers between which there will be an exchange of data using the network. This operation is carried out in a standardised way using the same interface by applying a series of protocols and an established procedure.

This technology has two basic characteristics that have largely determined its expansion, which are:

- Multi-platform capacity: It is independent of how the systems are configured in terms of source and destination devices. Both use the same protocol to communicate, as established by the web service.
- Distributed model: While it is possible that only one client may be allowed access to the service published by a server, it is common for several or numerous clients to make requests to the server.

The tool uses a series of protocols, which define its operation in terms of establishing the connection and the flow of information.

The two most commonly used technologies for implementing Web Services are *Simple Object Access Protocol* (SOAP) and *Representational State Transfer* (REST).

2.3.- DATABASE

In the technological field, a database or database manager is required whenever there is a need to store a large amount of data and make it available for consultation or exploitation.

Different types of database are used according to the purpose for which the data is to be used. For example, there are transactional databases that send and receive a large number of transactions that are useful in a banking environment. Another example could

be full-text indexing-oriented document databases, which are widely used for historical documents.

a) Relational databases

Considering the purpose of this research, we will focus on a particular type of database, called relational databases. These databases present a model of representation of the information structured in tables, a framework that facilitates subsequent administration, consultation, and exploitation tasks. The added value of this type of database is the possibility of establishing relationships between information in different tables, thus providing more powerful information retrieval.

Before entering data into the database, it will be necessary to have the business model that it will host. Subsequently, a specific type of diagram called an entity-relationship diagram is developed to store and relate the data.

Now, a database manager is needed to store, manage, query, and retrieve the stored data. It is responsible for ensuring data availability, integrity, and confidentiality. There are different solutions for this, each with its own relational database management model. These include Oracle, Amazon Aurora, PostgreSQL, MySQL, MariaDB, Microsoft SQL Server, etc.

3.- PRACTICAL DESIGN AND IMPLEMENTATION

This section deals with the design of the system as regards the different modules that will make it up, as well as the interrelation between them. This design is then be translated into a practical implementation which is subjected to the necessary tests to check whether it achieves the objective.

3.1. Design

When designing a system, the first thing to consider are the different needs to achieve the desired functionality, which is to check how integrating the OCR cameras installed in certain municipalities, within the Guardia Civil's existing infrastructure provides more effective and efficient solutions regarding the protection and investigation of crimes against public safety.

With this objective in mind, the following is the list of needs to be addressed:

- Data collection
- Data transmission
- Data storage
- Real-time check
- Alert generation

a) Functional modules

With these premises in mind, the following design issues will be developed as a basis to further develop the functional modules to be implemented in the practical phase:

- Data collection: The vehicle registration data makes up the basic and essential information. Good data collection will facilitate more accurate data recognition and consequently a better functioning of the system. Integrated OCR technology on an ALPR is used to make use of this functionality.
- Data transmission: Once the registration plate to be checked is available, a Web Service is used to send it to the Guardia Civil database. The SOAP message contains the registration plate and the geolocation parameters of where the registration plate has been captured.
- Data storage: This information is stored in the form of records in a database user created for this purpose and is checked against the registration plates for which there is a requisition in the Integrated Operational Management System (IOMS), using a routine created specifically for this purpose.
- Detection and management of alerts: Two different cases are envisaged on the basis of which to generate an alert in the system:

    - Proactive case: This corresponds to the situation in which the registration plate of a vehicle has been captured by an OCR camera, the registration plate has been sent, using the Web Service, to the Database and in its subsequent comparison with the IOMS, the response has been that this vehicle has a requisition registered. In this case, the system will generate a proactive alarm as follows:

