Exploring the car accidents involving pedestrians

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1. Introduction

1.1. Background

- Pedestrians are the most vulnerable road users. They have a little chance in a collision with a car, because they have no protection between themselves and the vehicle striking them.
- According to WHO, each year more than 270 000 pedestrians are killed in car accidents around the world.[1] People just go to work, school or shopping and never come back. A lot more pedestrians are injured and some of them are forced to live with a permanent disabilities.
- The root causes of accidents with pedestrians are known and well documented, however analysis of accidents in a close neighborhood can give a policymakers, politician and educators more arguments to make more insightful decisions or educational actions.
- Detailed and more precise data can be used to make a small changes, like improving the street lights on a given crosswalk or convince more people to stay sober while driving.

1.2. Problem

- A local data can reveal which places in the city are the most dangerous for pedestrians and which factors are the most important in preventing the most tragic accidents.

1.3. Interest

- A local policymakers would be very interested in prediction of places and factors related to accidents. Also teachers and other educators might use this insight to stress the importance of sobriety and obedience with the road rules.

2. Data

2.1. Data source

- Data and metadata were downloaded from the Seattle Geo Data portal (link). Data include all types of collisions from 2004 to present.

2.2. Data construction

- Data are provided by Seattle Police Department and recorded weekly by Traffic Records. The data contains 39 attributes (described in Tab. 1.) and 221 389 entries.

Tab. 1. Data attribute information.

Attribute	Description
X,Y	Geographic location.
OBJECTID	ESRI unique identifier.
INCKEY	A unique key for the incident.
COLDETKEY	Secondary key for the incident.
REPORTNO	Report number.
STATUS	N/A
ADDRTYPE	Collision address type: Alley, Block, Intersection.

[1] Pedestrian safety: a road safety manual for decision-makers and practitioners, WHO 2013.

INTKEY	Key that corresponds to the intersection associated with a collision.
LOCATION	Description of the general location of the collision.
EXCEPTRSNCODE	N/A
EXCEPTRSNDESC	N/A
SEVERITYCODE	A code that corresponds to the severity of the collision: 3 - fatality, 2b - serious injury, 2 - injury, 1 - property damage, 0 - unknown.
SEVERITYDESC	A detailed description of the severity of the collision.
COLLISIONTYPE	Collision type.
PERSONCOUNT	The total number of people involved in the collision.
PEDCOUNT	The number of pedestrians involved in the collision. This is entered by the state.
PEDCYLCOUNT	The number of bicycles involved in the collision. This is entered by the state.
VEHCOUNT	The number of vehicles involved in the collision. This is entered by the state.
INJURIES	The number of total injuries in the collision. This is entered by the state.
SERIOUSINJURIES	The number of serious injuries in the collision. This is entered by the state.
FATALITIES	The number of fatalities in the collision. This is entered by the state.
INCDATE	The date of the incident.
INCDTTM	The date and time of the incident.
JUNCTIONTYPE	Category of junction at which collision took place.
SDOT_COLCODE	A code given to the collision by SDOT.
SDOT_COLDESC	A description of the collision corresponding to the collision code.
INATTENTIONIND	Whether or not collision was due to inattention. (Y/N)
UNDERINFL	Whether or not a driver involved was under the influence of drugs or alcohol.
WEATHER	A description of the weather conditions during the time of the collision.
ROADCOND	The condition of the road during the collision.
LIGHTCOND	The light conditions during the collision.
PEDROWNOTGRNT	Whether or not the pedestrian right of way was not granted. (Y/N)
SDOTCOLNUM	A number given to the collision by SDOT.
SPEEDING	Whether or not speeding was a factor in the collision. (Y/N)
ST_COLCODE	A code provided by the state that describes the collision.
ST_COLDESC	A description that corresponds to the state's coding designation.
SEGLANEKEY	A key for the lane segment in which the collision occurred.
CROSSWALKKEY	A key for the crosswalk at which the collision occurred.
HITPARKEDCAR	Whether or not the collision involved hitting a parked car. (Y/N)

2.3. Data selection and initial cleaning

- The unnecessary columns were removed. For the next stages the following columns were selected: X, Y, ADDRTYPE, LOCATION, SEVERITYCODE, COLLISIONTYPE, FATALITIES, INCDATE, INATTENTIONIND, UNDERINFL, WEATHER, ROADCOND, LIGHTCOND, PEDROWNOTGRANTED, SPEEDING.
- Entries with attribute "PEDESTRIAN" were selected in order to obtain a dataset regarding only the collisions with pedestrians.
- After choosing the "PEDESTRIAN" attribute, the COLLISIONTYPE column wasn't needed anymore, so it was removed.
- New dataset has 12 columns and 7665 rows.
- There were a couple of problems with data:
    - In column INATTENTIONID there were only two types of entry: Y and NaN. I have assumed that NaN stands for no or unknown. I have replaced Y with 1 and NaN with 0. Similar situation was with columns PEDROWNOTGRNT and SPEEDING.

- In column UNDERINFL there were four types of entry: Y, N, 0 and 1. I have assumed that 0 stands for No and 1 stands for Y Data were standardized to 0 and 1.
- Column INCDATE was contaminated by time string containing only zeroes: ”00:00:00+00”. Unnecessary string was removed.

2.4. Data application

Obtained dataset will be used to point which places in Seattle city are the most dangerous for pedestrians and which factors are the most important regarding the severity of pedestrian’s injuries. Data will be used to prepare appropriate statistical analysis and decision tree machine learning algorithm.

3. Methodology

3.1. Basic analysis

- Using function pd.to_datetime(), the date format was changed to YYYY-MM-DD. It was necessary for function dt.day_name() which enables to obtain names of the days related with the given date. Result was written in a new column named “Day of week”.
- In order to prepare more readable plots, column names were changed to a more convenient ones: 'ADDRTYPE' : 'Area', 'LOCATION' : 'Address', 'INCDATE' : 'Date', 'INATTENTIONIND' : 'Inattention', 'SEVERITYCODE' : 'Severity Code', 'FATALITIES' : 'Fatalities', 'UNDERINFL' : 'Under Influence', 'WEATHER' : 'Weather', 'ROADCOND' : 'Road Conditions', 'LIGHTCOND' : 'Light Conditions', 'SPEEDING' : 'Speeding', 'PEDROWNOTGRNT' : 'Pedestrian Rights Violation', 'day_of_week' : 'Day of week'.
- Because it was impossible to change previously obtained from NaN data “0” in INATTENTIONID, PEDROWNOTGRNT and SPEEDING columns, it was necessary to change NaN entries directly to “No” strings.
- Histograms were plotted using df.plot(kind=’hist’) function and described using pyplot scripting layer. Size of the figure was set to (10,6), color was set to “coral”.
- Bar charts were plotted using df.plot(kind=’bar’) function and described using pyplot scripting layer. Size of the figure was default, color was set to “mediumseagreen”.
- In order to obtain the map of places with the highest numbers of accidents with pedestrians, a new dataframe was needed. Using the df.value_counts() function, a series containing places with the highest accident count was obtained. Then it was necessary to combine it with the geographical location from the original dataframe. It was done using functions df.groupby([column1,column2,column3]).size(). New dataframe was sorted (by number of accidents) and cut in order to obtain places where more than 15 accidents were registered. To obtain a proper dataframe, index was reseted and a new column with accident count was renamed to “Count”. In order to meet the criteria of folium map creator, in “Count” column a string: “No of accidents:” was added and the data type was casted to string.
- A part of new dataframe is depicted on Fig. 1.

	X	Y	Address	Count
0	-122.302777	47.606176	23RD_AVE_AND_E_JEFFERSON_ST	No of accidents: 16
1	-122.337592	47.611207	4TH_AVE_AND_PINE_ST	No of accidents: 16
2	-122.277664	47.551176	RAINIER_AVE_S_AND_S_ORCAS_ST	No of accidents: 16
3	-122.320799	47.615235	BROADWAY_AND_E_PINE_ST	No of accidents: 17
4	-122.316579	47.661292	11TH_AVE_NE_AND_NE_45TH_ST	No of accidents: 17

Fig. 1. A part of dataframe created to obtain a map of places with the highest accident count.

