Applications of Data Science in Policing: VeriPol as an Investigation Support Tool

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Abstract
Data Science is an interdisciplinary field involving the development of processes and systems to extract knowledge and understanding from data in different formats and from different sources. Considering the large amount of data generated and managed by public safety agencies, *Data Science* applications in the police sector are numerous. More important are the advantages that the different applications of *Data Science* could provide the police on issues such as the optimization of resources, the increase of efficiency and effectiveness, the modernization and its exemplariness when compared with other institutions. In this paper we present different potential applications fields of Data Science for the police. In addition, we focus on the case of *VeriPol*, a tool for automatic detection of false violent robbery reports, currently under development by the Spanish National Police. In particular, we illustrate a detailed analysis of the results of a recent pilot study aimed at assessing the effectiveness of the tool.

Keywords: Data Science, Policing, Optimization, *VeriPol*.

1. Introduction

Every day we are in contact with systems that collect large amounts of information in order to model our behaviour. Spotify does it to recommend artists who might like you, based on the songs you listen to; Netflix builds a profile for each user, allowing to customize each person's experience, and even some banks use it to detect fraudulent transactions.

To transform these huge amounts of data into knowledge, it is necessary to design and use statistical and computational tools. The interdisciplinary field that concerns the development of processes and systems to extract knowledge and understanding from data in different formats and coming from different sources is called Data Science. In Data Science, techniques and theories, which derive from many fields within diverse areas such as mathematics, statistics or computer sci-

ence, are used. These include for example: probability and uncertainty models, automatic learning and statistical learning, data mining, information retrieval and retrieval, pattern recognition and visualization, and predictive analysis.

These techniques and sciences have achieved a dramatic reduction in the cost of storing and processing information and have led Data Science to become a technological trend that continues to grow. You could say that at present there is not a single Fortune 500 company that is not investing human and economic capital in any area related to Data Science, with Facebook and Google being two of the most notable cases. Data Science influences the economy, business and finance (Patil & Davenport, 2012). From a business perspective, Data Science is an integral part of competitive intelligence.

The use of Data Science techniques is not limited to companies seeking to retain their customers to increase their profits (such as Spotify, Netflix, Facebook or Google), there are also use cases in which these same methods have been used to tackle problems with a great social impact. This is the case of "*The Data Science for Social Good Fellowship*" of the University of Chicago[1]. Data analysis can help us to improve decision making in companies, provide new perspectives to our entrepreneurs and be a powerful ally to combat problems of social development and public health.

This paper relates to this last social and public interest and describes the applications that *Data Science* can have in security and safety. More concretely, the applications that the Spanish National Police is considering developing in the near future and in particular the case of *VeriPol*, a tool for automatic detection of false violent robbery reports, currently under development by the Spanish National Police.

2. Applications of Data Science for Security and Safety

The importance of data analysis for police and citizen security activities has been recognized even by the former President of the United States, Barack Obama, who in 2015 launched the Task Force on 21st Century Policing initiative[2]. Within this is the Police Data Initiative which recommends the use of innovative Data Science techniques to improve police action, relations with citizens and public safety.

Considering the large amount of data generated and managed by the different National Police Institutions around the world, the applications of Data Science in the police sector are innumerable. Specifically, in this paper, the focus will be in the different applications that Data Science could provide to the Spanish National Police, with issues such as resource optimization, efficiency and effectiveness, modernization, or exemplarity compared to other global institutions. Next, some of these ideas are detailed.

2.1 Prediction of Crimes

Predictive Policing is the use of police data to identify individuals, locations and events with a high risk of crime. The prediction of crimes allows to focus the police effort in the areas with greater risk in a dynamic way and that adapts to the criminal tendencies of the moment and of a specific territory. Numerous pilot projects (Miami, Chicago and London, among others) have proved useful. *PredPol*, an initiative in Santa Cruz, California, uses historical data to point out to agents 10 to 20 high-risk areas (Perry, 2013). The result has been a reduction in the first year of the 27% of the thefts and of 11% of the robberies in houses.

The interest for the definition of reliable crime prediction models is evident. Currently sponsored by the National Institute of Justice, a competition is underway for the definition of predictive models with economic awards totalling $1.2 million dollars[3].