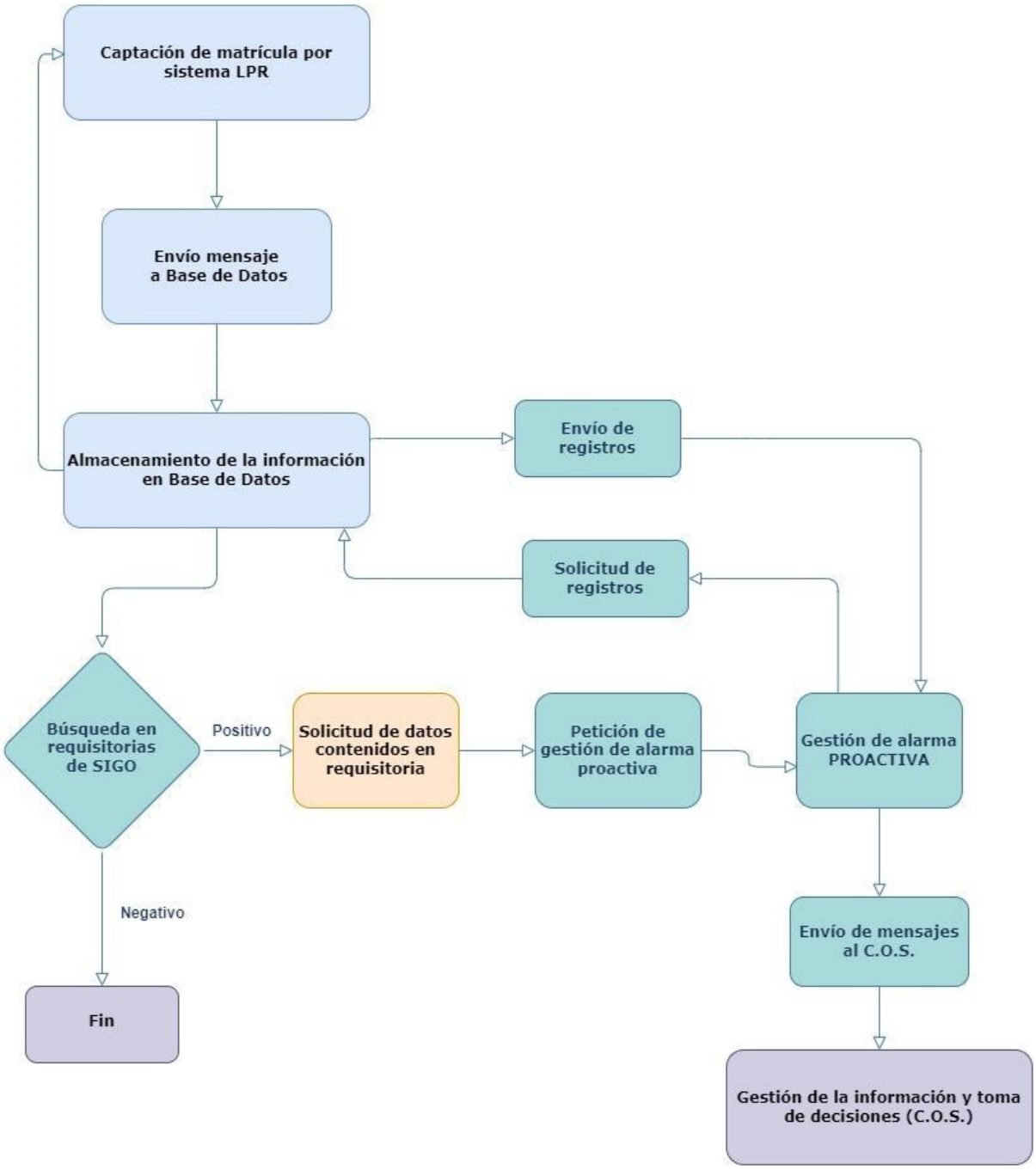
        - A SOAP message is sent to the headquarters' Service Operations Centre (SOC) containing registration plate data, other vehicle data extracted from the requisition record, photo capture time and geolocation where the vehicle has been detected.
        - Perform a cyclic search in the database, filtering by the detected registration plate in search of new positives and send a SOAP message to the SOC including the registration plate, time of detection and new geolocation.

    - Reactive case: This would be a situation where a criminal offence has been committed where a vehicle has been used and the vehicle registration number has been reported to the SOC, at which point a reactive alarm is generated, consisting of:

        - Request from the Command SOC to the database of all existing records containing the reported registration plate, which will be sent by SOAP message containing the data on the registration plate, the time at which it was captured and the geolocation where the vehicle was detected. Other data regarding vehicle characteristics such as colour, make, model, etc., can be obtained by querying IOMS.
        - Perform a cyclic search of the database filtering by the reported registration plate in search of new positives and send a SOAP message to the SOC including the registration plate, time of detection and new geolocation.
        - With the available information the SOC will evaluate the possibility of the establishment of a closure device, and the effectiveness of the measure. If the decision is to establish it, it will have the necessary information to set up patrols in strategic locations for subsequent arrest.

