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Original Article

Development of Artificial Intelligence Algorithm for the Analysis and Prediction of Car Accidents on the Roads of Peru

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Abstract *- In recent years in Peru, there has been an increase in car accidents that have occurred on the roads. Where these figures are worrying because year after year, the curve of accidents and deaths skyrockets without having sought a definitive solution; only in these last 5 years the accident curve has increased to a thousand accidents per year where a definitive solution has not been seen, causing these accidents to cause fear in the Peruvian and foreign populations who want to get to know this beautiful country and its cultural diversity. Therefore, in this research, it has been proposed to develop an artificial intelligence algorithm to be able to analyze and predict car accidents throughout Peru, with the final result that these final results can serve as strategies for the development of emerging technologies to be able to counteract these accidents. Automobile, the final data of this investigation is to be able to specify where these accidents are occurring most through a set of collected and cleaned data to be able to provide much more precise analysis and apply a decision tree model to be able to identify where there is a probability that they occur these accidents again. This research is intended to contribute to the scientific community.*

Keywords *- Prototype, Alarm, Scrum, IoT, Car accidents.*

1. Introduction

Peru is one of the countries categorized in the world as the meeting point of different races and cultures in its wide territory comprised of 24 departments and their capitals. There is a multiculturality of traditions, among which it is 3 regions that are the mountains or also considered the Andean region, the jungle or Amazon region and the coast, which have a great multicultural significance. Although Peru is a country with a lot of diversity and traveling in this beautiful country is a great pleasure for Peruvians and foreigners themselves, there is a great concern that has been identified as indicated by the Ministry of Transport and Communications in the last 5 years. A total of 14,000 people deceased [1] from automobile accidents that occurred on the roads in Peru, where it is also indicated that the necessary measures are not being taken to reduce or prevent these automobile accidents. As required by the National Institute of Computer Statistics [2], it can be seen that from 2017 to 2021, a brutal growth in road accident victims where will mean that the curve of accidents and deaths continues to increase if the necessary measures are not taken to counteract this problem. In the current decade, various technologies are in our favor to be able to use them and put them into practice to change realities, but it is necessary before these technologies can be used to analyze and predict car accidents on the road in this way. Implement emerging technologies in specific departments.

Therefore, in this research, the objective is to be able to analyze and predict automobile accidents that have occurred on the road. In order to be able to provide strategies through information technologies to counteract the increase in these cases that is more alarming every year throughout the world—Peruvian territory.

In this research, specialized techniques in Machine Learning will be used using a set of structured data extracted from open data from Peru. [3]which this set of data has been over-structured and improved with the different small data obtained from other national and international institutions. This research aims to contribute to the scientific community and can serve as a scientific basis for the integration of projects to solve emerging cases in Peru.

2. Literature Review

Machine learning is increasingly applied in the field of medicine to help both doctors and patients. This is the case of the following investigation where using artificial intelligence; they managed to help patients with rheumatology to predict

the course of the disease and identify risk factors. All this was achieved thanks to the fact that they had a solid base of information capable of being used to train data and thus find a result. Finally, the authors hope that in the future, this technology will not only help prevent disease but also propose treatment proposals and estimate their benefits [16].

On the other hand, in the following investigation, they used machine learning to present a solution to landslides; since it is the cause of numerous deaths, they sought to predict possible landslides. For this, they investigated issues related to the detection of landslides analyzed by images; they evaluated the level of susceptibility of the land, and finally, the development of alerts before this phenomenon, concluding that these technologies have been effectively applied for the prevention and they were able to predict, however, they still present limitations and great challenges, that is why they recommend a gradual increase in information, and in this way obtain a better result when making the prediction [5].

In the same way, in the following investigation, they predicted house prices with machine learning algorithms. For this, they used different algorithms, such as Gradient Magnification Machine (GBM) and Random Forest (RF), where they discovered the best results. They got it using RF and GBM as they got better performance. Finally, they conclude that machine learning is an alternative that is highly capable of valuing and evaluating the price, whether of housing or some other product [6].