- In the case of data analysis regarding the accidents with the fatal outcome, data wrangling was similar.

3.2. Decision tree

- To prepare a decision tree the following features have been selected: UNDERINFL (under influence), WEATHER, ROADCOND (road conditions), LIGHTCOND (light conditions), PEDROWNOTGRNT (whether or not the pedestrian right of way was not granted).
- A target value for the decision tree was SEVERITYCODE.
- All entries (rows) containing "Unknown" value were removed.
- Entries in columns UNDERINFL and PEDROWNOTGRNT were set to "0" (No) and "1" (Yes).
- All remaining rows with NaN entries were removed.
- A single entry with "0" value in SEVERITYCODE column was removed.
- In order to clean a categories in WEATHER and ROADCOND, less frequent entries were replaced by category "Other". In LIGHTCOND column names of some categories were simplified. Details are presented in Tab. 2.

Tab. 2. Replacement of category names.

Column name	Was	No of entries	Replaced by
WEATHER	Fog/Smog/Smoke	19	Other
	Sleet/Hail/Freezing Rain	6	Other
	Blowing Sand/Dirt	1	Other
	Severe Crosswind	1	Other
ROADCOND	Sand/Mud/Dirt	2	Other
	Standing Water	2	Other
LIGHTCOND	Dark - Street Lights On	2487	Street Lights
	Dark - No Street Lights	62	Dark
	Dark - Street Lights Off	57	Dark
	Dark - Unknown Lighting	3	Dark

- Because the number of cases described as "Other" was relatively small and it didn't give any significant information, rows having this attribute were removed.
- Because of the big differences between number of fatal accidents (127) and accidents with a minor injury (5741), the fatal accidents and serious injury (825) were joined in one category as those are both the serious adverse events we want to avoid. Details are presented in Tab. 3.
- In order to prepare data to decision tree requirements, features (X) and target value (y) were encoded using numerical dummy values. Details are summarized in Tab. 3.

Tab. 3. Dummy codes

Category	Descriptive value	Dummy value
SEVERITYCODE	fatality – 3 serious injury – 2b	2
	injury - 2	1
	property damage - 1	0
UNDERINFL	Yes	1
	No	0
PEDROWNOTGRNT	Yes	1
	No	0
WEATHER	Clear	0
	Overcast	1
	Raining	2
	Snowing	3
ROADCOND	Dry	0
	Wet	1
	Snow/Slush	2
	Ice	3
LIGHTCOND	Daylight	0
	Street Lights	1
	Dusk	2
	Dawn	3
	Dark	4

- As it was mentioned before, analyzed data is unbalanced in terms of difference between number of serious accidents with fatal outcome and accidents with a minor injury. In order to observe the effect of this issue a three decision trees were constructed:
    - unbalanced (all data were taken into account, only the fatal accidents and accidents with a serious injuries were joined),
    - balanced 1:1 - the number of accidents with a minor injuries were equaled with other types of accidents (fatal, serious injury and property damage - 1582),
    - balanced 1:2 – the number of accidents with a minor injuries were taken twice more than other (3164).
- Samples of minor injury accidents were taken randomly using df.sample() function.
- Accuracy was calculated using metrics.accuracy_score() function.
- Decision trees parameters:
    - Testing dataset size = 30%
    - Random state = 3
    - Maximum tree depth = 4.

4. Results and Discussion

4.1. Basic analysis

- In the Seattle (USA) city, in the period 2004-2020 a 221524 car accidents were registered, from which a 7664 accidents were the accidents involving pedestrians.
- The most frequent outcome of accidents with pedestrians were a non-serious injuries (6006), the second group was serious injuries (853) and third were the accidents involving only a property damage (677). The smallest group were the fatal accident – 129 cases. The summary is presented in Fig. 2.

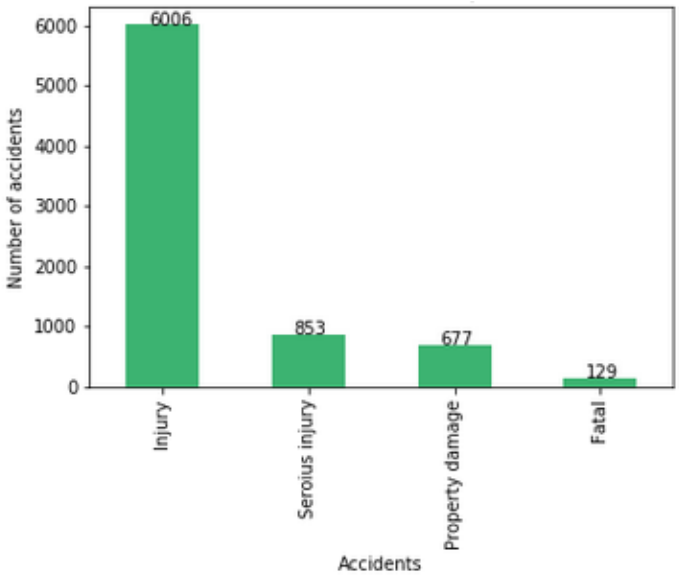


Fig. 2. Outcomes of accidents with pedestrians.

- Intersection is the place where most accidents with pedestrians were observed (5340), next type of area is block (2240). The most safe for pedestrians type of places are alleys, because during the last 15 years only 40 accidents with pedestrians were recorded in this type of area. In the case of fatal accidents only, also the most dangerous places were intersections (85) and blocks (44). No fatal accident was registered in the alleys. The summary is presented in Fig. 3.

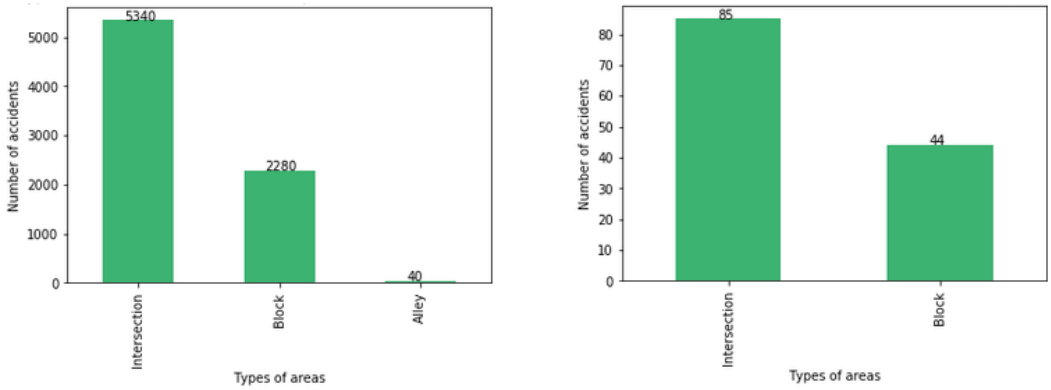
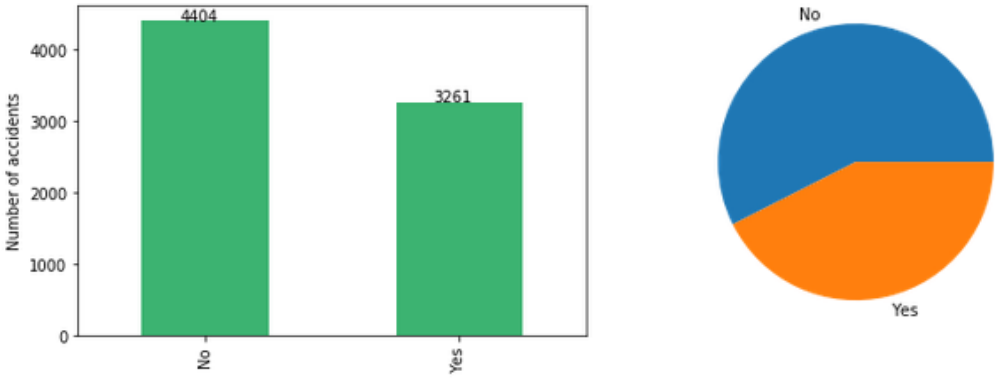


Fig. 3. Types of areas where accidents with pedestrians were most frequent. Comparison with the fatal accidents.

