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Using artificial intelligence to know how bike-friendly cities are.

Abstract

In this paper, the city of Amsterdam will be analyzed on bike friendliness of its roads from a user point of view by collecting data (images of the city) from Google Street View. The data will be analyzed using the object detection method and artificial intelligence. The results are locations on maps showing the objects found in the images of the city. Different maps are compared with each other and correlations between the elements found on the images and the road accidents are tried to be found. The conclusion is that traffic signs, traffic lights, and streetlights are good influences for road safety in Amsterdam.

Politecnico di Milano – ABC Department
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1. Introduction

In 2012 an American study showed that the amount of bicycle use all over the world is not the same. The study declared that bicycling is underused for transportation in Australia, Canada, Ireland, the United States, and the United Kingdom. Those countries are constituting an estimated 1% to 3% of trips by bicycle. At the same time, Northern Europe is scoring much better. In countries such as Denmark, Germany, Finland, the Netherlands, or Sweden the estimated trips by bicycle are much higher and go from 10% to 27% of the trips (Teschke et al. 2012). The study also shows that the use of bicycles in cities for transportation has public and health benefits. Not to mention that moving by bike is way better for the environment than moving by car.

With the environmental crisis we are living in 2023, many cities all around the world have invested in sustainable transportation during the past few years (Daraei, Pelechrinis, and Quercia 2021). Biking has become one of the most important subjects for local governments all around the world. Cities invest in biking infrastructure such as bike lanes, bike parking racks, shared (city) bike systems, etc.

The two studies mentioned just before show that in cities the use of bicycles is encouraged and will be encouraged more in the future. Knowing what the safest places to bike in a city are and how comes that those places are safe becomes a more important question.

Different studies explained later in the State of the Art more in detail, focused on the correlation between the route infrastructure of cities and the risk of injuries to bicyclists or/and to the other road users. Those studies focused mainly on road infrastructure, density of the roads, width of roads and bike lanes, etc. This research in contrast aims to find a correlation between bike friendliness on roads and the signs available on the streets.

1.1. Research question

This leads to the next research question and sub-questions. <u>How well are the roads marked/signalized for bicycle use in a city?</u> How many signs are available to help cyclists drive safely through the city of Amsterdam? Is there a correlation between the number of bicycle signs available in a certain zone and the number of bicycle accidents in that location?

By analyzing this topic and finding correlations, different local governments could be informed about the way it is possible to invest in more bike-friendly roads.

Amsterdam was mentioned in the sub-question of this research. The city is chosen because of its world-famous popularity in terms of biking. This same study can be later applied to different other cities (e.g., Milano) to see the differences. The research will be made by using artificial intelligence and image detection. Amsterdam is a good choice, to begin with as the city should contain many road signs which the computer will be able to detect. The method to conduct this research will be explained next.

1.2. Strategy

First, the dataset used for this analysis is images taken from the roads all over the cities. An area will be selected, and the Google Street View images will be collected at all different points in the selected area. Those images will then be analyzed. For the analysis, the image detection method is applied. This is a technique based on artificial intelligence. The technique will try to detect symbols/road-marking in the data of collected images. In the end, it will be possible to map all the symbols/road markings and in such a way see if there is a correlation between the number of symbols/road-marking available in a certain zone and the number of bicycle accidents on that location. In the end, a visualization as shown in Fig. 1. of the number of road signs available on the streets combined with the road crashes in that same region will be obtained.