Likewise, machine learning was applied to detect patterns with risk factors to change diabetes. For this, they conducted a study and tests with 5 different machine learning algorithms to improve the results, thus obtaining a prediction with a minimum margin of error. To train the algorithm, they used a large amount of stored data, and in this way, they sought to classify patients as diabetics and non-diabetics [17].

The use of machine learning is varied; proof of it is a large amount of research carried out to predict the yield of crops, which is why in the following investigation, they analyzed the algorithms used to predict their yield. In total, they recovered 567 studies. Among them, 50 were selected, from which they obtained that the most used characteristic is temperature, rainfall and soil type. In addition, the most used algorithm is Artificial Neural Networks. Segmenting the research further, they were left with 30 articles based on deep learning, from which they obtained that convolutional neural networks (CNN) are the most used, followed by long- and short-term memory (LSTM) and deep neural networks (DNN) [8].

In conclusion, the application of machine learning is varied; according to the investigations addressed, they have helped to make predictions in various areas, where in each case, accurate predictions have been obtained; however, it is recommended to continue improving the algorithms, in turn, perform the training with the updated data to obtain the best result.

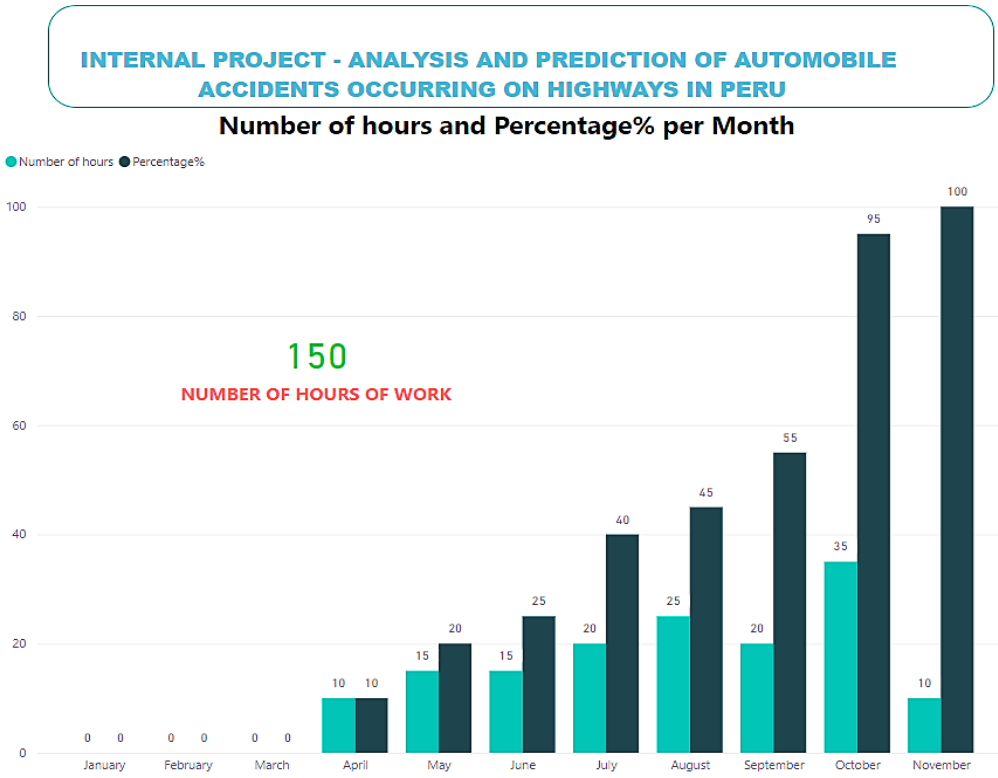

Fig. 1 Performance measurement of project progress

Table 1. Car Accident Term Dictionary

Title	Description	Datatype	Size	Additional Information
FECHA_CORTE	Information cut-off date	Numeric	8	
FECHA	Date of traffic accident	Numeric	8	
HORA	Time of traffic accident	Numeric	5	"NEITHER." means "unidentified". In 88 traffic accidents, the time was not recorded.
DEPARTAMENTO	Department where the traffic accident was located	Text	13	"NEITHER." means "unidentified". In 7 traffic accidents, the department was not registered.
CODIGO_VIA	Code of the road in which the traffic accident was reported	Alphanumeric	6	"NEITHER." means "unidentified". In 46 traffic accidents, the road code was not recorded.
KILOMETRO	Kilometer of the road where the traffic accident was reported	Numeric	4	"NEITHER." means "unidentified". In 45 traffic accidents, the kilometer was not recorded.
MODALIDAD	Modality of the traffic accident: run over, crash, mistake, special, rollover or N.I.	Text	9	"NEITHER." means "unidentified". In 28 traffic accidents, the modality was not recorded.
NUM_FALLECIDOS	Number of people reported as deceased	Numeric	2	"NEITHER." means "unidentified". In 3 traffic accidents, the number of deaths was not recorded.
NUM_HERIDOS	Number of people reported as injured	Numeric	2	"NEITHER." means "unidentified". In 10 traffic accidents, the number of injuries was not recorded.

3. Methodology

The development of this research work has an agile work methodology which has had to present in certain time limits the progress of structure. The work to be shown is focused on analysing and predicting automobile accidents that have occurred on the road in Peru. With respect to the year 2020 and 2021, which has applied interactive phases regarding Machine Learning techniques for information gathering and data training and provides a prediction that may be useful for the scientific community of researchers in Peru and the world. Next, all methods applied in this internal project research proposed at the University of Sciences and Humanities will be explained.