- In the case of 3261 accidents one of the reasons of accident was the violation of pedestrian's rights (42.5%), in the other situations (4404 accidents, 57.5%) the pedestrian's right violation wasn't recorded. In the case of fatal accident less (46/129, 35.7%) accidents were caused by pedestrian's right violation (vs 83 fatal accidents not caused by pedestrians right violation). Summary of data is presented in Fig. 4.

Accidents with pedestrians where one of the reasons was the pedestrian's rights violation.



Fatal accidents with pedestrians where one of the reasons was the pedestrian's rights violation.

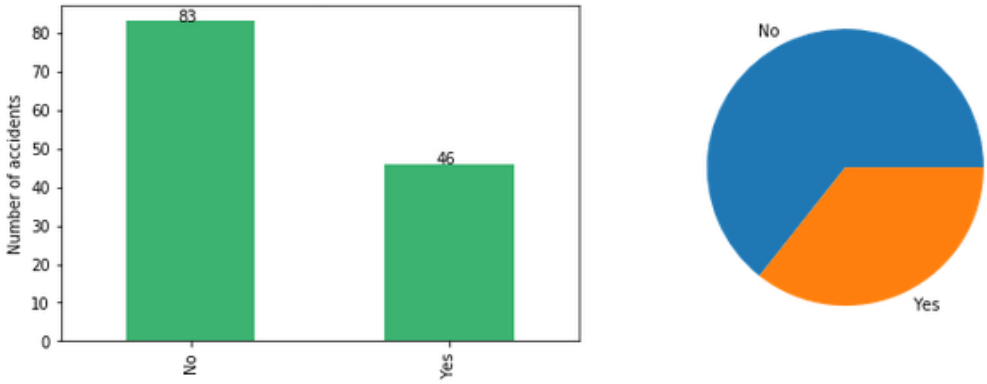
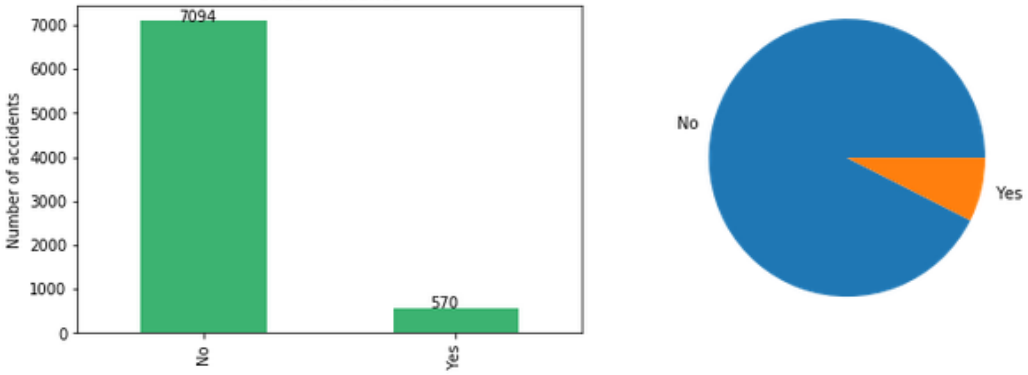


Fig. 4. Comparison of the percentage of accidents in which one of the reasons was the pedestrian's rights violation.

- In the case of 570 (7.4%) accidents the driver was under influence of alcohol or drugs. In the other situations (7094 accidents, 92.6%) the driver was sober. However, it is important to stress, that 21,7% (28) of fatal accidents were caused by driver that was under influence. Summary of data is presented in Fig. 5.

Accidents with pedestrians where one of the reasons was the driver under influence of drugs or alcohol.



Fatal accidents with pedestrians where one of the reasons was the driver under influence of drugs or alcohol.

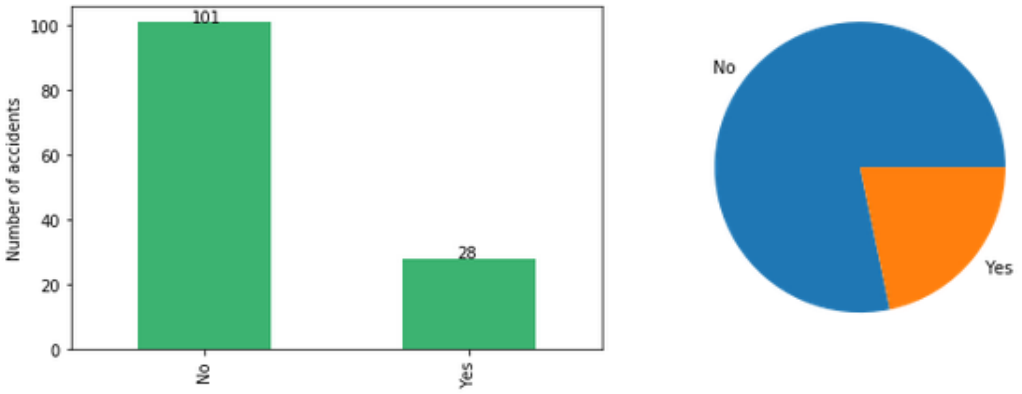
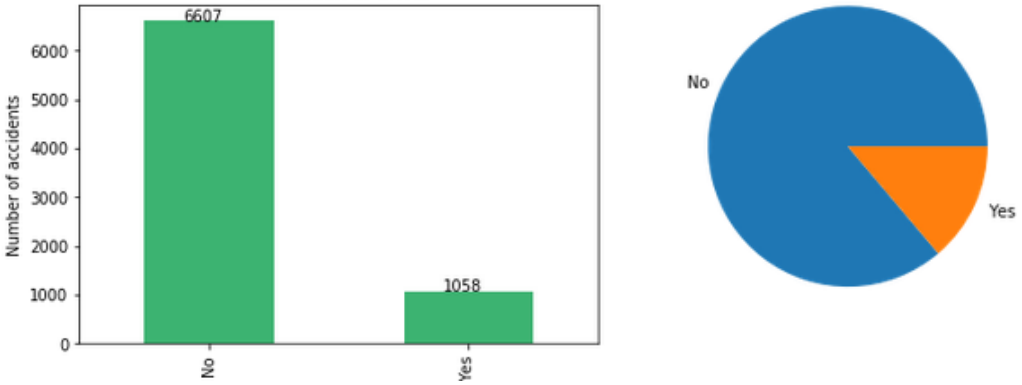


Fig. 5. Comparison of the percentage of accidents in which one of the reasons was that the driver was under influence of drugs or alcohol.

- In the case of 1058 accidents one of the reasons was the driver's inattention (13.8%), in the other situations (6607 accidents, 86.2%) the inattention wasn't recorded. Even more evident situation can be observed in the case of fatal accidents: only 7,7% (10) of fatal accidents were caused by driver's inattention. Summary of data is presented in Fig. 6.