2.2 Definition of Police Districts and Patrol Optimization

The prediction of crimes represents the first step towards the definition of a protocol of police action that fits the profile of each police beat or shift duty. Through optimization techniques it is possible to define the distribution of patrol agents in a district to improve different objectives, assuming an improvement in the distribution of the workload between agents and an improvement in the efficiency in the actions (Camacho-Collados, Liberatore & Angulo, 2015; Camacho-Collados & Liberatore, 2015; Liberatore & Camacho-Collados, 2016).

1 https://dssg.uchicago.edu/

2 https://cops.usdoj.gov/policingtaskforce

3 https://www.nij.gov/topics/law-enforcement/strategies/predictive-policing/Pages/welcome.aspx

2.3 Itinerant Crime and Criminal Series

Methodologies such as the Series Finder (Wang, Rudin, Wagner & Sevieri, 2013), developed at MIT in collaboration with the Cambridge (MA) Police Department, can identify criminal patterns and detect crime series. More specifically, this tool builds profiles of *Modus Operandi* and detects crimes that belong to the same series. In a pilot study with theft crimes in housing Series Finder has excluded crimes from crime series previously identified by police. This has reduced the number of suspects automatically.

2.4 Gender Violence Risk Estimation

Applying learning methodologies such as Case-Based Reasoning (Aamodt & Plaza, 1994) it is possible to obtain very powerful and effective models based on similarities with previous cases for the estimation of the risk for abused women. These models could also provide information on risk factors and their relevance by introducing machine learning predictive models (Bishop, 2006).

2.5 Analysis of Organized Crime Network Vulnerabilities

The Social Network Analysis (Bishop, 2006) discipline provides tools for studying social networks and identifying major actors as well as hidden structures. Among their techniques are methodologies to identify the most important elements of these networks and the communities within them. In the context of policing, similarly to what is presented in Baker and Faulkner (Baker & Faulkner, 1993), these basic applications could identify the most important individuals within an organized crime network, differentiating the different roles (central and linking elements). More advanced models (i.e., interdiction and fortification optimization models) can be used to define network vulnerabilities, that is, which individuals "attack" (stop or damage) to dismantle the network in the most efficient and effective way (Liberatore, Scaparra & Daskin, 2011; Liberatore, Scaparra & Daskin, 2012; Liberatore, & Scaparra, 2011). This model would require the evaluation of the relation between the actors, leading to the application of Tie Strength models (Liberatore & Quijano-Sanchez, 2017).

2.6 Analysis of Images of Police Cameras

Police cameras (e.g., body, helmet, and vehicle cameras) are a powerful tool that generates a large amount of data daily. However, the large amount of information produced makes an analysis by experts impossible. Fortunately, it is possible to develop tools (Wu, Liu, Li, Gu, Si & Tan, 2009; Hampapur, 2008) that process the recordings automatically to search for information of interest, both *a posteriori* (for example, identification of sequences of persecutions) and real time (reading of license plates, identification of faces of suspects).

2.7 Analysis of Work Productivity

At present, the productivity measurement of a police station does not take into account the work of crime prevention, which has the advantage of reducing costs for both the police, the judiciary system and society as a whole, as well as the economical and human benefit associated with avoiding the conversion of a citizen into a criminal. By applying statistical and optimization models (D'Amico, Wang, Batta & Rump, 2002) it is possible to design more sophisticated productivity measures that take into account all factors of police work. In addition, these models would allow the identification of police stations where good work is being done in particular, allowing them to model their techniques and to open the possibility of training courses to other police stations or agents, thus sharing expert knowledge that would increase national performance.

2.8 Detection of False Reports

False allegations represent an expense of money and resources for the Police. In addition, this type of crime is often accompanied by other crimes, such as fraud. Early detection of such complaints would allow inspectors to focus more efficiently. This type of Data Science tool is currently being built at the Spanish National Police. In the following Section the description of such tool and in particular, a detailed analysis of the results of a recent pilot study aimed at assessing the effectiveness of the tool are presented.

3. Case Study: *VeriPol*, a decision support tool for false violent robbery reports detection

Police investigations that are carried out in the different police departments of the Spanish territory are generally influenced by quantitative parameters, although many of them also consider qualitative ones. Generally, these investigations start from a report made by a person harmed or offended by an illegal act that, directly and by legal imperative, it forces the officers of the Security Forces to undertake the investigation and clarification of what has been brought to his/her attention.