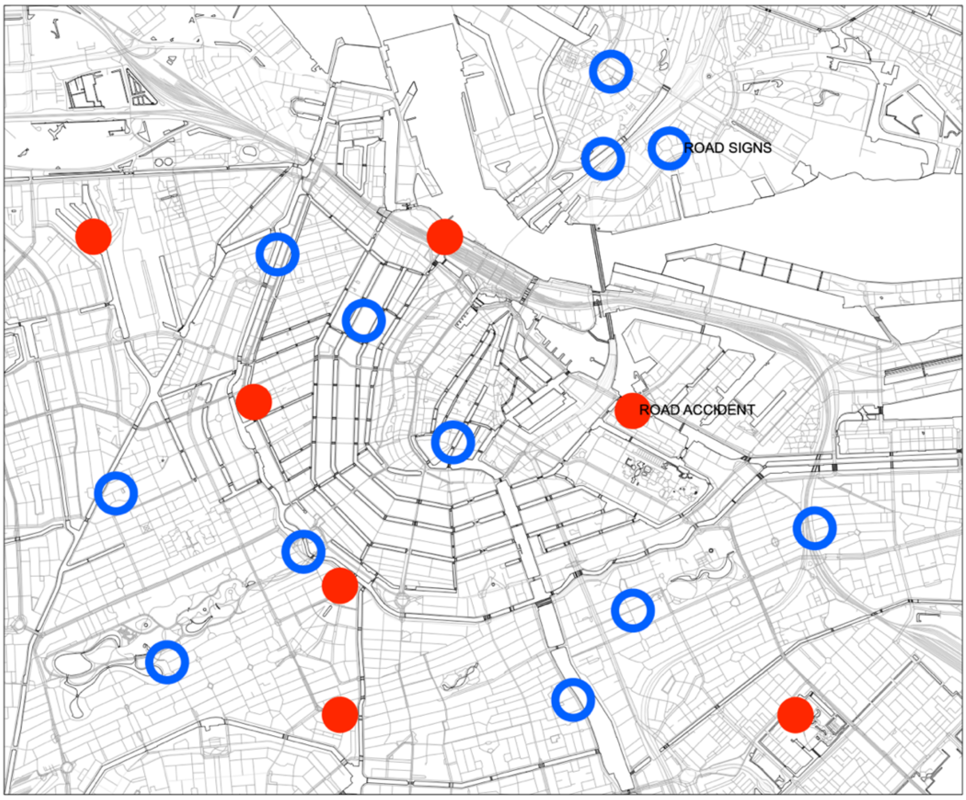

Fig. 1. Example of the mapping of road signs and road accidents in Amsterdam. Source: (CADMAPPER 2023)

2. State of the art

In the next three chapters, examples are shown of studies that examine the road safety of cities by looking mainly at road infrastructure, the density of the roads, the width of roads, speed limit, street topology, bike lanes, etc. It is important to note that in none of those three examples, GSV was used for the analysis of the cities.

2.1. The density of street intersections in cities

A study conducted by Wesley Marshall in 2011 showed that high bicycling cities generally show a much lower risk of fatal crashes for all road users when compared to most of the other cities. The fact that this pattern of low fatality risk is constant for all classes of road users, and not only bicycle users, strongly suggest that the crashes are taking place at lower speeds. The study identified the density of street intersections as the most prominent factor between safer and less safe cities.

For this study over 150 cities of California were analyzed. Twenty-four medium-sized cities out of the 150 were chosen. The first 12 cities had good safety records and the other 12 had basic safety records. The cities were chosen all out of California to assure consistency in the comparison of severe injury outcomes of those cities.

2.2. Route types and infrastructure

The study made by Teschke et al. in 2012 first divided all the possible types of roads into 14 different types and defined them all specifically. Afterward, a comparison between the number of injuries in the different sites is made. The most frequently observed route type for crashes is the major streets with parked cars and no bike infrastructure. Route infrastructure significantly associated with increased injury risk are the next ones: downhill grades, streetcar or train tracks, and construction. All other route types showed lower injury amounts. The route types with the lowest risks of the analysis are major streets without parked cars and with no bike infrastructure, major streets without parked cars and with bike lanes, local streets with no bike infrastructure, local streets designated as bike routes, and cycle tracks. It is important to know that this study did not include cycling during mountain biking but looked especially at cycling used for transportation.

The most important findings of this research are that busy streets are associated with higher risks than quiet streets and that bicycle-specific facilities are associated with lower risks. In general, the study found that sidewalks and multi-use paths have higher risks than bike-only paths and cycle tracks. The safest route types were the following ones: cycle tracks, local streets, bike-only paths, and major streets with bike lanes and no parked cars. These route types have a big potential as they have both lower injury rates and increase cycling. This increase in cycling is a positive aspect because increased ridership has been associated with increased safety.