3.1. Scrum

This research has planned an opening start and an end with respect to the year 2021, which has been necessary to have an agile work order so that the team can work on this research project in a scalable way, therefore the method of scrum agile work as applied in the scrum guide [9]following good practices reaching efficiency and a good expectation in the recurring progress of the requirements as can be seen in Fig.1 where a measurement of the project's performance has been created, it can be seen that an end is shown in the month of October, noting that progress has been satisfactory with the research team.

3.2. Machine Learning

In order to apply the prediction model with respect to road car accidents, machine learning techniques have had to be applied using supervised learning, which is based on research from [10][12][18]where it can be seen that all these models have applied supervised learning because all the information is standardized. Therefore it is necessary to consider that the data set to be used is structured and has a standard so that the analysis and prediction can be carried out related to automobile accidents.

3.3. Techniques for modeling Machine Learning

For the creation of the model, a previous investigation has been taken as a basis where the steps to be able to train our model are explained in detail [10]. The steps for creating an existing model were also addressed in this investigation. However, this time theoretical aspects of each of the phases will not be argued if it does not go directly to the technical part of the development of this project.

3.3.1. Data set and understanding of the problem

It is necessary to be able to classify the data well and delimit the space and time where the research is planned to land. Initially, it was thought to cover a greater number of years with respect to analyzing and predicting automobile accidents. However, due to the current and real structured data sets, It has had to delimit between the years 2020 and 2021 due to the standardized information from the open data platform of Peru [3], which will be the base source for the prediction of the occurrence of automobile accidents. As shown in Table 1, the dictionary of terms can be seen regarding the data to be used, which will be our primary data to be able to go through the Machine Learning model. As seen

in the additional information column, there is an indication where it is determined that there was some information that could not be correctly systematized. Therefore it will have the acronym N.I.; it is necessary to be aware of this. In this way, our data cleaning will be more precise. The Highway code is the meaning given to a predetermined highway in Peru, as can be seen in Fig. 2 extracted from [20], where all the highways in Peru are identified, each one of them has a code of road where the difference of each automobile accident with respect to the accident is through the number of kilometers identified, that means that there may be several accidents in the same road code but in different kilometers, in total in this research work it will be taken into Consider the road code.