The referred investigations cover all types of crimes contained in the Spanish Penal Code, although in some cases it is easily determined who the author is. In others, it is very difficult, even at times impossible, to determine the culpability of the crime. In those cases that are not possible to close, uncertainties and doubts usually appear in the course of the investigation, including whether the complainant has told in the report everything in his/her knowledge, or if this complainant has any malicious interest in his story, or even if he/she is openly lying to get a benefit.

Articles 456 and 457 of the Spanish Penal Code concern false reports and the simulation of crimes respectively, that is, they punish the fact of falsely filing a report before a judicial or administrative to provoke procedural actions such as the police investigation. In certain cases, the police responsible for these investigations, after a time spent collecting information about the complainant and the information provided by the complainant, may suspect that it is a false report or a simulation of crime. However, since the majority of these complainants are respected citizens and, above all, they are not criminals, care must be taken in dealing with them and with the facts to be investigated, always without violating the principle of presumption of innocence that every person has.

In recent years it has been observed that, partly motivated by a social phenomenon such as an economic crisis, a very high percentage of "normal" citizens, that is, not ordinary criminals, are being detained or charged with a crime that they had never known existed as such, although it does not justify their action. This situation entails an additional cost of time and resources to the National Police that could be invested in other more appropriate tasks.

This fact is causing great concern among those in charge of criminal control, since the statistical indices of false reports have reached a very high level of concern. Not only because it is a statistical modulator index, but because when analysing this phenomenon in depth, the following conclusions, that are quite striking and that directly and indirectly affect police effectiveness, can be drawn.

- Firstly, it affects the beginning of the investigation. Since it should be presumed that the information coming from the complainant is truthful, these falsehoods hinder and delay the beginning of the police action.
- More often than not, in the course of the investigation, it is found that the reason that motivates the investigative police intervention is not true.
- This hampers police work and calls for new investigation in another direction, thus generating unnecessary stress and strain. A properly targeted approach from the start would undoubtedly have a better outcome.

Motivated by the analysis of the current situation, an innovative project has been carried out within the scope of "predictive policing," the result of which is, *VeriPol*, a computer tool to estimate the likelihood that a violent robbery report is false. The program takes the text of the complaint as input. Therefore, it does not need any information on the part of the user and is completely automatic. In addition, it integrates perfectly with the SIDENPOL system (Police report system). That is, the system entry consists of a document (in PDF format) of each complaint, from which the descriptive text of the complaint is obtained. The program processes the text, extracting useful characteristics for its classification using techniques of Natural Language Processing (Winograd, 1972). These characteristics are passed to a mathematical model that uses Artificial Intelligence techniques (Michalski, Carbonell & Mitchell, 2013) and estimates the likelihood of falsity of the complaint. The output of the program is the probability that the complaint entered is false. Empirical experiments show that the accuracy of the tool is more than 90%.

The purpose of this novel project is the creation of a global and automatic system for the detection of false allegations, in addition to the definition of a research protocol for this type of crime. In this first phase, the problem has focused on the specific case of allegations of violent robbery. The promising results inspire to continue with this process and design of successive models for other types of reports.

3.1 Pilot Study

To test the efficacy and effectiveness of *VeriPol*, a pilot study has been undertaken in the urban areas of Murcia and Málaga, Spain. More in detail, the pilot study was run in Murcia (four police departments involved) from the 5th to the 9th of June 2017, while it took place in Málaga (six police department involved) from the 12th to the 16th of June 2017.

In each destination, two agents, experts in false report detection and in *VeriPol,* were sent to install the software, give a short course on its use to the local agents and investigators, and supervise all the activity. After

that, all the new violent robbery reports as well as all the open violent robbery cases of 2017, were analysed by *VeriPol*.

The results of the pilot study are shown in Table 1. As it could be observed, the implementation of *VeriPol* allowed for an impressive increase in productivity in terms of number of false cases of violent robbery detected and successfully closed.

Table 1: Comparison between the number of false violent robbery cases closed during the pilot study and the average number of false violent robbery cases closed in June.