b) Diagram of data flow in proactive alarm management

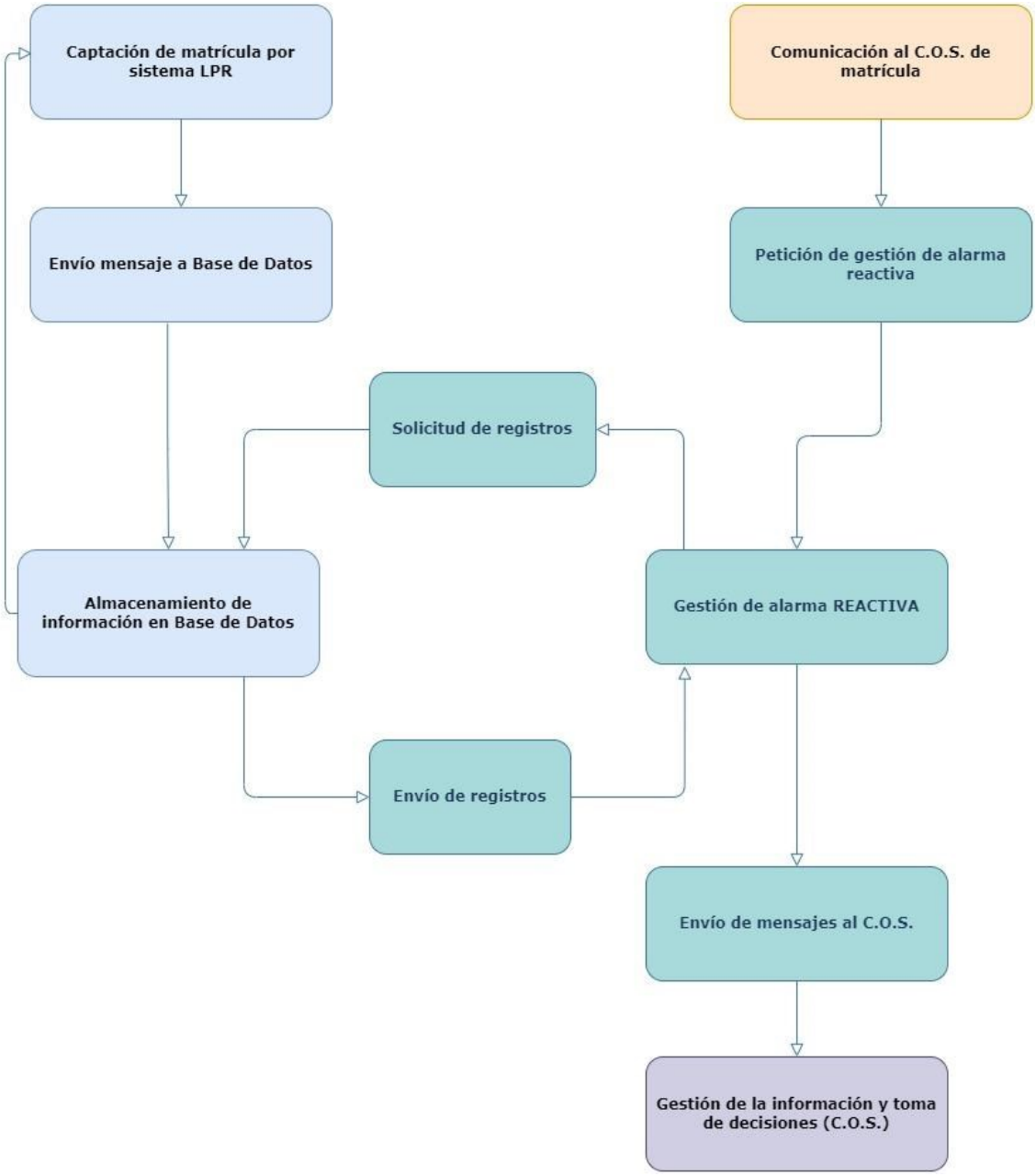
Figure 7. Diagram of data flow in proactive alarm management



