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Introduction

- Questions that we tried to answer:
 - Which features in the data set are significant when accidents occur?
 - Can we classify certain features in dependence of a subset of other features?
 - Can we find the underlying probability distributions of the samples?
 - and what do they tell us?

Data preparation

- The given data sets are quiet messy.
- The goal is to clean up all the data sets and save them in distinct tables.
- Link the data sets by certain features.
- With additional merging in a separate table.

Data preparation, accidents in Zurich

- Drop unimportant columns

A	B	C	D	E	F
AccidentUID	AccidentType	AccidentType_de	AccidentType_fr	AccidentType_it	AccidentType_en
1 A2D2677533867004E0430A865E337004	at0	Schleuder- oder Selbstunfall	dÃ©rapage ou perte de maÃ®trise	Incidente di sbandamento o per colpa propria	Accident with skidding or self-accident
2 9FD6441F802C20A6E0430A865E3320A6	at0	Schleuder- oder Selbstunfall	dÃ©rapage ou perte de maÃ®trise	Incidente di sbandamento o per colpa propria	Accident with skidding or self-accident
3 9FDA0DC4856A6094E0430A865E336094	at0	Schleuder- oder Selbstunfall	dÃ©rapage ou perte de maÃ®trise	Incidente di sbandamento o per colpa propria	Accident with skidding or self-accident
4 A3B66E42396E6000E0430A865E336000	at5	Ãœberqueren der Fahrbahn	accident en traversant une route	Incidente nell'attraversare la carreggiata	Accident when crossing the lane(s)
6 9FDA0DBE8CCE9096E0430A865E339096	at0	Schleuder- oder Selbstunfall	dÃ©rapage ou perte de maÃ®trise	Incidente di sbandamento o per colpa propria	Accident with skidding or self-accident
7 9FDA0DC484276094E0430A865E336094	at3	Abbiegeunfall	accident en quittant une route	Incidente nello svoltare	Accident when turning left or right
8 9FC221265A3BEOFOE0430A865E33EOF0	at2	Auffahrurunfall	accident par tamponnement	Incidente di tamponamento	Accident with rear-end collision
9 9FC221265BADE0FOE0430A865E33EOF0	at1	Ãœberholunfall oder Fahrstreifenwechsel	accident lors d'un dÃ©passement ou lors d'un changement de voie de circulation	Incidente di sorpasso o al cambiamento di corsia	Accident when overtaking or changing lanes
10 9FD68C1FBAD4D0FEE0430A865E33D0FE	at7	Parkierunfall	accident en parquant	Incidente nel parcheggiare	Accident when parking

G	H	I	J	K	L	M	N	O	P
AccidentSeverityCategory	AccidentSeverityCategory_de	AccidentSeverityCategory_fr	AccidentSeverityCategory_it	AccidentSeverityCategory_en	AccidentInvolvingPedestrian	AccidentInvolvingBicycle	AccidentInvolvingMotorcycle	RoadType	RoadType_de
2 as4	Unfall mit Sachschaden	accident avec dommages matÃ©riels	Incidente con danni materiali	Accident with property damage	FALSCH	FALSCH	FALSCH	rt433	Nebenstrasse
3 as3	Unfall mit Leichtverletzten	accident avec blessÃ©s lÃ©gers	Incidente con feriti leggeri	Accident with light injuries	FALSCH	WAHR	FALSCH	rt433	Nebenstrasse
4 as4	Unfall mit Sachschaden	accident avec dommages matÃ©riels	Incidente con danni materiali	Accident with property damage	FALSCH	FALSCH	FALSCH	rt439	andere
5 as3	Unfall mit Leichtverletzten	accident avec blessÃ©s lÃ©gers	Incidente con feriti leggeri	Accident with light injuries	FALSCH	FALSCH	FALSCH	rt433	Nebenstrasse
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8 as4	Unfall mit Sachschaden	accident avec dommages matÃ©riels	Incidente con danni materiali	Accident with property damage	FALSCH	FALSCH	FALSCH	rt433	Nebenstrasse
9 as4	Unfall mit Sachschaden	accident avec dommages matÃ©riels	Incidente con danni materiali	Accident with property damage	FALSCH	FALSCH	FALSCH	rt433	Nebenstrasse
10 as4	Unfall mit Sachschaden	accident avec dommages matÃ©riels	Incidente con danni materiali	Accident with property damage	FALSCH	FALSCH	FALSCH	rt433	Nebenstrasse

Data preparation, accident data

- Change strings to integer, and change false/true statements to 0/1

A	B	C	D	E	F
AccidentUID	AccidentType	AccidentType_de	AccidentType_fr	AccidentType_it	AccidentType_en
2 A2D2677533867004E0430A865E337004	at0	Schleuder- oder Selbstunfall	dÃ©rapage ou perte de maÃ§trise	Incidente di sbandamento o per colpa propria	Accident with skidding or self-accident
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10 as4	Unfall mit Sachschaden	accident avec dommages matÃ©riels	Incidente con danni materiali	Accident with property damage	FALSCH	FALSCH	FALSCH	rt433	Nebenstrasse

Data preparation, accident data

- Merge date objects to one column called Date

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	RoadType_fr	RoadType_it	RoadType_en	AccidentLocation_CHLV95_E	AccidentLocation_CHLV95_N	CantonCode	MunicipalityCode	AccidentYear	AccidentMonth	AccidentMonth_de	AccidentMonth_fr	AccidentMonth_it	AccidentMonth_en
2	route secondaire	Strada secondaria	Minor road	2684605	1245194 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
3	route secondaire	Strada secondaria	Minor road	2682382	1246980 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
4	autre	Altro	Other	2682791	1247749 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
5	route secondaire	Strada secondaria	Minor road	2681199	1247102 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
6	route secondaire	Strada secondaria	Minor road	2682479	1250690 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
7	route secondaire	Strada secondaria	Minor road	2683365	1253681 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
8	route secondaire	Strada secondaria	Minor road	2681841	1249487 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
9	route secondaire	Strada secondaria	Minor road	2683299	1247929 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	
10	route secondaire	Strada secondaria	Minor road	2682866	1247664 ZH	261	261	2011	1 Januar	janvier	Gennaio	January	