Destination	Number of false violent robbery cases closed during the pilot study	Average number of false violent robbery cases closed in the month of June, years 2008-2016
Murcia	31	3,33
Málaga	49	12,14

3.2 Survey

To understand the level of acceptance and satisfaction associated with the use of *VeriPol*, all the agents and officials that participated in the pilot study were asked to answer to an anonymous questionnaire (illustrated in Table 2) on a voluntary basis.

Table 2: Questionnaire structure. For each question, the original text in Spanish and a translation to English are provided. The third and the fourth columns show the type of question and the allowed answers, respectively.

#	Question	Type of question	Allowed answers
1	Would you like the National Police to explore new methodologies to reduce costs and decrease the workload? ¿Te gustaría que en la Policía Nacional se exploraran nuevas metodologías para reducir costes y disminuir la carga de trabajo?	Multiple choice	Yes, No *Sí, No*
2	Do you think that the national police should provide investigator staff of more and better technological means to deal with the crime? ¿Crees que la Policía Nacional debería dotar al personal investigador de más y mejores medios tecnológicos para enfrentarse a la criminalidad?	Multiple choice	Yes, No *Sí, No*
3	Have you worked in the investigation of violent robberies? ¿Has trabajado la investigación de robos con violencia y/o tirones?	Multiple choice	Yes, No *Sí, No*
4	Did you use *VeriPol*? ¿Has usado VeriPol?	Multiple choice	Yes, No *Sí, No*
5	Do you think that *VeriPol* could be useful for the investigation of violent robberies? ¿Crees que VeriPol podría ser útil para la investigación de robos con violencia y/o tirones?	Multiple choice	Yes, No *Sí, No*
6	How useful do you think that *VeriPol* is as a investigation tool? ¿Cómo de útil crees que es VeriPol como herramienta investigativa?	Linear scale	1 (Not at all, *Nada*) to 5 (A lot, *Mucho*)
7	Do you think that *VeriPol* would be easy to integrate into your daily tasks? ¿Crees que VeriPol sería fácilmente integrable en tus tareas diarias?	Linear scale	1 (Not at all, *Seguro que no*) to 5 (Absolutely, *Seguro que sí*)
8	If you had *VeriPol* available, would you use it on a regular basis? ¿Si tuvieras VeriPol a disposición, lo usarías de forma regular?	Linear scale	1 (Not at all, *Seguro que no*) to 5 (Absolutely, *Seguro que sí*)
9	Do you think that *VeriPol* would expedite the investigation of cases? ¿Crees que VeriPol agilizaría la investigación de los casos?	Linear scale	1 (Not at all, *Seguro que no*) to 5 (Absolutely, *Seguro que sí*)
10	Would you like to have *VeriPol* installed in a way regular in all the National Police computers? ¿Te gustaría que VeriPol se instalase de forma regular en los ordenadores de la policía?	Linear scale	1 (Not at all, *Seguro que no*) to 5 (Absolutely, *Seguro que sí*)

#	Question	Type of question	Allowed answers
11	Do you think that it would be useful to extend *VeriPol* to other types of complaints? ¿Crees que sería útil que VeriPol se extendiese a otros *tipos de denuncias?*	Linear scale	1 (Not at all, *Seguro que no*) to 5 (Absolutely, *Seguro que sí*)
12	Would you like to receive training to learn new interrogation techniques? ¿Te gustaría recibir formación para aprender nuevas técnicas de interrogatorio?	Multiple choice	Yes, No *Sí, No*
13	Sex *Sexo*	Multiple choice	Male, Female *Hombre, Mujer*
14	Age in years *Edad en años*	Short answer	Short-answer text
15	Police Department *Comisaría*	Short answer	Short-answer text
16	Rank *Escala*	Multiple choice	*Básica, Subinspección, Ejecutiva, Superior*

21 agents and officials took part to the survey. The results are summarized in Table 3.

Table 3: Summary of the survey's result (in this context, NA means "Not Answered"). For each question, the frequency of each answer is given. Question #14 is an exception as its answer is continuous numerical. For this reason, summary statistics (minimum, 1st quartile, median, mean, 3rd quartile, and maximum) are given.