Source: Prepared internally

c) Diagram of data flow in proactive alarm management

Figure 8. Diagram of data flow in proactive alarm management



Source: Prepared internally

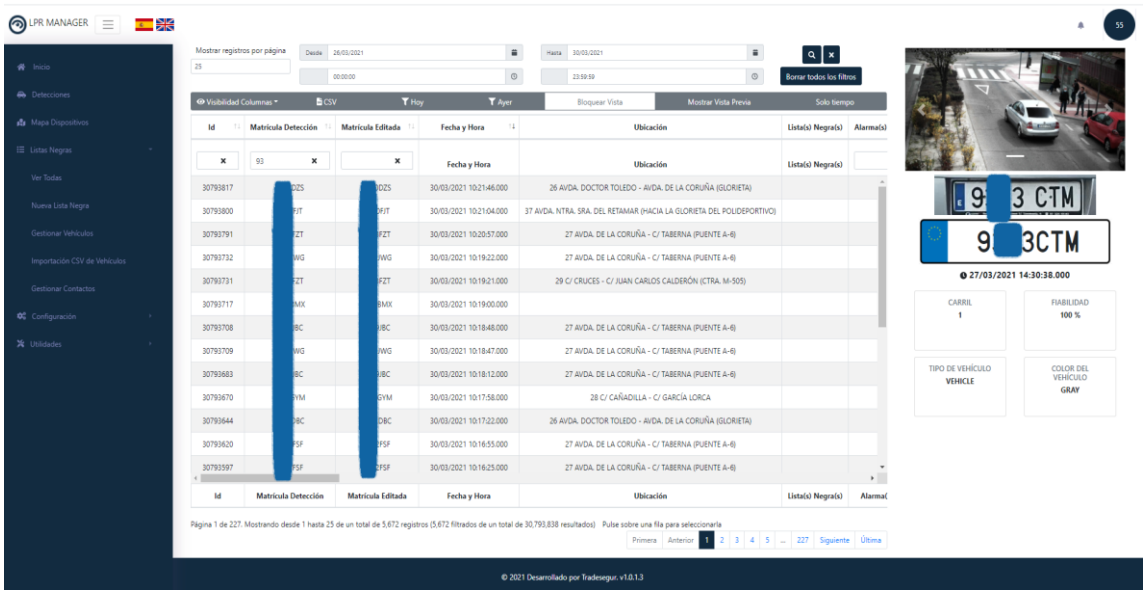
3.2. Practical implementation

In this stage, the specifications to be used in each of the technologies involved in the proposed solution will be presented.

Registration plate capture will be carried out by means of the ALPR system used by the Local Police in the municipality of Las Rozas (Madrid), which consists of a network of 61 cameras distributed throughout the municipality, 14 of which have OCR technology. The latter are positioned at the entrances and exits of the town. The camera

network is managed by the LPR Manager software, which has numerous configuration options, including the ability to search for an incomplete registration plate. Therefore, if you have two numbers, two letters or any other combination, you can search for vehicles with the specified characteristics on their registration plate. A timeband-based search or the search by vehicle colour is also interesting. It should not be overlooked that these cameras work with images which they store and can process to, among other things, discern the colour of the vehicle with a certain registration plate.

Figure 9. Search for incomplete registration plates with missing numbers and determine the time band with the LPR Manager application.



Source: Prepared internally

As regards the means of data transmission, the plan is to use Oracle Bus Service (OBS), which is the Web Service product implemented in the Guardia Civil's IT Service.

An *Internet Protocol* (IP) address would be published using a secure protocol, which would provide a connection to the local police forces that wish to take part in the project and on which a Web Service would be implemented using the SOAP protocol to exchange messages requesting and sending information on the registration plates of interest.

Since there is as yet no agreement between the Spanish Federation of Municipalities and Provinces and the Ministry of the Interior the sharing of this type of information, its transmission requires the exchange of a file using the *Comma Separated Value* (CSV) protocol containing the information collected by the system within a period of two days with which to carry out the necessary tests to search for registration plates in the Guardia Civil database containing the requisitions on vehicles. For personal data protection reasons, the CSV file provided by the Local Police in Las Rozas contains all the real data except for the registration plate. To continue with the research work, a routine has been implemented when loading this data into the database so that the registration number of each record is simulated.

With regard to storage of the registration plates logged by the camera system implemented in the town of Las Rozas, a database user is created in an Oracle database deployed in the Guardia Civil's IT Service, whose schema will contain a table. This table will store the registration number of the vehicle photographed, the time of capture, the georeferencing coordinates and the incident that led to the storage.

4.- TESTS AND RESULTS

This section covers all the steps taken to conduct tests and obtain the relevant data based upon which the achievement of the proposed objective can be assessed. It should be noted that, for security reasons, all names referring to tables or other objects defined here are fictitious.

Step 1: Processing the CSV file provided by the Las Rozas Local Police with an empty registration plate field, to insert a simulated registration plate.