	AD	AE	AF	AG	AH	AI	AJ
1	AccidentWeekDay	AccidentWeekDay_de	AccidentWeekDay_fr	AccidentWeekDay_it	AccidentWeekDay_en	AccidentHour	AccidentHour_text
2	aw406	Samstag	samedi	Sabato	Saturday	0	00h-01h
3	aw406	Samstag	samedi	Sabato	Saturday	1	01h-02h
4	aw406	Samstag	samedi	Sabato	Saturday	2	02h-03h
5	aw406	Samstag	samedi	Sabato	Saturday	2	02h-03h
6	aw406	Samstag	samedi	Sabato	Saturday	3	03h-04h
7	aw406	Samstag	samedi	Sabato	Saturday	4	04h-05h
8	aw406	Samstag	samedi	Sabato	Saturday	4	04h-05h
9	aw406	Samstag	samedi	Sabato	Saturday	5	05h-06h
10	aw406	Samstag	samedi	Sabato	Saturday	13	13h-14h

Data preparation, meteo data

- Drop unimportant rows and columns
- Take the average of the remaining data with respect to n measurement locations.

A	B	C	D	E	F	G	
1	Datum	Standort	Parameter	Intervall	Einheit	Wert	Status
2	01.01.2011 00:00	Zch_Schimmelstrasse	Hr	h1	%Hr	88.11	bereinigt
3	01.01.2011 00:00	Zch_Schimmelstrasse	RainDur	h1	min	0	bereinigt
4	01.01.2011 00:00	Zch_Schimmelstrasse	T	h1	Â°C	2.79	bereinigt
5	01.01.2011 00:00	Zch_Schimmelstrasse	WD	h1	Â°	329.12	bereinigt
6	01.01.2011 00:00	Zch_Schimmelstrasse	WVv	h1	m/s	0.76	bereinigt
7	01.01.2011 00:00	Zch_Schimmelstrasse	p	h1	hPa	974.22	bereinigt
8	01.01.2011 00:00	Zch_Stampfenbachstrasse	Hr	h1	%Hr	92	bereinigt
9	01.01.2011 00:00	Zch_Stampfenbachstrasse	RainDur	h1	min	0	bereinigt
10	01.01.2011 00:00	Zch_Stampfenbachstrasse	T	h1	Â°C	1.6	bereinigt

Data preparation, counts of cars on the road

- Drop unimportant columns. (Note: nans were not dropped)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
MSID	MSName	ZSID	ZSName	Achse	HNr	Hohe	EKoord	NKoord	Richtung	Knun	Kname	An	D1ID	D2ID	D3ID	D4ID	Messung	DatZeit	LieferDat	AnzF	AnzFahrzeuge
2	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 00:00	03.02.2021		Fehlend
3	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 01:00	03.02.2021	256	Gemessen
4	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 02:00	03.02.2021	186	Gemessen
5	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 03:00	03.02.2021	142	Gemessen
6	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 04:00	03.02.2021	116	Gemessen
7	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 05:00	03.02.2021	67	Gemessen
8	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 06:00	03.02.2021	73	Gemessen
9	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 07:00	03.02.2021	43	Gemessen
10	Z001M001	Unbekannt	Z001	Seestrasse (Strandbad Wollishofen)	Seestrasse	451	Unbekannt	2683009.89	1243936.2	auswärts	789	Badanstalt Wollishofen	1	2	Unbekannt	Unbekannt	Unbekannt	01.01.2012 08:00	03.02.2021	52	Gemessen

Data preparation, counts of pedestrians and bicycles on the road

- Drop unimportant columns. (Note: nans were not dropped)
- Add counts together on both sides of the lane to get the total.
- The measurements were taken every 15 min; get the total for one hour.