Question #	*Answers*					
1	**Yes**: 21		**No**: 0		**NA**: 0	
2	**Yes**: 21		**No**: 0		**NA**: 0	
3	**Yes**: 21		**No**: 0		**NA**: 0	
4	**Yes**: 18		**No**: 1		**NA**: 1	
5	**Yes**: 21		**No**: 0		**NA**: 0	
6	**1**: 0	**2**: 0	**3**: 0	**4**: 8	**5**: 13	**NA**: 0
7	**1**: 0	**2**: 0	**3**: 0	**4**: 3	**5**: 18	**NA**: 0
8	**1**: 0	**2**: 0	**3**: 0	**4**: 3	**5**: 18	**NA**: 0
9	**1**: 0	**2**: 0	**3**: 1	**4**: 4	**5**: 16	**NA**: 0
10	**1**: 0	**2**: 0	**3**: 0	**4**: 2	**5**: 19	**NA**: 0
11	**1**: 0	**2**: 0	**3**: 0	**4**: 3	**5**: 18	**NA**: 0
12	**Yes**: 21		**No**: 0		**NA**: 0	
13	**Man**: 20			**Woman**: 1		
14	**Minimum**: 33.00; **1st Quartile**: 36.50; **Median**: 40.00; **Mean**: 41.45; **3rd Quartile**: 44.50; **Maximum**: 55.00; **NA's**: 1					
15	**Cartagena**: 3		**Fuengirola**: 1		**Lorca**: 4	
	Málaga Centro: 3		**Murcia el Carmen**: 1		**Torremolinos**: 8	
16	**Básica**: 16		**Subinspección**: 3		**Ejecutiva**: 2	

From the observation of the participants' answers the following conclusions can be drawn:

— There is a unanimous interest in innovation in the Spanish National Police (questions 1, 2, and 12).
— Concerning *VeriPol*, the participants reckon that:
  ° It is a very useful investigation tool (questions 5 and 6).
  ° It would be easy to adopt and they would use it regularly, as it would simplify their job (questions 7 to 9).
  ° It should be installed to all the computers of the Spanish National Police and it should be extended to include other types of crimes.

Overall, given the extremely impressive results obtained in terms of false reports cases closed and the enthusiastic answers provided by the survey's participant, the pilot study has been considered a huge success that has motivated the head of the Spanish National Police to proceed with the implementation of *VeriPol* into the reports management software.

4. Conclusions

Data Science allows us to analyse information flows, which are generally unpolished, to become valuable, organised, and hierarchical information. As an example, in recent years, multinationals such as General Electric, Banco Santander (Quijano-Sanchez & Liberatore, 2017) or BBVA have implemented the role of the Chief Data Officer or Chief Science Officer in their organizations, with the mission of making the most of their business data. As the Internet was 20 years ago, Data Science will mark a before and after in the history of technological development and will influence many more areas than we imagine. With this, we can conclude that Data Science will be the solution that requires our time, but as the famous Stephen Hawking said, *"Intelligence is the ability to adapt to change."*

In the security field, the implementation of a system and protocol such as *VeriPol*, would allow a better use of police resources (especially human resources), a reduction of crime due to greater research effectiveness, and an improvement of the quality of police data relating to crime, as it entails a significant reduction of false information in the databases. In addition, as mentioned through the paper this type of initiative could open the door to a new form of investigation individualized in the crimes of robbery with violence or intimidation, for its special incidence and social repercussion, and with the possibility of extending to any type of police investigation as this is the beginning of an unusual and innovative system.

Finally, the implementation of the tool would make the Spanish National Police the first in the world to use a system of this type. In fact, there is no other system with similar characteristics, neither at academic level nor at the industrial level, and research on detecting lies from text is still in its infancy. Similar initiatives in foreign police have had a very strong media impact. For example, the previously mentioned *PredPol* tool, developed between the Los Angeles Police Department and the University of California Los Angeles, has been named by Time Magazine as one of the 50 best inventions of 2011 (Grossman, Brock-Abraham, Carbone, Dodds, Kluger, Park & Walsh, 2011).

The implementation of the system proposed in this document would put the Spanish National Police at the forefront as one of the most advanced police in the world, with a very positive impact on its image, both nationally and internationally. Looking at the results of the Pilot Study, this is more than likely to occur.

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