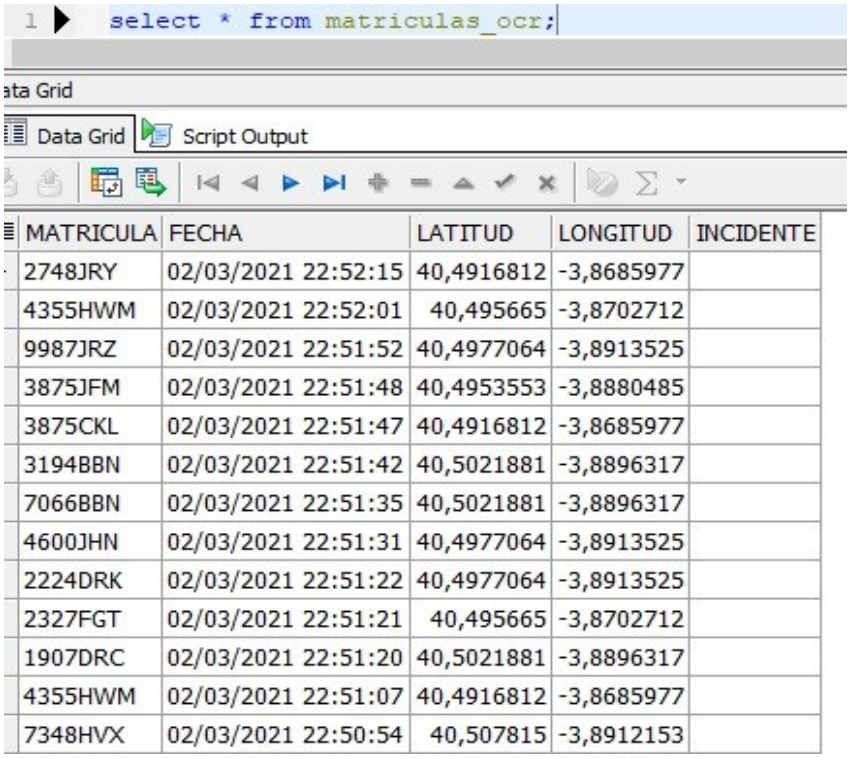
Step 2: Inserting the 134,000 records in the CSV file into the MATRICULAS_OCR database table.

The insertion order of one of these records is shown below:

INSERT INTO MATRICULAS_OCR VALUES('6696JNH',TO_DATE('02/03/2021 23:59:53','DD/MM/YYYYYY HH24:MI:SS'),40.4953553,-3.8880485,null);

The data in the table MATRICULAS_OCR is arranged as follows:

Figure 10. Data stored from the system in the Database collected from the ALPR system.



MATRICULA	FECHA	LATITUD	LONGITUD	INCIDENTE
2748JRY	02/03/2021 22:52:15	40,4916812	-3,8685977	
4355HWM	02/03/2021 22:52:01	40,495665	-3,8702712	
9987JRZ	02/03/2021 22:51:52	40,4977064	-3,8913525	
3875JFM	02/03/2021 22:51:48	40,4953553	-3,8880485	
3875CKL	02/03/2021 22:51:47	40,4916812	-3,8685977	
3194BBN	02/03/2021 22:51:42	40,5021881	-3,8896317	
7066BBN	02/03/2021 22:51:35	40,5021881	-3,8896317	
4600JHN	02/03/2021 22:51:31	40,4977064	-3,8913525	
2224DRK	02/03/2021 22:51:22	40,4977064	-3,8913525	
2327FGT	02/03/2021 22:51:21	40,495665	-3,8702712	
1907DRC	02/03/2021 22:51:20	40,5021881	-3,8896317	
4355HWM	02/03/2021 22:51:07	40,4916812	-3,8685977	
7348HVX	02/03/2021 22:50:54	40,507815	-3,8912153	