2.3. Detection of possible road accidents through road features

The research is conducted in 2021 by Daraei, Pelechrinis, and Quercia. First of all, it is important to mention that also these three researchers agree on the fact that bringing more bikes onto the city roads and making the city more bike-friendly, increases the safety for all road users. Further, the research is about creating a method to detect possible road accidents by looking at the road features. The used features in this data-driven research come from

OpenStreetMap and are both geographical and infrastructural. The following features were observed: bike lanes, speed limit, street topology (straight/curved), and distance from an intersection.

The research was done on three different cities and then compared with each other. The three cities are in this case London, Boston, and Pittsburgh. For all those three cities data on road accidents with bikes were collected as also the street features of each location in which those incidents occurred. The features of the street at the place of the accidents were analyzed and a model was created to detect those features and be able to detect where a road accident can occur. The model was tested on the other two cities and the results showed that those models are transferable. This research mapped different zones of the cities which were dangerous for bike users. Using this tool (interactive map), governments can easily take a look at those dangerous locations and understand what is the problem and what is the best solution.

3. Materials and Methods

The AI program is pre-trained in the detection of objects. This means the program will be able to detect objects on the sides of the streets as well as on the asphalt. If the objects are not visible in the GSV pictures, it means that neither the bike that will be driving on that road will be able to see that sign. In conclusion, there is no problem concerning the cars on the roads.

A street-view image from the city is chosen to explain better the concept. The detection of bike signalization on the roads is now made by a person. If a human can make the detection, the AI program will also succeed *(generally).* In Fig. 2. is visible the image is visible from Google Street View. The human eye will then recognize the road signalization for bikes as visible in Fig. 3.

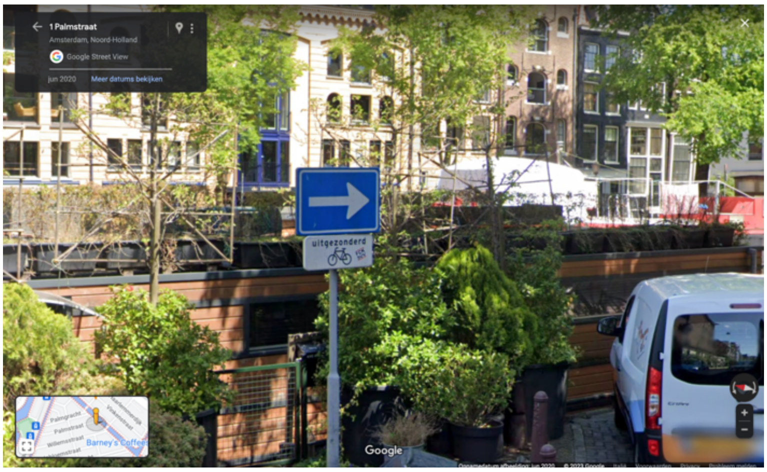

Fig. 2. Street image in Amsterdam. Source: (GSV 2023)

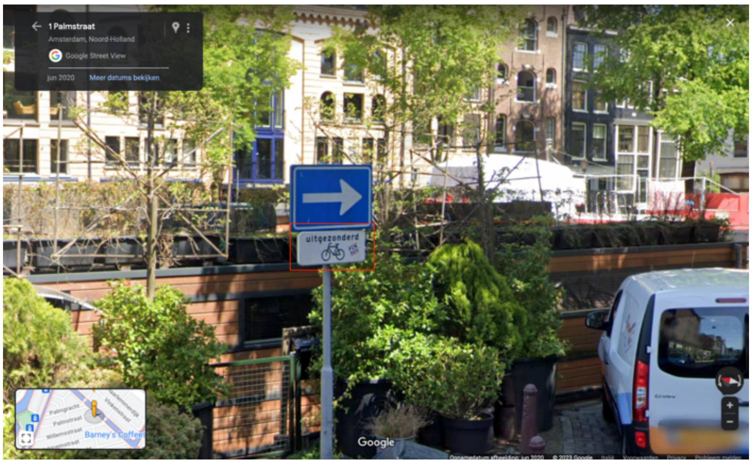

Fig. 3. Human object detection on a street image of Amsterdam. Source: (GSV 2023)

The biggest part of the used Python codes was provided by the instructors of Politecnico di Milano. For this research, the use of a pre-trained set of data was used from open images dataset V4. To show how the code works, an image Fig. 4. is taken as an example. In Fig. 5. Is now visible how the code recognizes elements in the images and gives a certain detection score on every object that is detected.