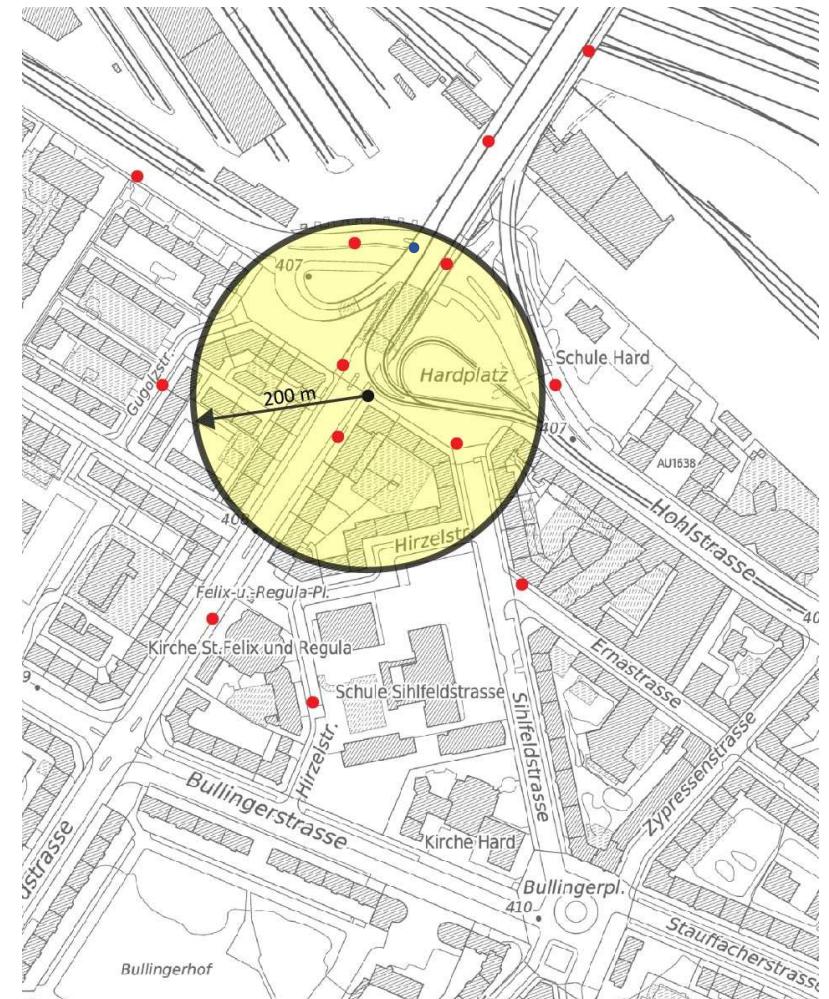
	A	B	C	D	E	F	G	H	I
1	FK_ZAEHLER	FK_STANDORT	DATUM	VELO_IN	VELO_OUT	FUSS_IN	FUSS_OUT	OST	NORD
2	ECO09113499		6 01.01.2011 00:00	1	0			2682873	1245891
3	ECO09113506		12 01.01.2011 00:00	0	0			2681385	1247736
4	ECO09113501		8 01.01.2011 00:00	0	0			2683573	1248545
5	Y2G12102806		54 01.01.2011 00:00	5	1			2684006	1246566
6	ECO09022739		5 01.01.2011 00:00	2	0			2682933	1248821
7	ECO09113507		13 01.01.2011 00:00	0				2682683	1250570
8	Y0410090357		52 01.01.2011 00:00	0	0	0	0	2678956	1250443
9	Y0412032046		53 01.01.2011 00:00	0	0	0	0	2679028	1250674
10	ECO09113502		9 01.01.2011 00:00	0	0			2684578	1251967

Data preparation, merging

- The average temperature and rain durations were added to every accident according to the date.
- The count data sets were merged with respect to the location and the date.
- To do this, we located the counting stations within a radius of 200m from an accident.

Data preparation, merging

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- To do this, we located the counting stations within a radius of 200m from an accident.



Data preparation

- The merged and cleand data sets are now ready to undergo some analysis.

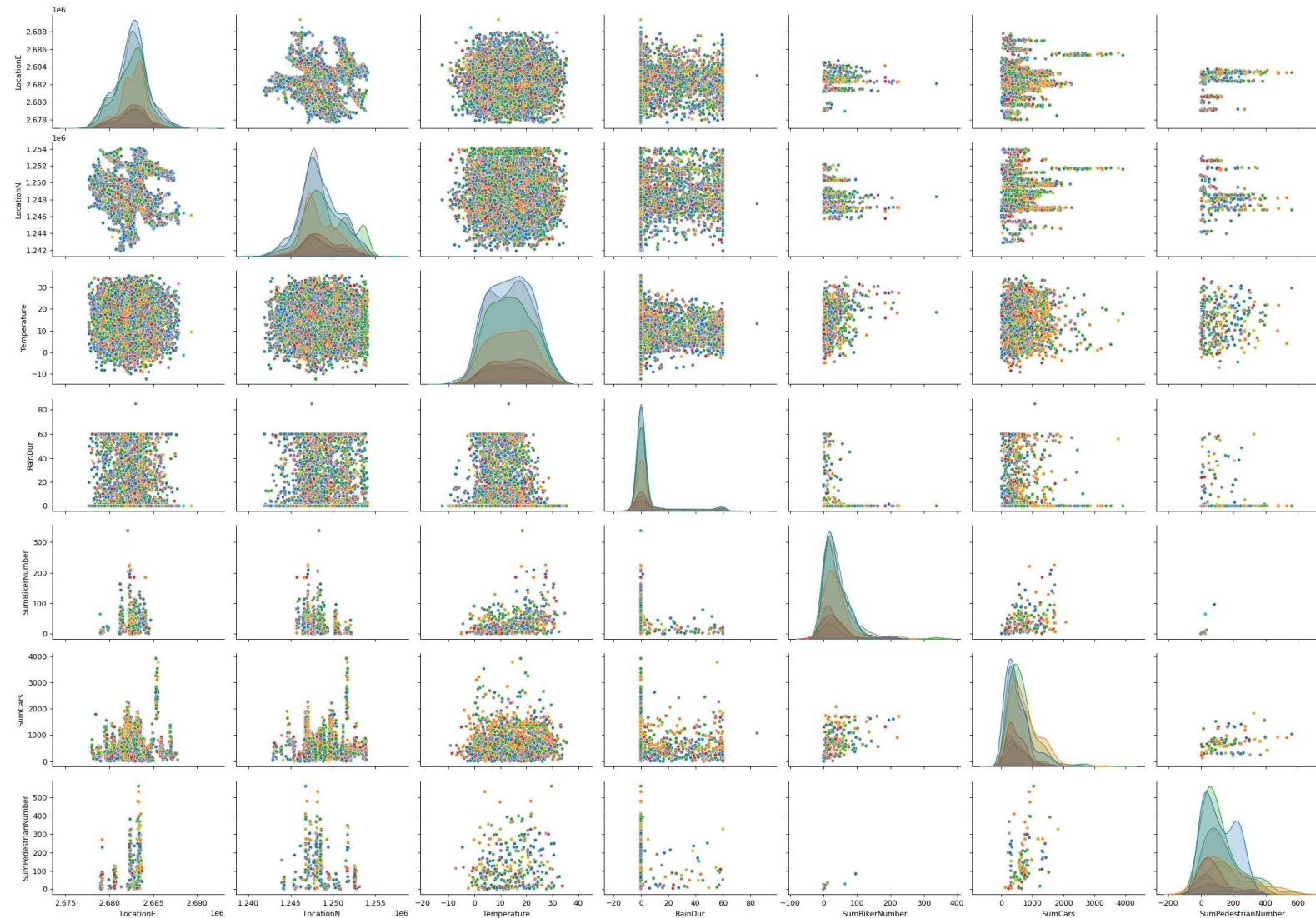
Date	AccidentType	Severity	Pedestrian	Bicycle	Motorcycle	RoadType	LocationE	LocationN	Temperature	RainDur	SumBiker	SumPedestrian	SumCars
01.01.2011 00:00	0	4	0	0	0	3	2684605	1245194	2.2	0			
01.01.2011 01:00	0	3	0	1	0	3	2682382	1246980	2.3	0	6		
01.01.2011 02:00	0	4	0	0	0	9	2682791	1247749	2.3	0			
01.01.2011 02:00	5	3	0	0	0	3	2681199	1247102	2.3	0			
01.01.2011 03:00	0	4	0	0	0	3	2682479	1250690	2.5	0			
01.01.2011 04:00	3	4	0	0	0	3	2683365	1253681	2.7	0			
01.01.2011 04:00	2	4	0	0	0	3	2681841	1249487	2.7	0			
01.01.2011 05:00	1	4	0	0	0	3	2683299	1247929	2.8	0			
01.01.2011 13:00	7	4	0	0	0	3	2682866	1247664	3.2	0			