Source: Prepared internally

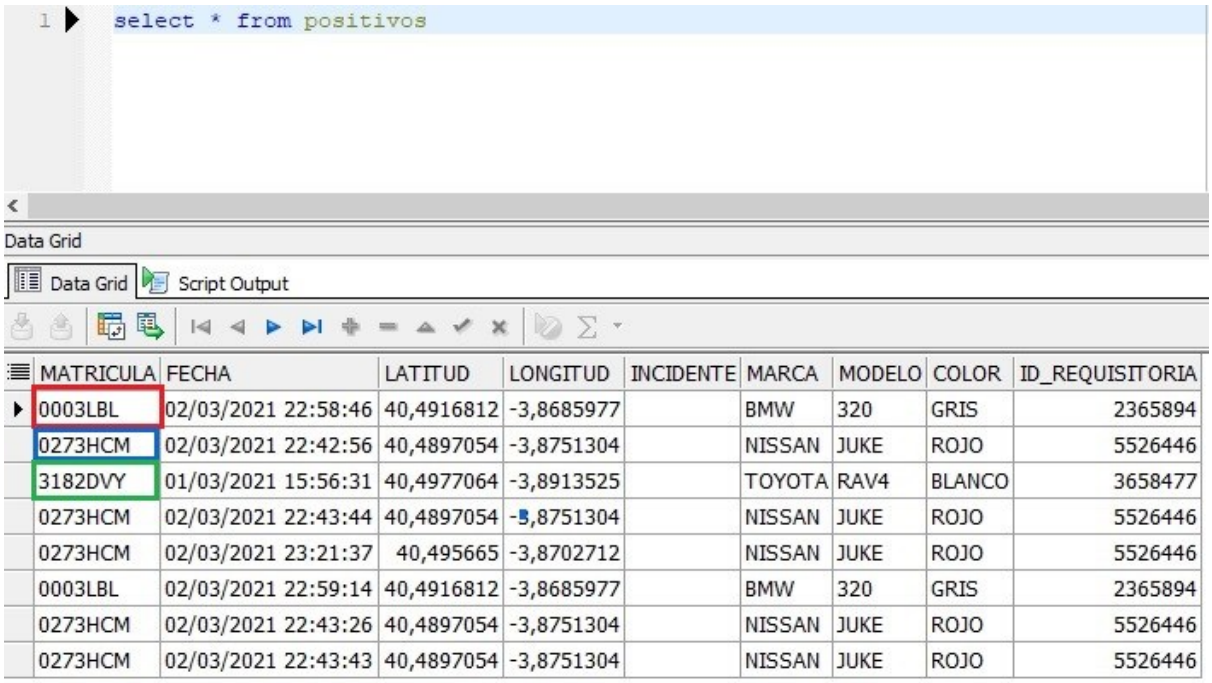
Step 3: Request and acquire the researcher role in the IOMS database, necessary to be able to make the necessary searches. This need stems from the obligation to justify the reason for the search in case of possible positives in requisition queries. The use of this role shows that the intention of the search is purely investigative and not operational.

Step 4: Create the database procedure with the name CHECK_MATRICULAS, whose purpose is to read the registration plate field of the MATRICULAS_OCR table and compare it with the registration plate field of the REQUISITIONS table corresponding to the requisitions existing in IOMS.

The positives from this check are inserted in another table which has been given the name POSITIVES, from which we will request new positionings.

Step 5: Having checked the data by running the procedure specified in the previous step, three positives have been obtained with an average query time per record of less than one millisecond.

Figure 11. Status of the POSITIVES table after the CHECK_MATRICULAS procedure has been executed.



MATRICULA	FECHA	LATITUD	LONGITUD	INCIDENTE	MARCA	MODELO	COLOR	ID_REQUISITORIA
0003LBL	02/03/2021 22:58:46	40,4916812	-3,8685977		BMW	320	GRIS	2365894
0273HCM	02/03/2021 22:42:56	40,4897054	-3,8751304		NISSAN	JUKE	ROJO	5526446
3182DVY	01/03/2021 15:56:31	40,4977064	-3,8913525		TOYOTA	RAV4	BLANCO	3658477
0273HCM	02/03/2021 22:43:44	40,4897054	-3,8751304		NISSAN	JUKE	ROJO	5526446
0273HCM	02/03/2021 23:21:37	40,495665	-3,8702712		NISSAN	JUKE	ROJO	5526446
0003LBL	02/03/2021 22:59:14	40,4916812	-3,8685977		BMW	320	GRIS	2365894
0273HCM	02/03/2021 22:43:26	40,4897054	-3,8751304		NISSAN	JUKE	ROJO	5526446
0273HCM	02/03/2021 22:43:43	40,4897054	-3,8751304		NISSAN	JUKE	ROJO	5526446

Source: Prepared internally

5.- CONCLUSIONS AND FUTURE LINES OF RESEARCH

To adapt the use of the information captured by the network of cameras installed with OCR technology in the municipality of Las Rozas and its management by the LPR Manager software to the current legislative framework, it became clear that these issues are governed by Organic Law 4/1997, which authorises the use of video cameras by the Security Forces and Corps in public places, as well as the Royal Decree that develops it. These regulations highlight the importance of the Government Delegate and the Guarantees of Video Surveillance Commission to authorise such recordings, basing their

application on the assessment of a prior suitability decision which, in a fair measure, weighs up the limitation of certain individual rights for the benefit of a collective interest like Citizen Security.