Fig. 2 Map of Peru and their respective roads

Currently, there are several highway codes in Peru, but in this work, the 10 highway codes where more incidences of car accidents in the years 2020 and 2021 will be shown, as shown in Table 2, because there are more than 200 highway codes and reflecting it in this document would extend the conditions of the document more than indicated.

Table 2. Car Accident Term Dictionary

CODIGO_VIA	Description
PE-1S	The Panamericana Sur, Longitudinal of the southern coast or National Route PE-1S, is the name given to Route 001 in southern Peru. It is part of the Pan-American Highway, running from Lima's department to the Chile border.
PE-1N	The Panamericana Norte, Longitudinal de la Costa Norte or National Route PE-1N, is the name given to the Pan-American highway in northern Peru. It is part of the Pan-American Highway, running from Lima to the border with Ecuador. It has six variants and seven branches
PE-5N	The PE-5N or Longitudinal Route of the Northern Jungle is the northern trajectory of the longitudinal Axis No. PE-5 of Peru'sNational Road Network.
PE-34E	Emp. PE-34 A (Dv. Vizcachane) - Vizcachane - Pulpera - Negro Mayo - Dv. Tintaya (PE-3S K) - Quello - Emp. PE-3S G (Yauri)
PE-22	The Central Highway of Peru, officially PE-22.2, is a transverse road of penetration in Peru that starts from the city of Lima and communicates with the department of Junín in the center of the country, reaching La Oroya.
PE-34H	JULIACA-TARACO-PUTINA-DV. SANDIA-SANDIA-SAN IGNACIO: Restricted traffic due to platform erosion in the Sandia-Quiquira Section, Huancaluque sector
PE-3S	The Longitudinal de la Sierra Sur, officially National Route PE-3S, is the name given to the southern section of the Longitudinal de la Sierra highway in Peru.
PE-30A	The Nazca-Abancay Road, officially Rutanational PE-30 A, is a transverse route that traverses the provinces of Nazca in Ica; Lucanas and Páucar of the Sara Sara in Ayacucho; Aymaraes and Abancay in Apurímac. Currently the road is paved.
PE-12B	EMP. PE-12 A (PARIASH) - HUAYLLABAMBA - QUICHES - PTE. SANTO CRISTO - URPAY - EMP. PE-10 C (TAYABAMBA)
LI-122	From Hamburgo X Manzanares to Los Pinos X Manzanares
PA-104	Located in Perry, Juniata, Snyder counties and Union in Pennsylvania
CU-130	From Avenida Alfonso Reyes, 815 to Ignacio Morones Prieto.
PE-14C	He travels the provinces of Sihuas, Pomabamba, Piscobamba, Carlos Fermín Fitzcarrald and Huari in the trans-Andean area of the Conchucos, Ancash region
PE-3NG	Emp. PE-3N (La Cima) - Azulmita - Altocsayo - Conocancha - Dv.Corpacancha - Chupas - Cueva - Coricocha - Emp. PE-22 (Chinchan)
LI-127	ItgoesfromAncush - Las Piedras - José Faustino Sánchez Carrión, Julcán District and Province - La Libertad Department

```
In [1]: import pandas as pd
        pd.options.mode.chained_assignment = None  # default='warn'

In [2]: datos_accidentes = pd.read_csv(r'C:/Users/Enrique/accidentes.csv' , sep=';')

In [3]: datos_accidentes['FECHA'] = pd.to_datetime(datos_accidentes['FECHA'], format='%Y%m%d'

In [4]: type(datos_accidentes)
Out[4]: pandas.core.frame.DataFrame

In [5]: datos_accidentes.columns
Out[5]: Index(['FECHA_CORTE', 'FECHA', 'HORA', 'DEPARTAMENTO', 'CODIGO_VÍA',
               'KILOMETRO', 'MODALIDAD', 'MODALIDAD-INT', 'FALLECIDOS', 'HERIDOS'],
              dtype='object')
```