Exploratory analysis, technicalities

- To get a grasp of the used data, we used the following Python modules/methods:
 - Quick Matplotlib plots.
 - Seaborn pair plot, to visualize immediate relations between the features.
 - Linear regression via statsmodels.
 - Kernel density estimation with default parameters in Seaborn, SciPy and scikit-learn.
- All with the help of pandas DataFrame class.

Exploratory analysis

SumPedestrian SumCar SumBicycle RainDur Temperature LocationN LocationE

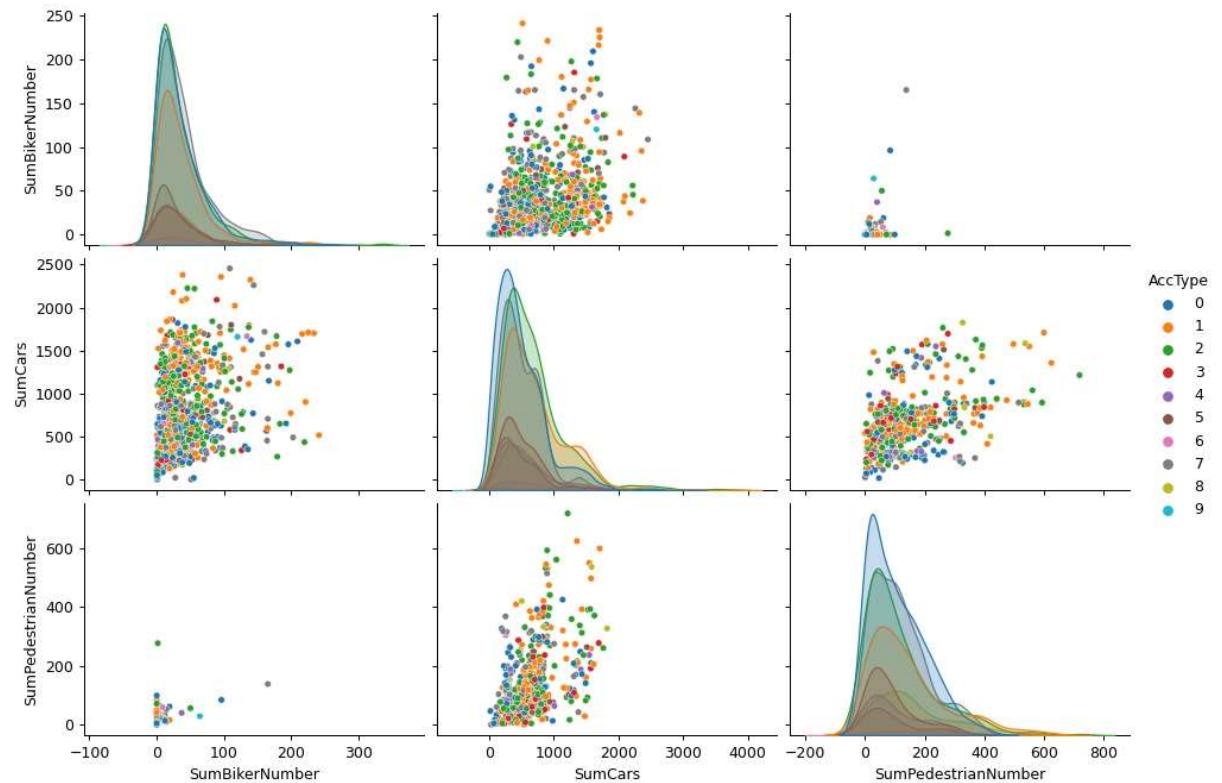


27.05.2021

LocationE LocationN Temperature RainDur SumBicycle SumCar SumPedestrian

Exploratory analysis