Fig. 4. Second street image in Amsterdam. Source: (GSV 2023)

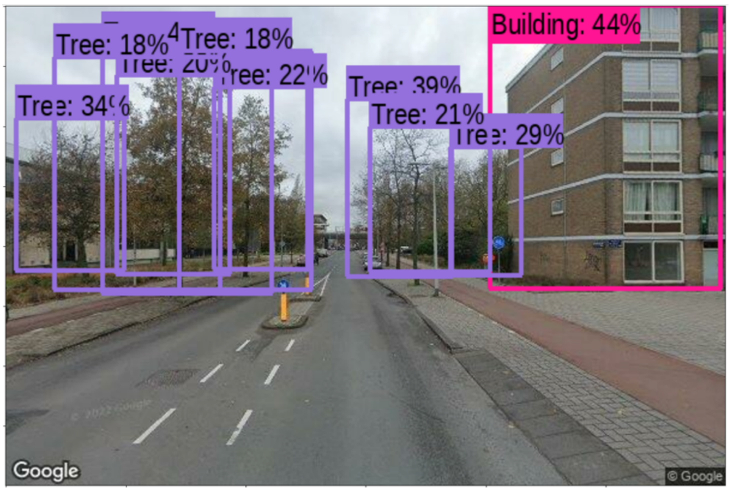

Fig. 5. Object detection on a second street image of Amsterdam by code. Source: (GSV 2023)

The code will take on every 50m in Amsterdam four images at four different angles: 0°, 90°, 180° and 270°. This means the images will display the whole 360° environment of Amsterdam every 50m. The points in which the images are taken are visible in Fig. 6. All those images will pass through the code of object detection which will recognize objects in the images and will give a certain detection score. In the following chapters, only the objects with a detection score higher than 10% will be mapped.

Fig. 6. Street network with places of collected images in Amsterdam. Source: (GSV 2023)

4. Results and Discussion

In this chapter, different maps will be shown of Amsterdam. The aim is to find a correlation between the objects detected in the images and the number of road accidents in Amsterdam. The code mapped only objects with a detection score of more than 10%. First, a map of road accidents in Amsterdam is provided. In Fig. 7. 130 points are visible. Those points are road accidents mapped in Amsterdam. With the use of a density analysis made by Kernel Density, the density of the road accidents in Amsterdam is made visible.

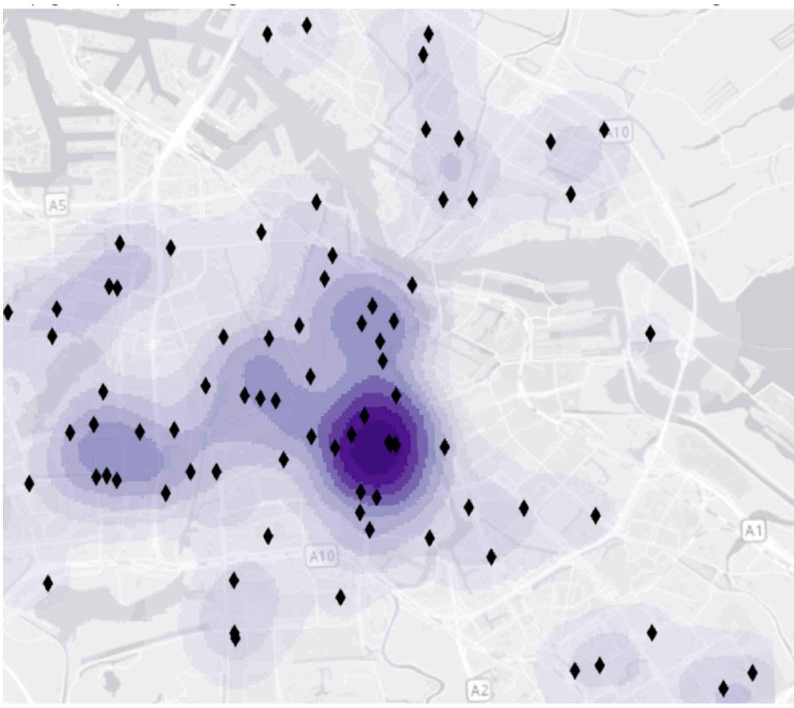

Fig. 7. Road accidents mapped in Amsterdam. Source: (Esri 2018)