Accidents with pedestrians where one of the reasons was the driver's inattention



Fatal accidents with pedestrians where one of the reasons was the driver's inattention

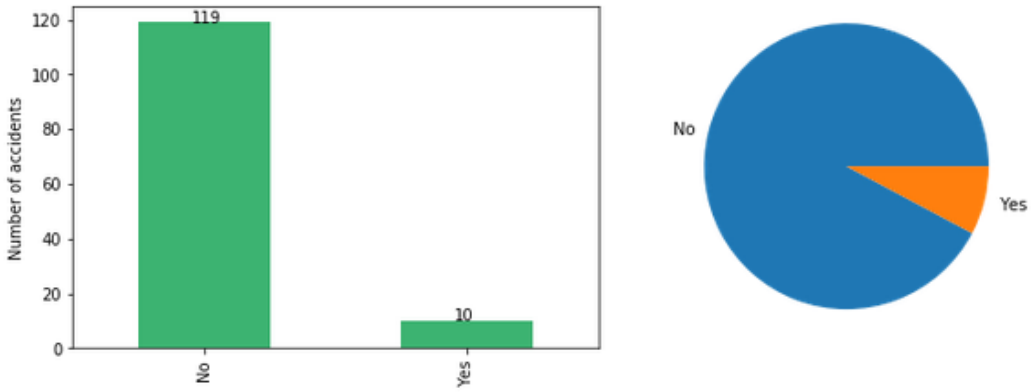
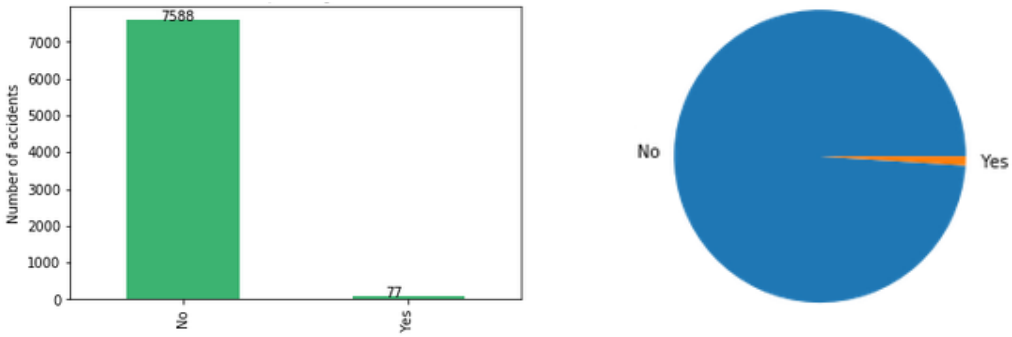


Fig. 6. Comparison of the percentage of accidents in which one of the reasons was the driver's inattention.

- Only in the case of 77 accidents one of the reasons was speeding (1.0%), in the other situations (7588 accidents, 99.0%) speeding wasn't recorded. Also relatively little (3,9%) fatal accidents were caused by speeding. The summary of data is presented in Fig. 7.

Accidents with pedestrians where speeding was one of the accident factors.



Fatal accidents with pedestrians where speeding was one of the accident factors.

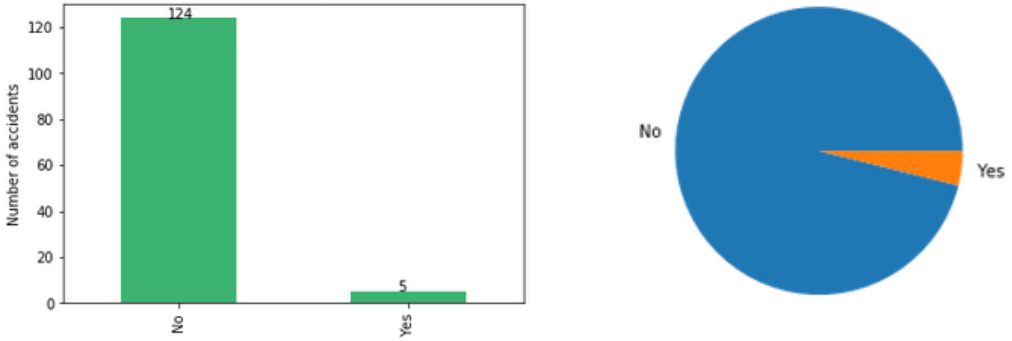


Fig. 7. Comparison of the percentage of accidents in which one of the reasons was speeding.

- Most of the accidents with pedestrians were in good weather – 4446 when the sky was clear and 1105 when it was only overcast. Bad weather was having its part in 2113 accidents, of which in 1832 cases were raining and in 25 cases were snowing. The summary of data is presented in Fig. 8.

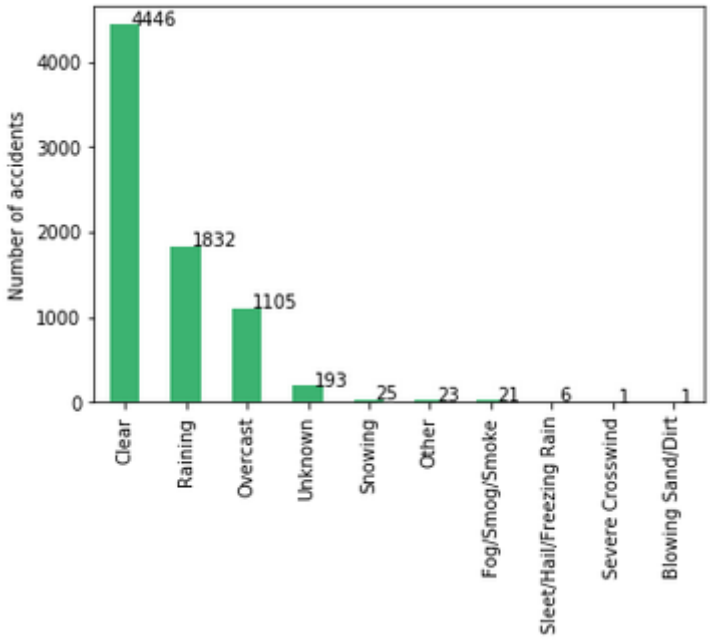


Fig. 8. Weather conditions during accidents with pedestrians.

- Also in the case of fatal accidents most of the accidents were in good weather – 85 when the sky was clear and 16 when it was only overcast. Bad weather was having its part in 28 fatal accidents, of which in 26 cases were raining and in 1 case a severe crosswind was recorded. In 1 case the weather conditions are unknown. The summary of data is presented in Fig. 9.

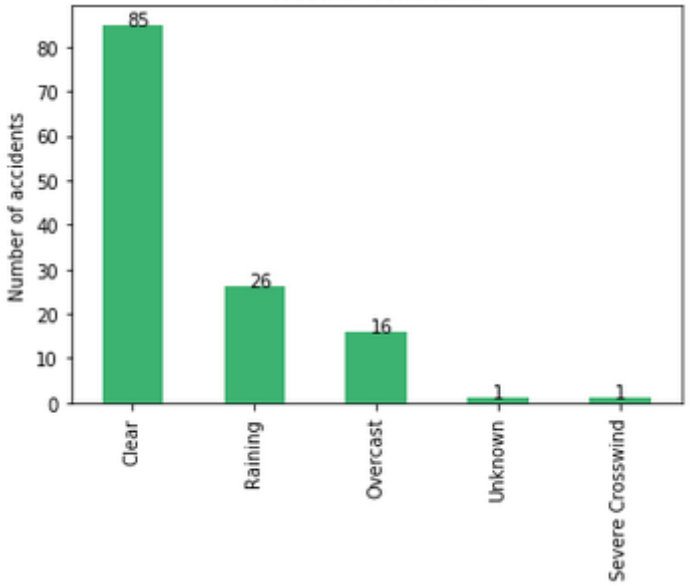


Fig. 9. Weather conditions during fatal accidents with pedestrians.

- Most of the accidents with pedestrians were on the dry roads (5022). In the case of 2389 accidents the road was wet. Other circumstances are: snow/slush (28), ice (16), standing water (2), sand/mud/dirt (2). In 197 cases the road conditions wasn't recorded. The summary of data is presented in Fig. 10.