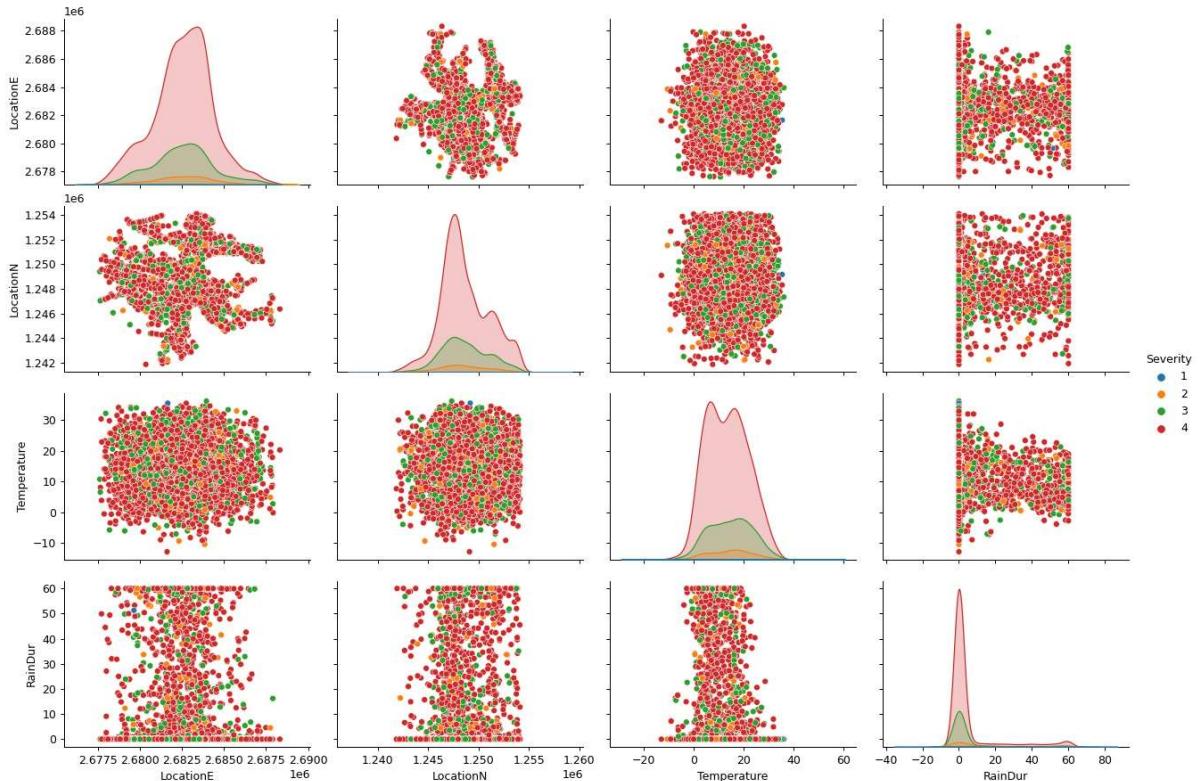
- There is no clear clustering visible.
- We see some trends in the scatter plot, but only trivial ones.



Exploratory analysis

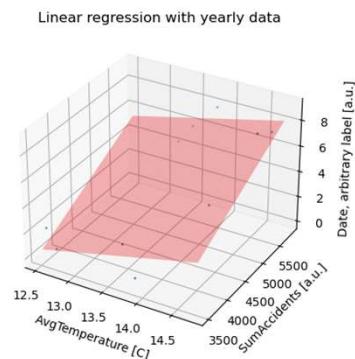
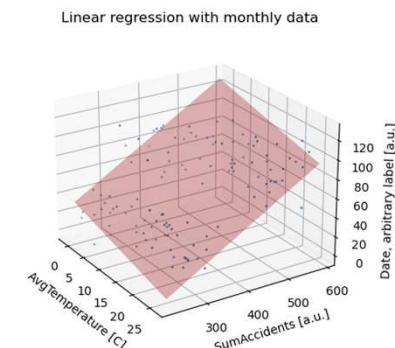
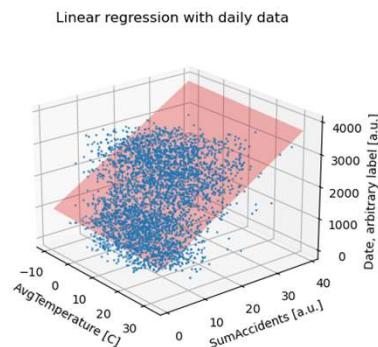
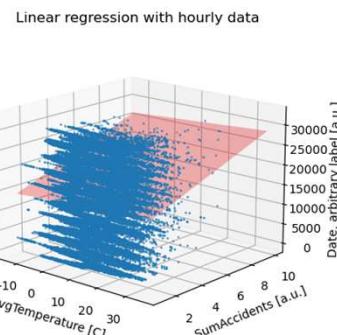
- There is no clear clustering visible.
- The class 4 seems to be dominant.

Severity classes:
1: Accident with fatalities
2: Accident with severe injuries
3: Accident with light injuries
4: Accident with property damage



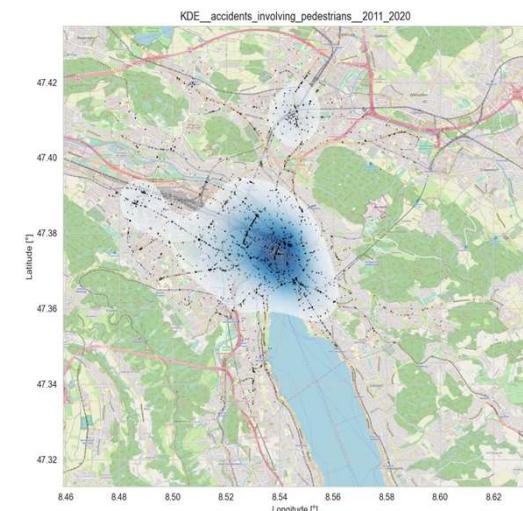
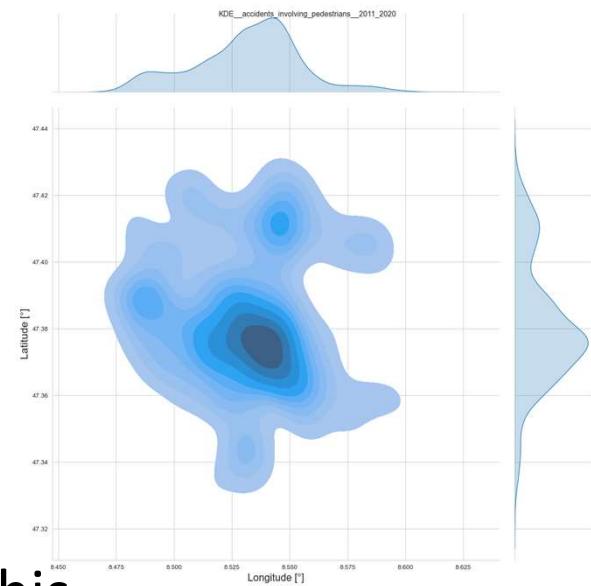
Exploratory analysis