4.1. Traffic signs

The objects detected in the images taken from the GSV of Amsterdam are the traffic signs. In Fig. 8. the points where traffic signs were detected together with the road accidents are displayed on the same map. The map shows that at the level of the highest density of road accidents, the traffic signs in Amsterdam are also less present.

Fig. 8. Road accidents and traffic signs (red) mapped in Amsterdam. Source: (Esri 2018)

4.2. Traffic light

The objects detected in the images taken from the GSV of Amsterdam are the traffic lights. In Fig. 9. the points where traffic lights were detected together with the road accidents are displayed on the same map. The code is indeed detecting fewer points than in the previous chapter about traffic signs. The reason therefore will be discussed in paragraph 6. When trying to look at those results it is visible (just as for the traffic signs) that the place whit the highest density of road accidents contains less detected traffic lights.

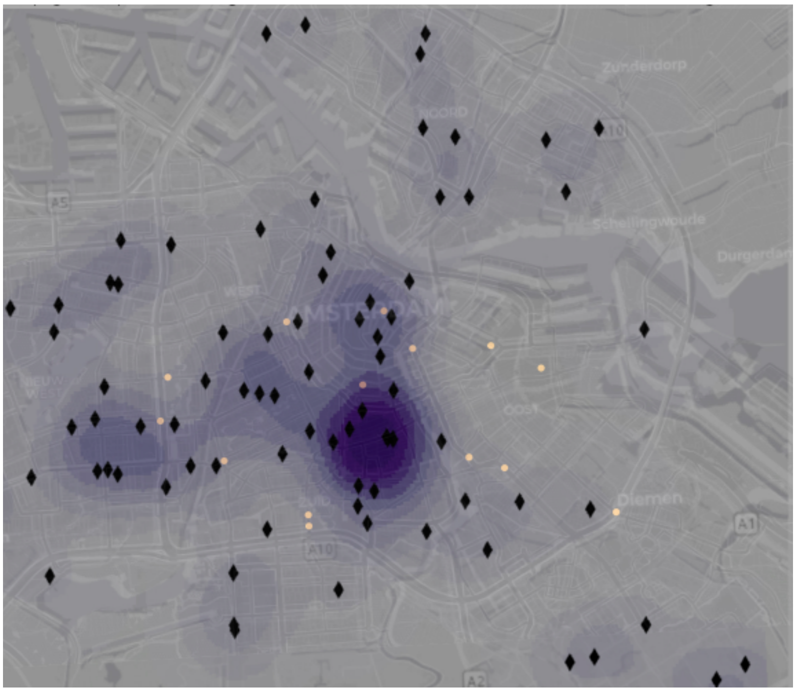

Fig. 9. Road accidents and traffic lights (orange) mapped in Amsterdam. Source: (Esri 2018)

4.3. Streetlight

The objects detected in the images taken from the GSV of Amsterdam are streetlights. In Fig. 10. the points where streetlights were detected together with the road accidents are displayed on the same map. The streetlights were chosen to be detected because those accidents can also happen at night. The idea was that if there is more lighting on the streets, everything will become clearer for all road users. On the right side of the zone with the highest density in terms of road accidents as well as on the southern part of the ring of Amsterdam, the code detects a lot of street lighting. Those areas contain fewer accidents than the rest.

Fig. 10. Road accidents and streetlights (gray) mapped in Amsterdam. Source: (Esri 2018)

4.4. Person

The objects detected in the images taken from the GSV of Amsterdam are persons. In Fig. 11. the points where persons were detected together with the road accidents are displayed on the same map. A map with the persons detected in Amsterdam was made with the initial idea that the areas with the most detected pedestrians will be safer zones and contain fewer road accidents. This case cannot be proven by the results on the map.