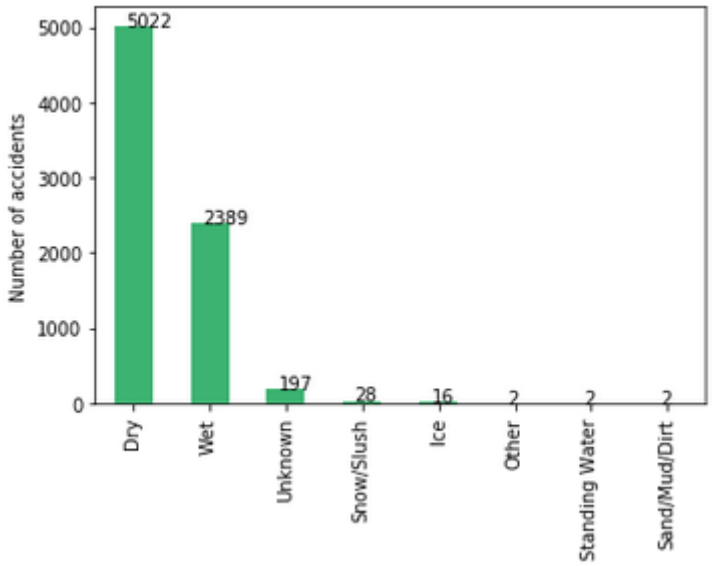


Fig. 10. Road conditions during accidents with pedestrians.

- 78.3% (101) of fatal accidents with pedestrians were on dry road. Other 21.7% (28) of fatal accidents were recorded we the road was wet. No more types of road conditions were recorded in the case of fatal accidents. The summary of data is presented in Fig. 11.

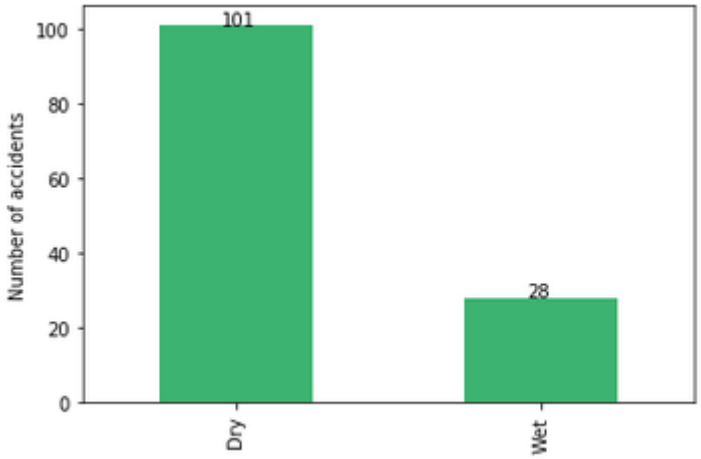


Fig. 11. Road conditions during fatal accidents with pedestrians.

- Most of the accidents with pedestrians were in good light conditions: 4430 during day and 2534 when the street lights were on. In the case of 428 accidents it was dusk (266) or dawn (162). 127 accidents were in darkness (street light were off, or there was no street lights). Also in 127 cases the light conditions wasn't recorded. The summary of data is presented in Fig. 12.

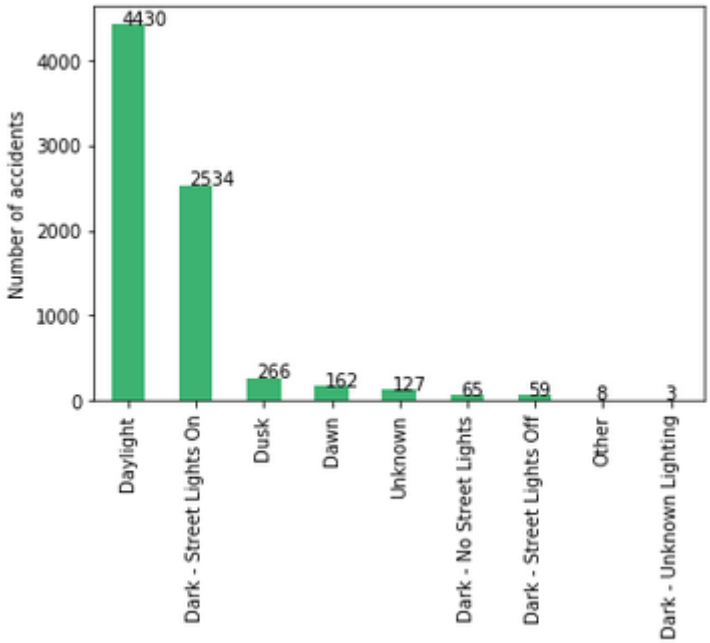


Fig. 12. Light conditions during accidents with pedestrians.

- Also in the case of fatal accidents most cases were in good light conditions: 65 during day and 53 when the street lights were on. In the case of 9 accidents it was dusk (6) or dawn (3). 2 accidents were in darkness (street light were off, or there was no street lights). The summary of data is presented in Fig. 13.

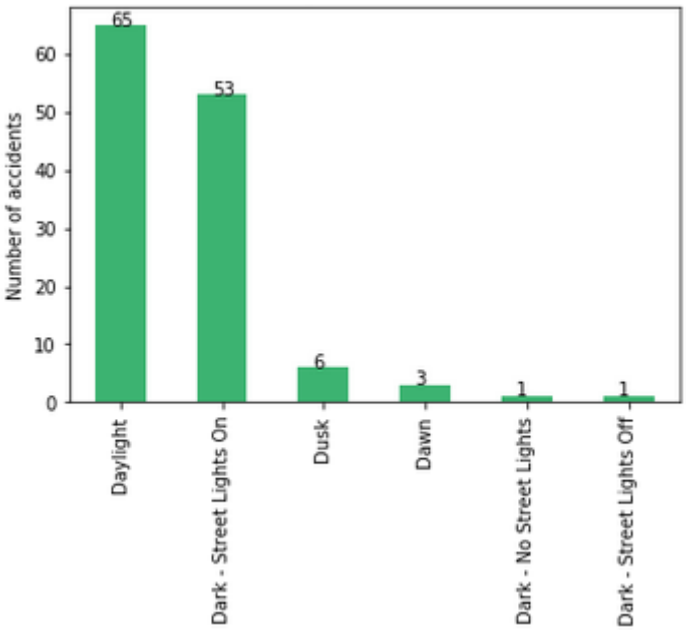


Fig. 13. Light conditions during fatal accidents with pedestrians.

- More accidents with pedestrians were recorded during a week days than during the weekend. The highest number of accidents were recorded on Fridays (1312) and the least on Sundays (678). The summary of data is presented in Fig. 14.

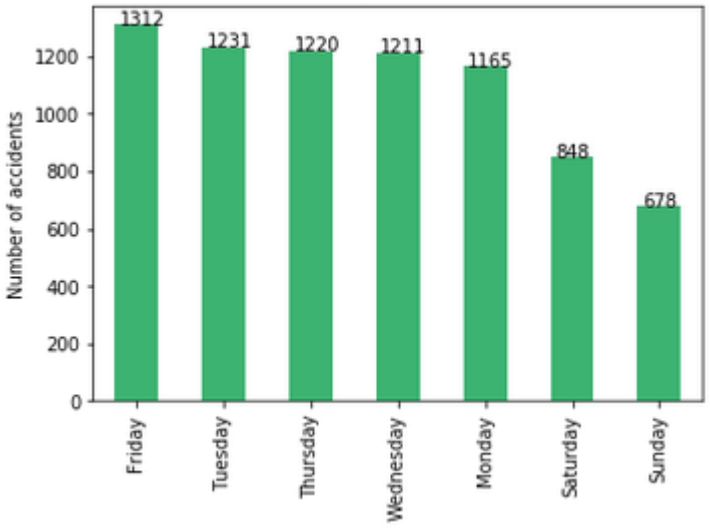


Fig. 14. Number of accidents with pedestrians recorded in a given day of week.

- The most tragic day of week was Wednesday with 26 fatal accidents. The least number of fatal accidents were recorded on Sunday (12). The summary of data is presented in Fig. *15*.