Fig. 3 Algorithm for obtaining data and date format

3.3.2. Processing of Car Accident Data

The data set in this research has to know how to treat from a specialized data processing tool. Therefore, the Python programming language with the Jupyter platform was used as a data analysis tool. In Fig.3, the algorithm used begins where we can see that in line one, the panda library is declared that will serve to treat the data set, which will be transformed by a "DataFrame" with the aim of using it in a much more agile. Line 2 shows the obtaining of the path of the data set that will be used with the "read.csv" method because our data set is in this format, which is separated by ";" in each of its columns; in this way, we will obtain our first DataFrame. In order to analyze the car accidents that occurred on the road in the year 2020 and 2021, it will have to be delimited by the respective dates in order to be able to delimit the analysis well with respect to each respective month, therefore, as shown in line 3 a format is made to the "DATE" column because this was initially found as a string preventing a respective filter with respect to the dates that are required to do the analysis, then in line 4 we make sure if we continue using the type of data that is a DataFrame for security reasons finally in line 5 the columns that represent the data sets are verified.

3.3.3. Data Cleansing for an Efficient Dataset

When working with a data set, it is always good to carry out an exhaustive analysis of the data to be able to clean the irrelevant information, give certain logical structures and give the desired format. For this reason, it is necessary to apply a rigorous cleaning which will be included between the parameter fields for data training. As shown in Fig.4, data cleaning encompasses 5 great benefits of doing a good cleaning.

Fig. 4 Benefits of Data Cleaning

Data without errors

It is necessary to consider that when data is collected from different sources, there is always the possibility of error. Cleaning the data will help to have these inconveniences. It is necessary to specify that when accurate data is available, more precise analyses can be carried out, making the developed algorithm show a great result with a much smaller margin of error.

Data quality

The quality of the data is very important to take into consideration because by having data with an adequate structure, much deeper logic can be applied. As in the case of analyzing between the range of dates where certain car accidents have occurred, a clear example would be that if the data quality had not been considered correctly, there would have been inaccuracies in the data analysis.

Accurate and Efficient

Being able to conclude that the data is accurate and efficient is a great advantage when having developed the correct cleaning of the data. It begins to be able to be totally sure to pass this data to the prediction model after giving an established analysis of car accidents.

Complete Data

Complete data is the maximum degree that must be achieved because, with this, a diversity of actions could be carried out depending on the needs of the investigation. Having complete, fully structured data is a great benefit after having gone through the data cleaning because it will significantly help to investigate real facts through real experience systematized in data sets.

3.3.4. Decision Tree

Due to the provision of the structured data of this research and the objective of being able to make predictions regarding automobile accidents that have occurred on the road, the famous decision trees will be used, which is a non-parametric supervised learning algorithm that is recurrently used in tasks of classification as regression [6]. In this work, 4 parameterized values will be used, which will be modeled in the decision tree, having as a prediction variable the "Codigo_via" and the department where these car accidents will occur.

3.3.5. Definition of Evaluation Criteria

In this phase, the evaluation criteria are proposed to measure the error. The MAE is recurrently used, which is the mean absolute error [15]; since it is recurrently used in the context of machine learning, this absolute error refers to the reference magnitude of the prediction of an observation and the actual value of that observation. In this case, it will be used with the following mathematical model (1).

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|y_i - \hat{y}_i| \quad (1)$$

4. Result

As a result of this investigation, the analysis and predictions of automobile accidents that occurred on the road were obtained. This section will show the progress achieved and the techniques applied to make these data available for analysis and investigation.