- We tried to find some relations via linear regression of a few non ordinal features.
- But we have not pursued it further.



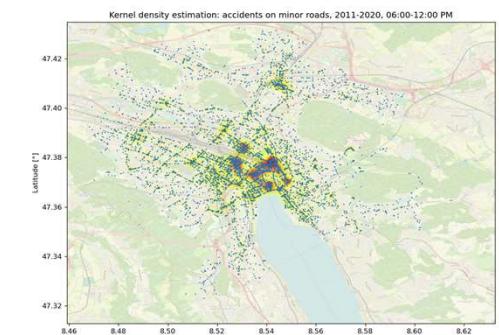
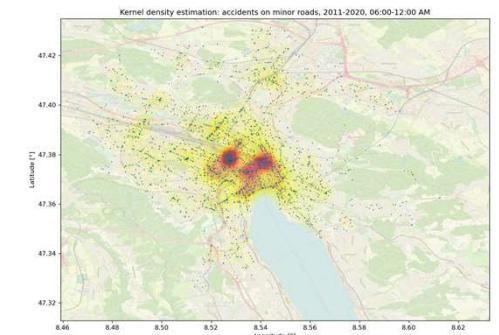
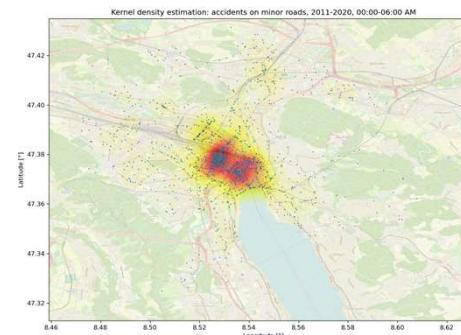
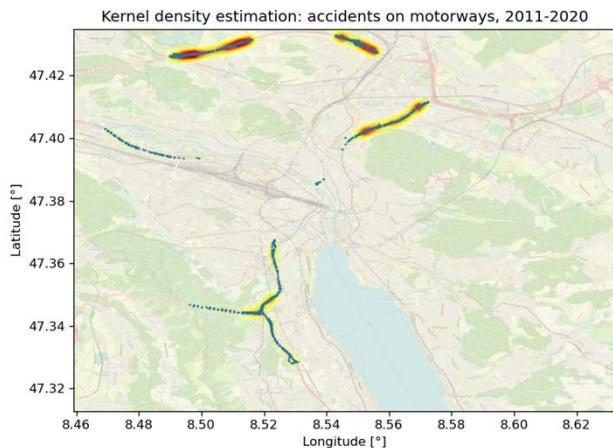
Exploratory analysis

- To see the distribution of the data points in addition with a probability density estimation, we have plotted them on the map of Zurich.
- We used Seaborn, SciPy and scikit-learn to do this.
Note the plots on the right are plotted via Seaborn and SciPy.
- For the exploratory part we only used the default parameters.



Exploratory analysis

- We decided to use the scikit-learn implementation. Since we can use the implemented 2-fold cross validation to estimate the best bandwidth.

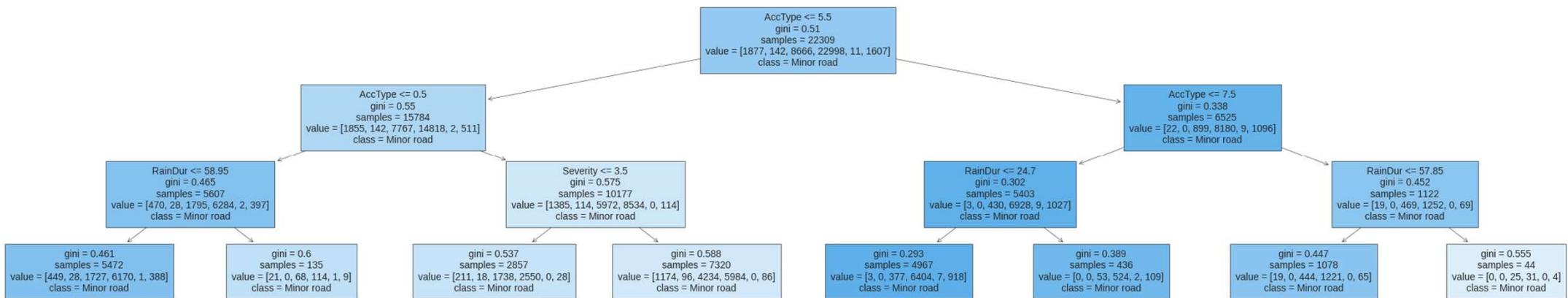
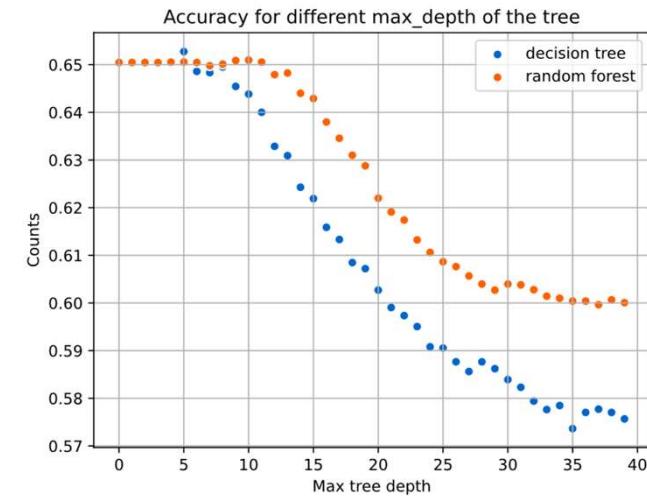