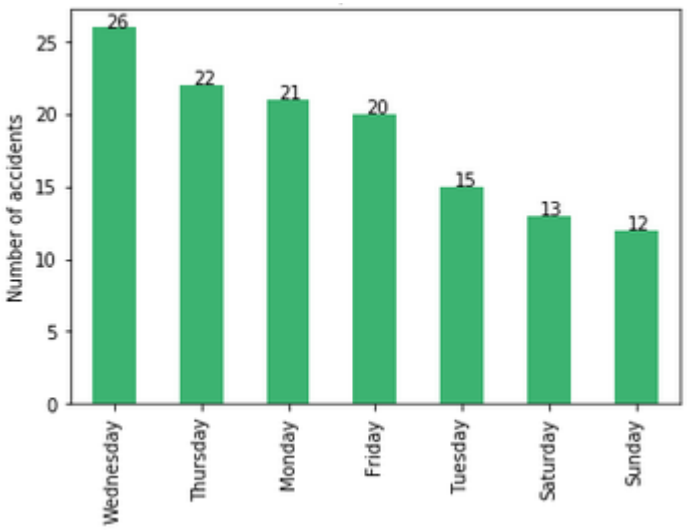


Fig. 15. Number of fatal accidents with pedestrians recorded in a given day of week.

- There are 19 intersections in Seattle where more than 15 accidents took place in 2004-2020 period. Those places are listed in Tab. 4 and presented in Fig. 16. and Fig. 17.

Tab. 4. List of places where more than 15 accidents with pedestrians took place.

No.	Address	Number of accidents
1	5TH Avenue and Spring Street	27
2	Broadway E and E Olive Way	26
3	3RD Avenue and Pike Street	26
4	Broadway and E Pike Street	24
5	Denny Way and Stewart Street	23
6	Roosevelt Way NE and NE 45TH Street	21
7	Boren Avenue and Pike Street	20
8	12TH Avenue and E Madison Street	19
9	Mercer Street and Queen Anne Avenue N	19
10	5TH Avenue and Pike Street	18
11	Brooklyn Avenue NE and NE 45TH Street	18
12	Rainier Avenue S and S Henderson Street	18
13	5TH Avenue S and S Jackson Street	18
14	Rainier Avenue S and S Bayview Street	18
15	6TH Avenue and Spring Street	17
16	11TH Avenue NE and NE 45TH Street	17
17	Broadway and E Pine Street	17
18	23RD Avenue and E Jefferson Street	16
19	Rainier Avenue S and S Orcas Street	16

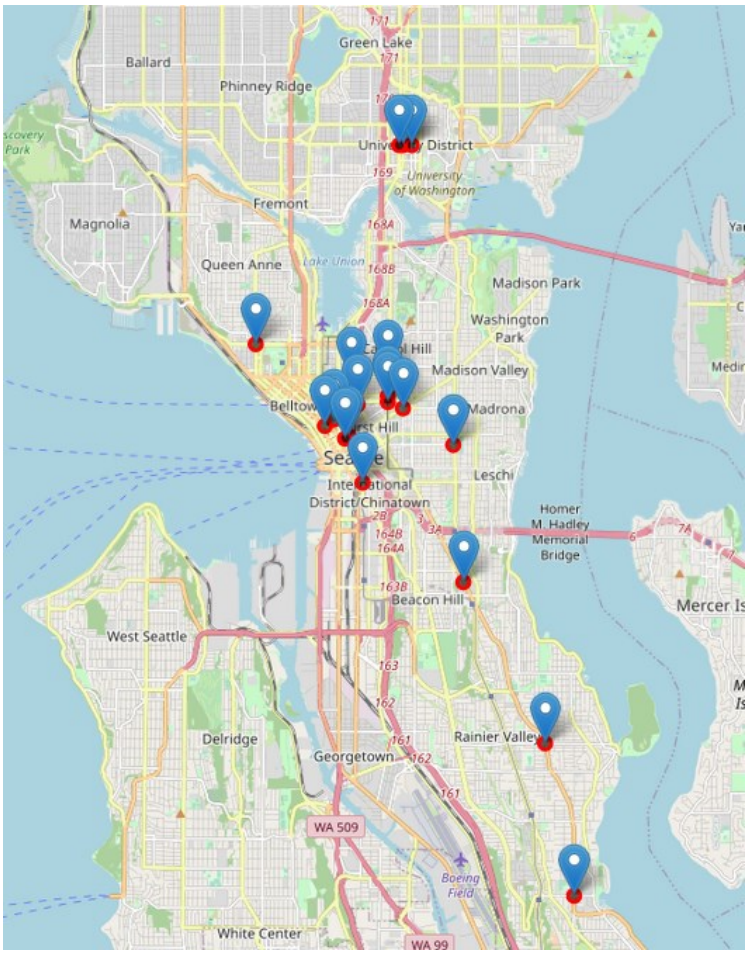


Fig. 16. Intersections in Seattle where more than 15 accidents with pedestrians took place.

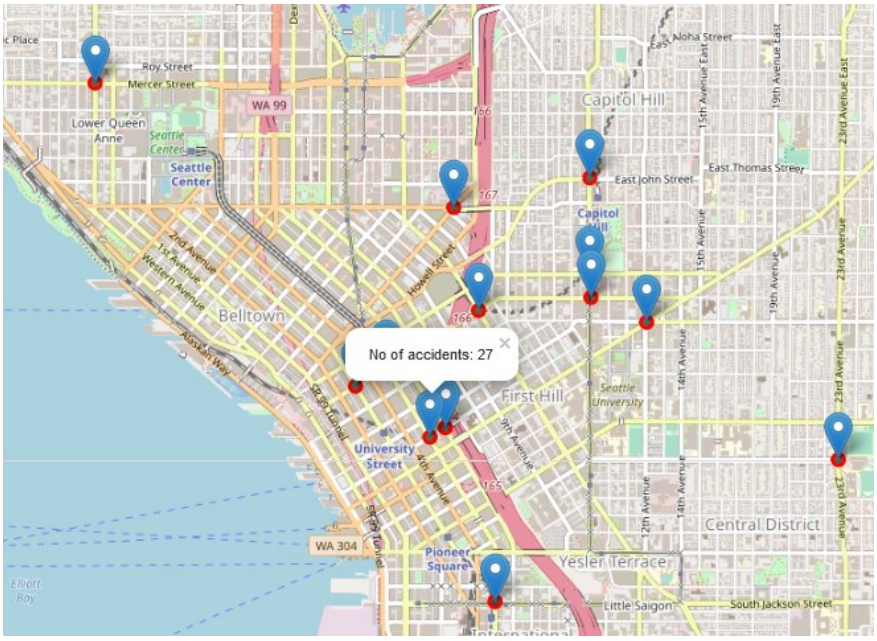


Fig. 17. Zoom in on the 5TH Avenue and Spring Street intersection where 27 accidents were recorded.

4.2. Decision trees

- Due to the specificity of the data three different decision trees were built:
  - Unbalanced decision tree
  - Decision tree balanced 1:1
  - Decision tree balanced 1:2

- Unbalanced decision tree (Fig. 18.):
  - all data were taken into account,
  - fatal accidents and accidents with a serious injuries joined (class = 2),
  - **Accuracy**: 0.79.
  - Too much data related to class 1 (minor injury) caused, that the fatal outcome is underestimated in unbalanced model.
  - Predicted 1 path leading to an accident with fatal or serious injury outcome:
    - Under Influence (Yes) + Pedestrian right not granted (Yes) + Road condition (Dry) + Weather (Clear).