4.1. Car Accident Analysis

In order to arrive at these final results, as explained in the methodology section, a robust cleaning of data has had to be carried out, which consisted of eliminating data that cause noise for a clean analysis, up to the adequate substitution of data for some data that is necessary. According to the significance of the objective analysis. As can be seen in Fig. 5, a large number of car accidents occurred in 2020, where the turquoise color represents the number of accidents and the red color the number of deaths that occurred this year. It can be seen that the city of Lima, being the city with the largest population in Peru, tends to have a greater number of cases, where the second place is seen in the city of Arequipa, thus making a reflexive analysis that it is necessary to look for ways to contemplate being a city of which there are 11 cities in Peru where they represent a large number of accidents with more than 100 injured.

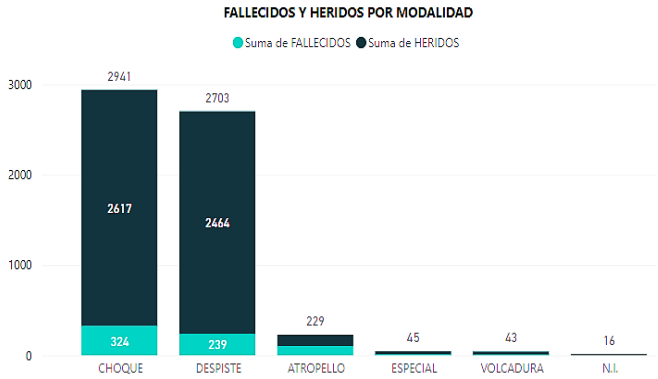

Fig. 6 Number of automobile accidents by type of modality

Regarding from another point of view, the automobile accidents that have occurred on the road, it can be seen as shown in Fig. 6, the number of automobile accidents that have occurred by their modality where it can be seen that there is an exorbitant number of crashes with a total of 2941 accidents and oversights with a total of 2703 accidents in 2020 compared to the number of accidents, special, rollover and unidentified.