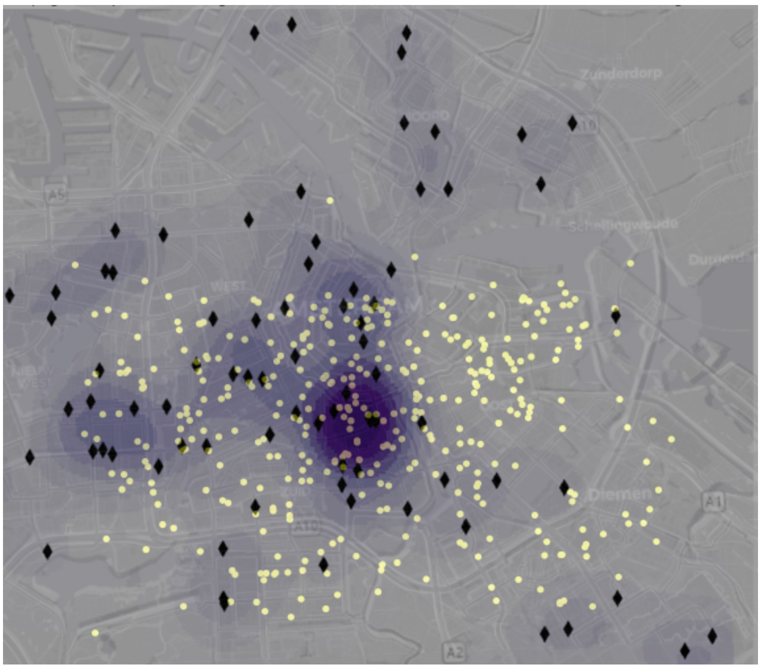

Fig. 11. Road accidents and persons (yellow) mapped in Amsterdam. Source: (Esri 2018)

4.5. Bicycle

The objects detected in the images taken from the GSV of Amsterdam are bicycles. In Fig. 12. the points where bicycles were detected together with the road accidents are displayed on the same map. The initial idea for detecting bicycles is the same as for the detection of pedestrians. The zones with more bikes were supposed to be more vigilant on the roads and contain fewer accidents. Out of the results on the map, nothing can be concluded.

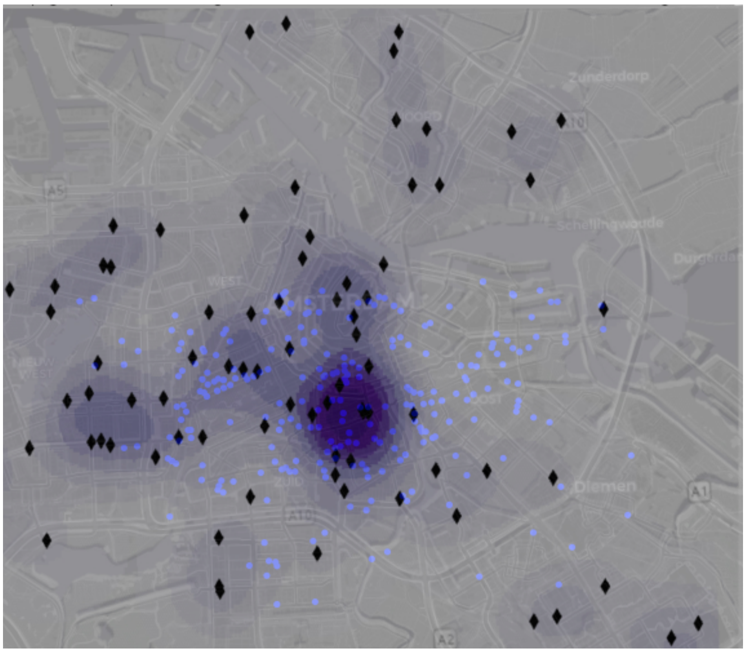

Fig. 12. Road accidents and bicycles (blue) mapped in Amsterdam. Source: (Esri 2018)

4.6. Car

The objects detected in the images taken from the GSV of Amsterdam are the cars. In Fig. 13. the points where cars were detected together with the road accidents are displayed on the same map. The initial idea of detecting cars in the streets of the city was that the areas with more cars will also be those areas with a higher density of road accidents. In this case, no correlation can be found on the map.