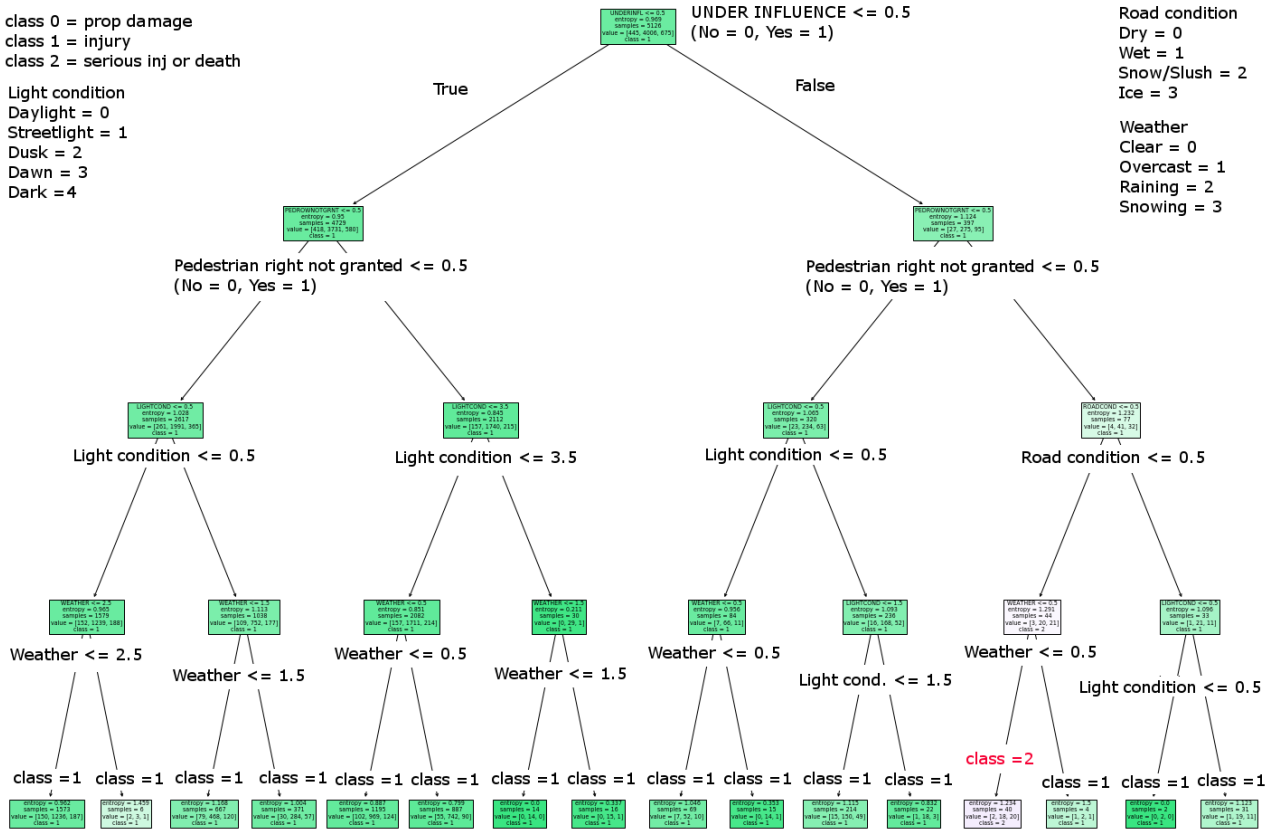


Fig. 18. Unbalanced decision tree.

- Balanced 1:1 decision tree (Fig. 19.):
  - number of accidents with a minor injuries were equaled with other types of accidents (fatal, serious injury and property damage - 1582),
  - fatal accidents and accidents with a serious injuries joined (class = 2),
  - **Accuracy**: 0.52.
  - Low accuracy.

- Predicted 6 paths leading to an accident with fatal or serious injury outcome (from left to right):
  - Under Influence (No) + Light conditions (Daylight) + Road conditions (Snow/Slush or Ice)
  - Under Influence (No) + Light conditions (Streetlights or Dusk or Dawn or Dark) + Pedestrian rights not granted (Granted) + Light conditions (Dusk or Dawn or Dark)
  - Under Influence (Yes) + Pedestrian right not granted (Granted) + Road condition (Dry) + Light condition (Daylight or Streetlight).
  - Under Influence (Yes) + Pedestrian right not granted (Yes) + Weather (Dry) + Light condition (Daylight).
  - Under Influence (Yes) + Pedestrian right not granted (Yes) + Weather (Dry) + Light condition (Streetlights or Dusk or Dawn or Dark).
  - Under Influence (Yes) + Pedestrian right not granted (Yes) + Weather (Wet or Snow/Slush or Ice) + Light condition (Daylight or Streetlight or Dusk).

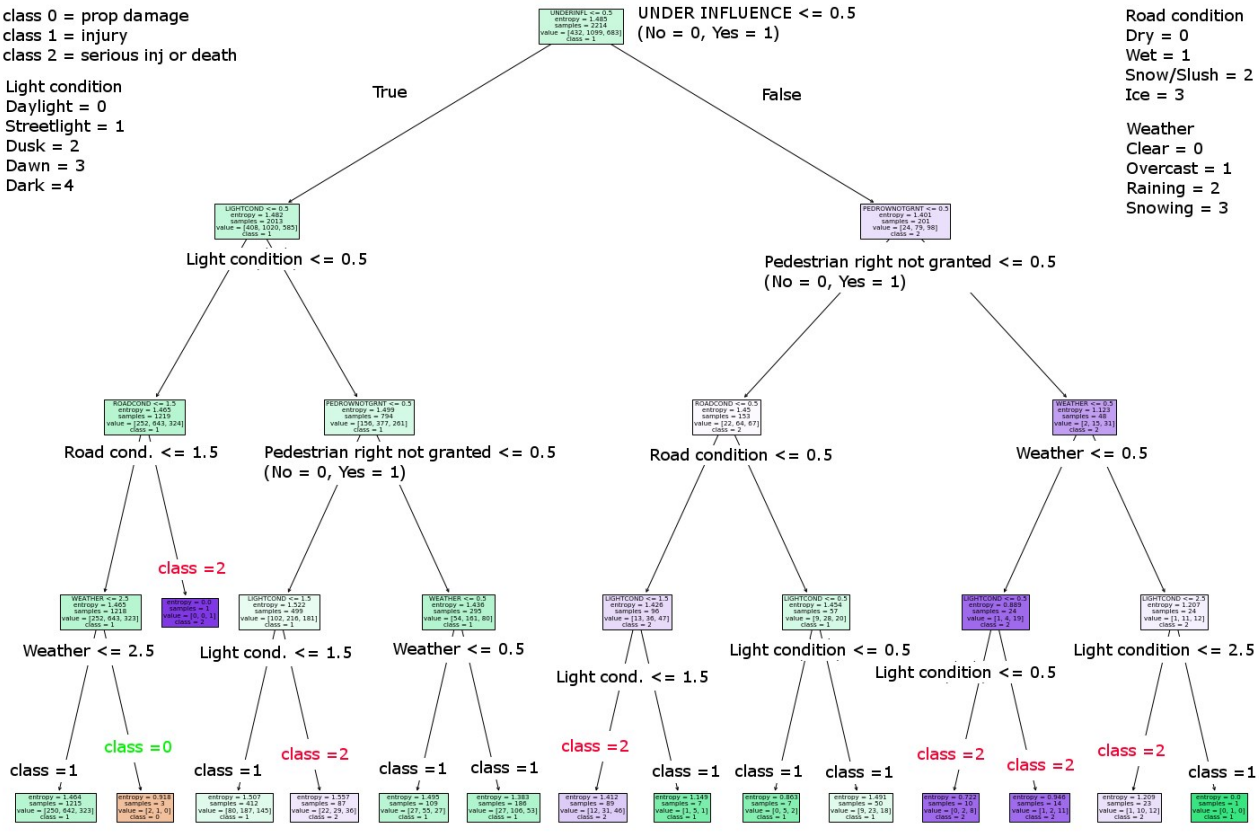


Fig. 19. Balanced 1:1 decision tree.