Continuing with the field of legal regulation, in the case of personal data protection, the use of recordings made on public roads by the Security Forces and Corps would comply with the provisions of Organic Law 7/2021 on the protection of personal data processed for the purposes of the prevention, detection, investigation and prosecution of criminal offences and the enforcement of criminal penalties, a transposition of Directive (EU) 2016/680. This Organic Law sets out the guidelines for how this personal data processing should be performed as established in Article 6 (1)(c), (e) and (f):

> (c) adequate, relevant, and not excessive in relation to the purposes for which they are processed.
>
> (e) kept in a manner which permits identification of the data subject for no longer than is necessary for the purposes for which they are processed.
>
> (f) processed in a manner that ensures appropriate security, including protection from unauthorised and unlawful processing and against accidental loss, destruction, or damage. Appropriate technical or organisational measures shall be used for this purpose.

Similarly, Article 8 (1) of this Organic Law refers to the period of time that this type of data may be stored, stating that: *The controller shall determine that personal data shall be stored only for the time necessary for the purposes set out in Article 1.*

Once it had been verified that the data processing to take place complies with the current legislation in this respect, a second feasibility trial was necessary, this time with a study of the technologies that would participate in the design of the different modules (data capture, storage, transmission and verification) whose subsequent practical implementation would enable the development of the appropriate tests with which to evaluate the extent to which ¡objectives set at the outset are achieved.

It is worth mentioning that as far as time measurement is concerned, the results of the tests are based on the average times obtained in other applications deployed in the Guardia Civil environment. These use a system similar to the one presented here, such as the SIAM application used for logging vehicles entering or leaving Spain and the application used to detect vehicles speeding on roads.

Due to the absence of an agreement between the Spanish Federation of Municipalities and Provinces and the Ministry of the Interior regulating the sharing of this type of information, it is impossible to implement the Web Service designed to transmit data between the client (Las Rozas Local Police) and the information server (Guardia Civil database).

The tests performed evaluated two types of alarm, one proactive and one reactive. The objective of both was to provide the COS with real-time, decisive information to facilitate the decision-making process following situations that threaten Public Security.

In the case of the proactive alarm, the time was measured from the moment the registration plate was captured by the video camera installed in the municipality until the

information was checked against the existing vehicle requisitions in the Guardia Civil database, and it was made available to the COS for the decision to be taken. Once this measurement has been made, the following measurements would correspond to new captures of successive movements of the vehicle through the municipal area and their corresponding disclosure to the COS so the decisions initially taken can be corroborated or modified.

In the case of a reactive alarm, the time measured starts when the COS has been informed of the registration plate of the vehicle involved in a criminal offence and has made its request to the database in which its positions have been recorded since it entered the municipality, the time elapsed between the request for the stored information corresponding to the said registration plate and the time it is made available to the COS for evaluation and decision making.

Based on the above, the following conclusions can be drawn:

- It is considered that the drawback encountered regarding the lack of the aforementioned agreement to be able to exchange data via Web Service does not affect the functionality of the service implemented, as the measurements are very close to those that could have been obtained by using it.

- It is considered that the drawback related to the fact of not being able to have real registration plates for reasons of personal data protection has not influenced the verification of the proper functioning of the implemented system.

- An important aspect to highlight with regard to the feasibility of this project is that almost all the necessary infrastructure is already in place. Both by the local police (ALPR) and the Guardia Civil (Databases, Web Service). Thus, the investment to be made in the implementation of this system would not generate a significant economic impact, a circumstance that would allow for its approval in budgetary terms.

- Taking into account optimal operating conditions, both in the case of proactive and reactive alarms, the estimated response time, based on other Guardia Civil applications that use the same technology, has been between 3 and 4 milliseconds.

- It can be seen that by having these two types of alarms at its disposal, the COS would have a tool capable of warning and alerting the potential on duty. It would also make almost immediate use of vital information to assess the situation and take decisions. This would have a direct impact on increasing the effectiveness of police work in the prevention and investigation of crime and consequently on the protection of public safety.