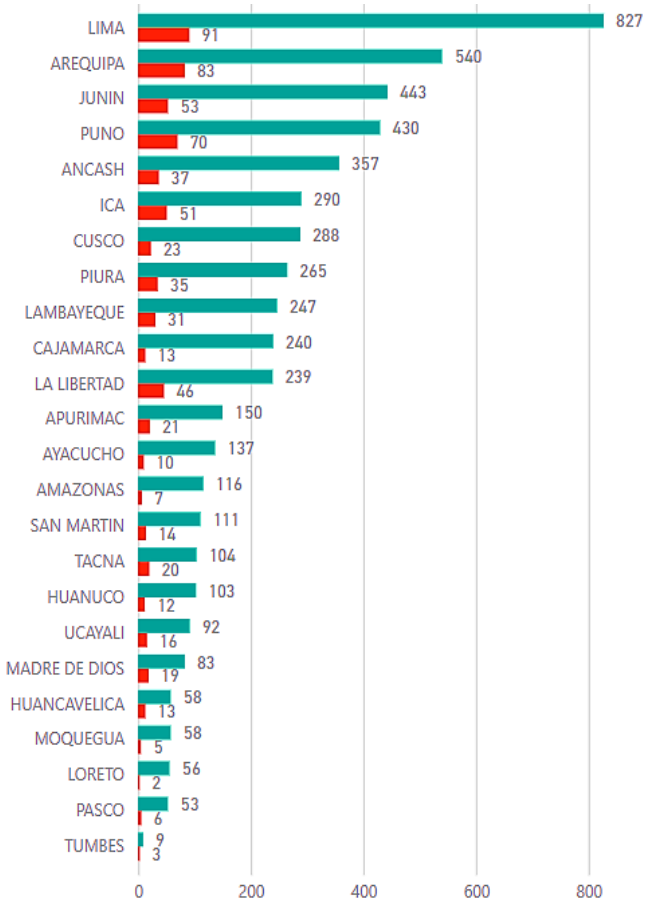

Fig. 5 Number of car accidents on the road in Peru 2020

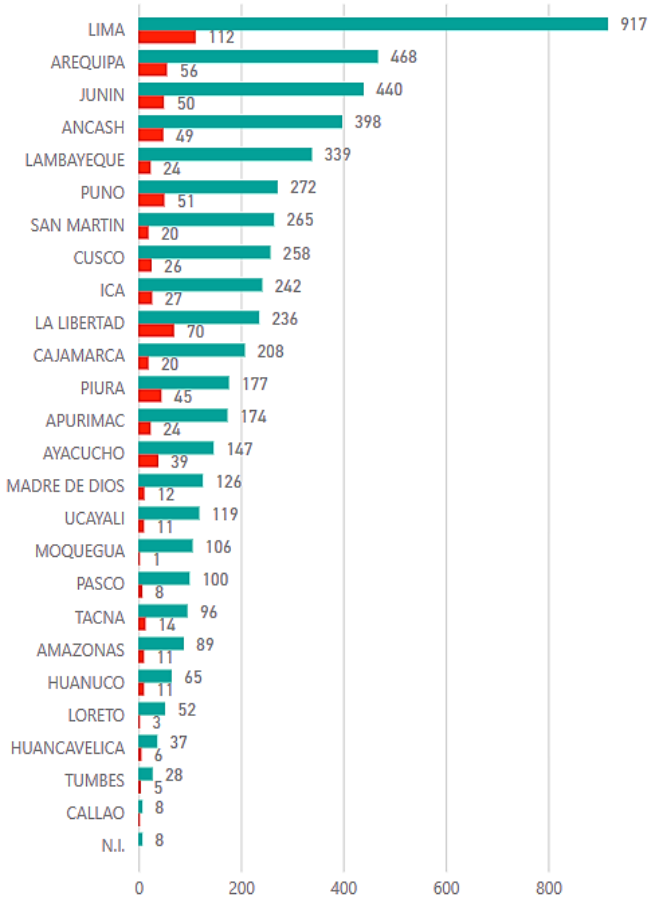

Fig. 7 Number of car accidents on the road in Peru 2021

Through the analyzes carried out on the data, it has also been possible to determine the car accidents that occurred in the year 2021, where it can be seen that there is a greater growth in these car accidents compared to last year. As shown in Fig. 7, it can be seen that in the city of Lima, there were a number of 917 injuries and 112 deaths. In addition to having 16 cities with more than 100 car accident incidents, it is also necessary to indicate that this set is information collected until September 2021, making it known that the accident curve is year after year.

Fig. 8 Georeferenced car accident prediction

4.2. Prediction of Car Accidents

With respect to the prediction of automobile accidents, the following was obtained, as shown in Fig. 8, where it is possible to see georeferenced points where there is a close probability that new incidents of road accidents will occur. This identification could be achieved thanks to putting machine learning into practice using the road code and the number of kilometers of the incident as the objective variable. With these values, it was possible to estimate the geographical points.

5. Discussions

In this investigation, it was concluded that it is necessary to be able to collect more data from fine-tuning the prediction of car accidents. Unfortunately, currently, in Peru, the obtaining of open data is very limited and therefore, the effort of this work has been able to collect the information and be able to shape it to achieve a correct analysis and prediction. This research could be improved if there were a set of data with specific longitude and latitude since correctly identifying the geographical point was a laborious task, taking the highway code and the kilometer as a starting point.

6. Conclusion

We can conclude that the use of Machine Learning to be able to analyze and predict car accidents was an excellent option. With a more refined set of data and certain future experiences that can be achieved, a high-level investigation can be proposed and considered in funds. Contests at the national level. In addition, with respect to this work, it was possible to conclude that it is necessary to take security measures, especially for the 10 cities with the highest probability of accidents, which are Lima, Arequipa, Junín, Ancash, Lambayeque, Puno, San Martin, Cusco, Ica and The freedom due to the fact that through the analysis and prediction of our Machine Learning algorithm, it has been identified that there will be more continuity of events in the coming years.

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