- Balanced 1:2 decision tree (Fig. 20.):
  - number of accidents with a minor injuries were taken twice more than other (3164),
  - fatal accidents and accidents with a serious injuries joined (class = 2).
  - **Accuracy**: 0.67.
  - Acceptable accuracy.

- Predicted 2 paths leading to an accident with fatal or serious injury outcome (from left to right):
  - Under Influence (Yes) + Pedestrian right not granted (Yes) + Weather (Dry) + Light condition (Streetlights or Dusk or Dawn or Dark).
  - Under Influence (Yes) + Pedestrian right not granted (Yes) + Weather (Wet or Snow/Slush or Ice) + Road conditions (Dry).

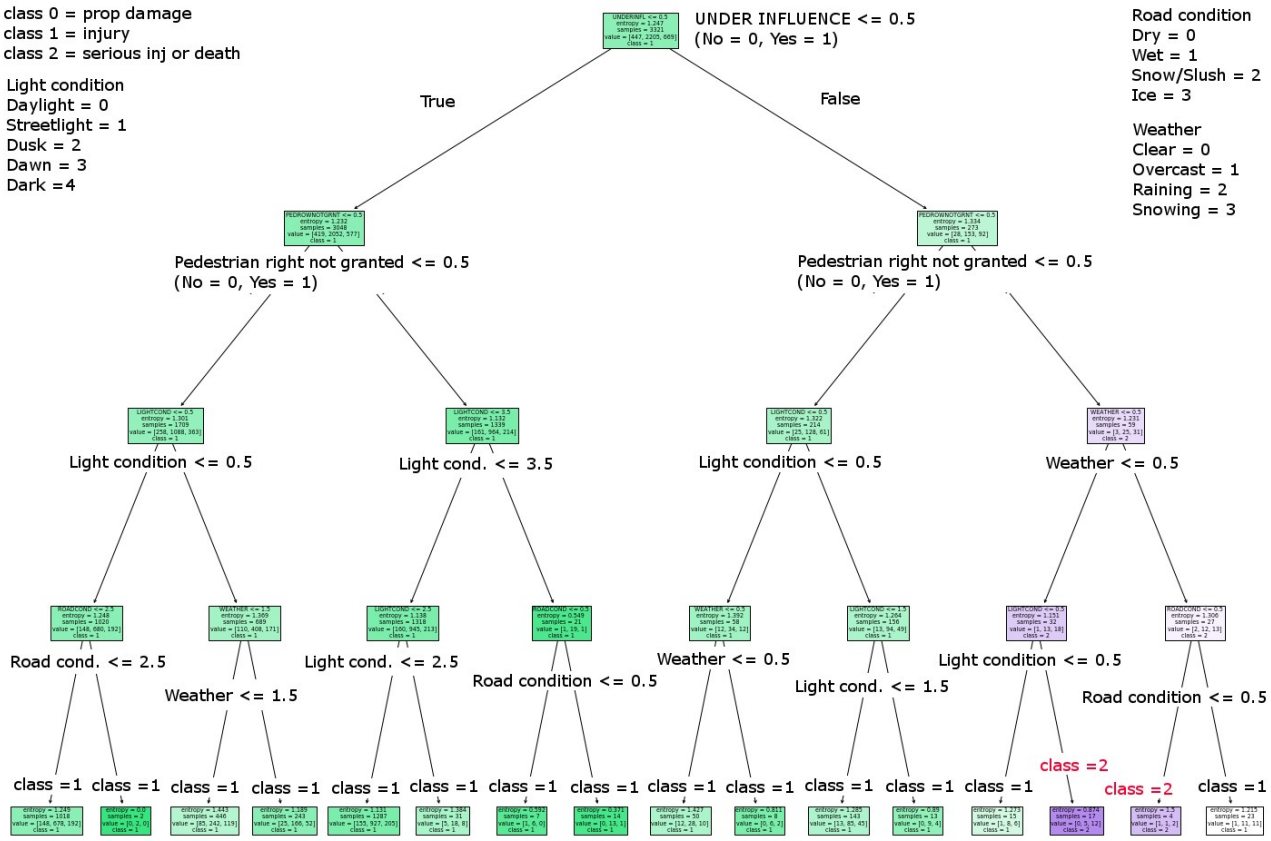


Fig. 20. Balanced 1:2 decision tree.

4.3. Discussion

- In period 2004-2020 in Seattle a 7664 accidents with pedestrians were registered, of which 6006 were non-serious injuries, 853 were serious injuries, 677 cases concerned a property damage and last, but not least in 129 cases the outcome was fatal.
- A separate analysis of causes of accidents (one at a time) does not provide the complete information about the probability of accident, especially the accident with tragic outcome. Most of the accidents were during the good weather, in a good light conditions and on a dry roads. Also most of the fatal accidents happened when the outer conditions were quite good.
- More information gives the analysis of the drivers behavior or condition. It is worth to stress that in the case of 42.5% of accidents with pedestrians a violation of pedestrian's right was recorded, also in the case of fatal accidents this percentage was relatively high (35.7%).
- 7.4% of all accidents were caused by a driver being under influence of drugs or alcohol, however in the case of fatal accidents this percentage grows to almost 22%.
- Inattention of drivers were the cause of more accidents (13.8%) than usage of drugs or alcohol (7.4%), but it was not a reason of much fatal accidents (7.7%).

- Another drivers behavior – speeding – in this circumstances was only a small factor (1.0% of all accidents, 3,9% of fatal accidents). Mainly because the data were recorded in the city, where speed limits apply.
- In order to analyze drivers behaviors and outer conditions leading to a serious injury or death, a tree decision trees were build. As it occurred, the highest probability of serious accident is when a several negative factors are added up. The most important mixtures of circumstances are:
    - when driver is under influence of alcohol or drugs and violates the pedestrians right - in this case the outer conditions are almost not important. The fatal accident were recorded when the road was dry and weather was good, as well as in the case of worse conditions;
    - when driver violated a pedestrian's right but was sober – in this case the bad light conditions lead to a fatal outcome;
    - when a driver was sober and didn't violate the pedestrian's rights – a mixture of bad light and road conditions were the factors.
- Results obtained using decision trees seem to be reasonable, but one need to bear in mind the following caveats:
    - Unbalanced decision tree provide the highest accuracy, however it underestimates the fatal and serious accidents.
    - Balanced 1:1 tree exposed a lot of serious accident paths, but offers the lowest accuracy.
    - Balanced 1:2 has more acceptable accuracy, but expose only the most evident cases.
    - Samples for balanced trees were taken randomly and trees obtained in another iterations are different than presented in the report. This leads to the conclusion, that more thorough analysis should be done using a bunch of randomly generated trees and average the results.
- Despite the disadvantages of the used method the overall conclusion holds true for all obtained trees – the main cause of the most tragic accidents is drug or alcohol usage leading to violation of pedestrian's right.

5. Conclusions and Recommendations

- The main cause of the most tragic accidents is drug or alcohol usage leading to violation of pedestrian's right. In this case the recommendations are:
    - conduct/intensify the educational campaign aimed at reducing the number of drunk (drugged) drivers,
    - increase the number of police patrols in order to increase the probability of elimination of drunk drivers before it comes to an accident,
    - conduct/intensify the educational efforts in teaching all potential pedestrians (especially children), that their rights always can by violated and they need to be careful when crossing the intersections.
- Less probable, but also important is the bad light and road conditions factor. In this case the recommendations are:
    - improve the street lightning on the intersections and improve the lighting repair system,
    - improve the snow clearing system in winter.
- In above analysis, 19 intersections where more than 15 accidents happened, were detected. In the case of fatal accidents such coincidence was not detected. In order to reduce the number of accidents on those intersections one can:

- inform the drivers and pedestrians, that those intersections are especially dangerous and a special care is needed (for example marking it as a “black city spots”),
- improve the street lightning and repair system on those intersections,
- improve the snow clearing system in winter.