Classifications

- Here we tried to predict three distinct features:
 - Severity
 - Accident type
 - Road type
- This has been done via three different methods:
 - Decision tree
 - Random forest
 - Sequential model in Tensorflow

Classifications

- This is a decision tree with a maximal depth of 3.
- We also tried it with various other depths.



Classifications

- Most important features used for sequential model:

['Severity', 'AccType', 'Bicycle']

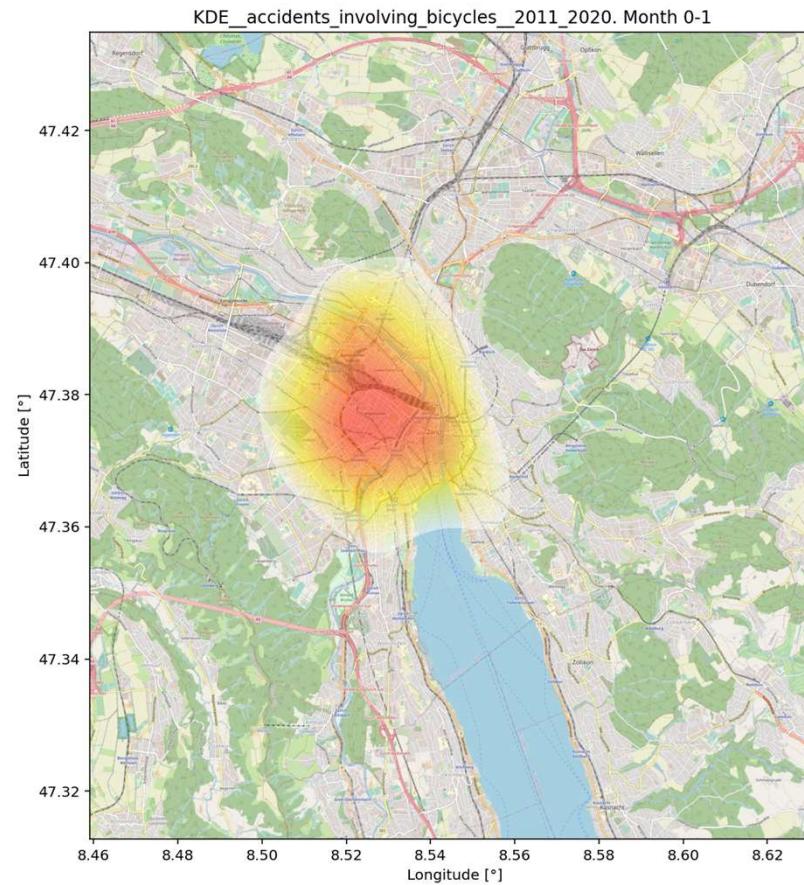
```
model = tf.keras.Sequential([
    feature_layer,
    layers.Dense(128, activation='relu'),
    layers.Dense(128, activation='relu'),
    layers.Dropout(.3),
    layers.Dense(num_units, activation='softmax')
])
optimizer = optimizers.Adam(learning_rate=0.01)
model.compile(optimizer=optimizer,
              loss=tf.keras.losses.SparseCategoricalCrossentropy(),
              metrics=['accuracy'])
```

Decision tree (sklearn)		Random forest (sklearn)		Sequential (Tensorflow)	
Target:	RoadType	Target:	RoadType	Target:	RoadType
Accuracy:	0.650	Accuracy:	0.651	accuracy:	0.6524
importance		importance		Sequential (Tensorflow)	
AccType	0.883294	AccType	0.707	Target:	RoadType
Bicycle	0.055726	Severity	0.116	accuracy:	0.658
Severity	0.033004	Bicycle	0.071		
Motorcycle	0.010788	Motorcycle	0.033		
Temperature	0.010688	Temperature	0.029		
RainDur	0.0065	Pedestrian	0.025		
Pedestrian	0	RainDur	0.018		