- The increase in efficiency provided by the implemented system would be determined by the temporal immediacy that would make it possible to have a very valuable advantage when taking the right decisions in order to prevent certain crimes or to have more elements of judgement to react to others that are already being committed. Similarly, the circumstance of being able to count on this temporal proximity between the execution of a criminal act and its knowledge would favour the development of a more effective subsequent investigation.

As a result of this work, some future lines of research could be undertaken, the following are proposed:

- Proposal 1: To make progress in the legal sphere with regard to the conclusion of the necessary collaboration agreements between the Spanish Federation of Municipalities and Provinces (FEMP) and the Ministry of the Interior concerning the sharing and processing of images provided by CCTV systems.

- Proposal 2: Provided that the necessary permissions were in place, it would be possible to have a database in the Local Police that would be integrated into the project, in which the list of registration plates for which there is a requisition would be kept and which would be permanently updated with the corresponding list of the Guardia Civil. This would effectively streamline the comparison process and obtain a positive result as these checks would be done in a local environment. As a result, the time needed to make the desired information available to the COS for evaluation and decision making would be reduced.

- Proposal 3: Integration of a module designed to obtain intelligence from data mining techniques to complement the proactive work of the system. Despite the limitation regarding the storage of information related to the image and the license plate recognised in it, as data that makes the person potentially identifiable, is limited to a legal period of 30 days, this aspect would not influence the viability in terms of the integration of this module, since such information would not be necessary. The data we would store would be the time at which the crime occurred, the georeference of the location and the type of crime committed. The storage of this data does not breach Organic Law 4/1997, which authorises the use of video cameras by the Security Forces and Corps in public places, or the provisions of Directive (EU) 2016/680 and its transposition Organic Law 7/2021. In this context, there would be no limit to the amount of information available to carry out the relevant studies. This intelligence would be used in day-to-day matters such as service planning, acting as another proactive element in crime prevention and therefore benefiting public safety.

- Proposal 4: Integration of this system with the existing mobility system so that, although management of the actions would continue to be the responsibility of the SOC, patrols would be able to better interpret the orders received by having real-time information on their devices regarding the position of the vehicle that makes the intervention necessary.

- Proposal 5: Extension of the application of the system to industrial estates. This would make it possible to log vehicle entries and exits at ungodly hours, as well as to facilitate a possible investigation once the offences have been committed.

BIBLIOGRAPHY

- Hongliang, B., & Changping, L. (2004). A hybrid license plate extraction method based on edge statistics and morphology. In Proceedings of the 17th International Conference on Pattern Recognition, 2004. ICPR 2004. (Vol. 2, pp. 831-834). IEEE.
- Sánchez, C., & Sandonís, V. (2015). Optical Character Recognition (OCR).
- Wang, S. Z., & Lee, H. J. (2003, October). Detection and recognition of license plate characters with different appearances. In Proceedings of the 2003 IEEE International Conference on Intelligent Transportation Systems (Vol. 2, pp. 979-984). IEEE. doi:10.1109/ITSC.2003.1252632 Retrieved from https://www.monografias.com/trabajos108/filtros-y-convoluciones/filtros-y-convoluciones2.shtml

LEGISLATION AND CASE LAW

- Spanish Constitution, (1978). (Official State Gazette 311 of 29 December 1978)
- Organic Law 4/1997, of 4 August 1997, which regulates the use of video cameras by the Security Forces and Corps in public places. (Official State Gazette 186 of 4 August 1997)
- Judgement of the Constitutional Court 37/1998 of 17 February 1998.
- Royal Decree 596/1999, of 16 April 1999, approving the Regulations for the development and execution of Organic Law 4/1997, of 4 August 1997, which regulates the use of video cameras by the Security Forces and Corps in public places. (Official State Gazette 93 of 19 April 1999)
- Directive EU 2016/680, OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of individuals with regard to the processing of personal data by competent authorities for the purposes of the prevention, investigation, detection or prosecution of criminal offences or the execution of criminal penalties, and on the free movement of such data and repealing Council Framework Decision 2008/977/JHA (Official Journal of the European Union of 4 May 2016)
- Organic Law 7/2021 on the protection of personal data processed for the purposes of the prevention, detection, investigation and prosecution of criminal offences and the execution of criminal sanctions. (Official State Gazette 126 of 27 May 2021)