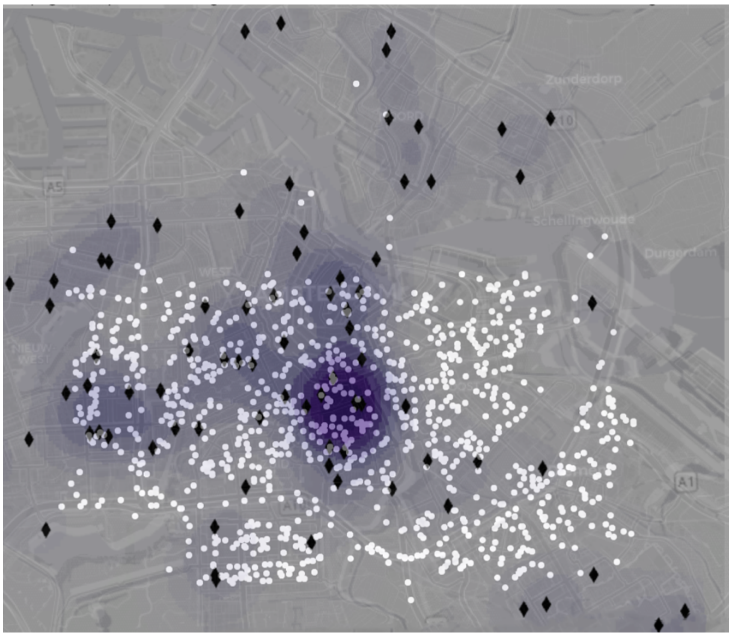

Fig. 13. Road accidents and cars (white) mapped in Amsterdam. Source: (Esri 2018)

5. Conclusion

The object detection method used for this research is a new and accurate method to analyze cities because everything visible in the images taken from the streets of the cities is real evidence of the objects available in the city. This method was able most of the time to find a correlation between road accidents and the detected objects on the streets. The conclusion is that the presence of the following objects makes road safety better: traffic signs, traffic lights, and streetlights. The detection of persons, cars, and bicycles didn't show any correlation with road accidents.

6. Comments

The time provided for doing this analysis was of one academic semester. In further steps, it would be interesting to train an object detection model specifically on the detection of road signalization for bikes. In that case, the research can be more precise. A personalized trained set of data will give more accurate results than the pre-trained ones. In that case, a new correlation can be analyzed between road signalization for bikes and road safety/injuries.

Another important point that can be done better in the next research can be the number of pictures taken in the city. For this research, images of Amsterdam were taken every 50m because of the high amount of data and the big surface that had to be analyzed. A better method for taking a smaller distance between the token images is to not anymore take the whole city but to analyze it in different smaller parts.

The correlations that were made in paragraph 4. are not so accurate. Those correlations were made by the eye and mind of the author and are not scientifically proven. A working point for the next research is to find a proper system that can detect scientific/objective correlations between the different points on the maps.

7. References

7.1. Reference 1

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Marshall, Wesley E., and Norman W. Garrick. 2011. "RESEARCH ARTICLE: Evidence on Why Bike-Friendly Cities Are Safer for All Road Users." *Environmental Practice* 13 (1):16-27. doi 10.1017/S1466046610000566.

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Teschke, Kay, M. Anne Harris, Conor C. O Reynolds, Meghan Winters, Shelina Babul, Mary Chipman, Michael D. Cusimano, Jeff R. Brubacher, Garth Hunte, Steven M. Friedman, Melody Monro, Hui Shen, Lee Vernich, and Peter A. Cripton. 2012. "Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study." *American Journal of Public Health* 102 (12):2336-2343. doi: 10.2105/AJPH.2012.300762.

7.4. Reference 4

Analyse op de Verkeersongevallen dataset. (2018, October 12). Esri Community. https://community.esri.com/t5/arcgis-content-esri-nederland-blog/analyse-op-de-verkeersongevallen-dataset/ba-p/886506