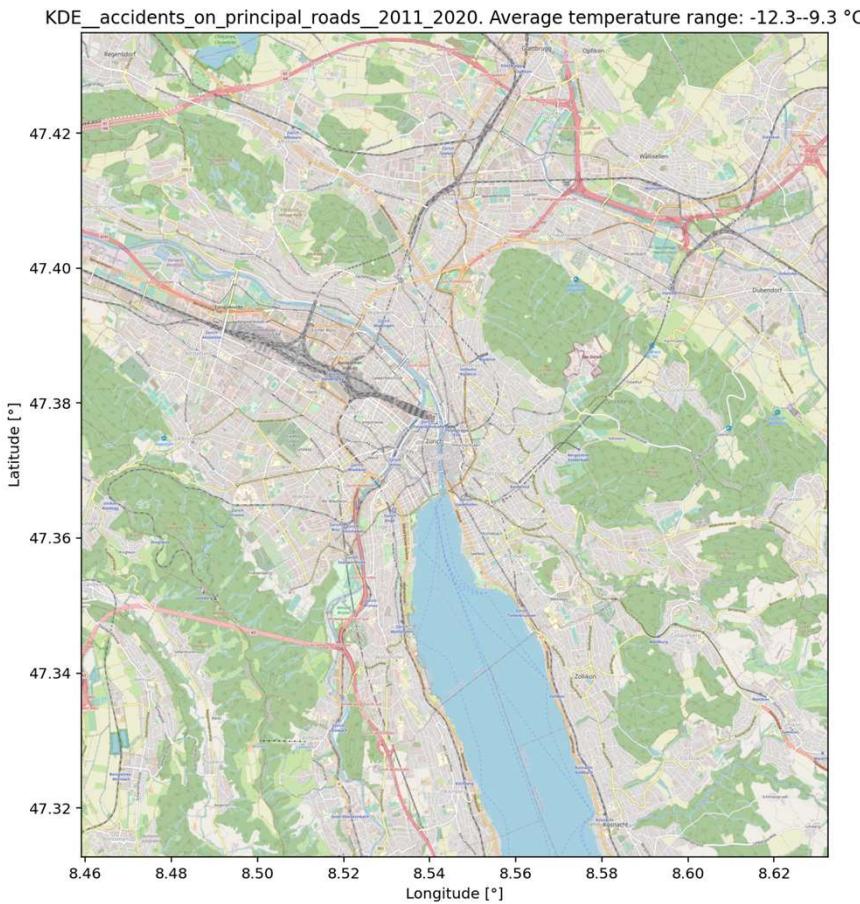
Kernel density estimation

- As mentioned before, 2-fold cross validation to find an estimation of the bandwidth of the kernel density.
- Further, gaussian kernels were used.
- To display them in a nice manner, we used a simple linear interpolation scheme between the calculated frames.

Kernel density estimation



Kernel density estimation

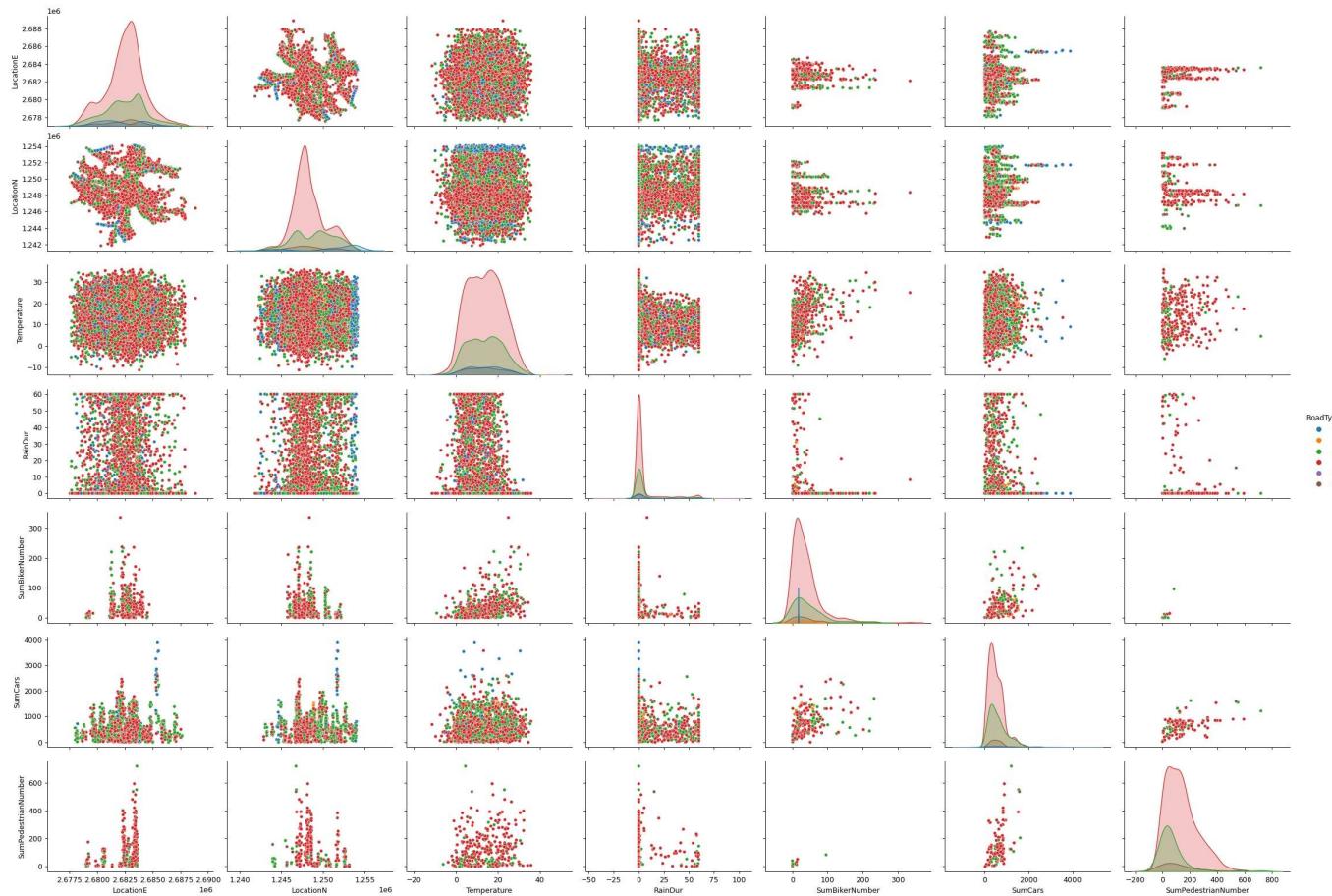


Questions ?

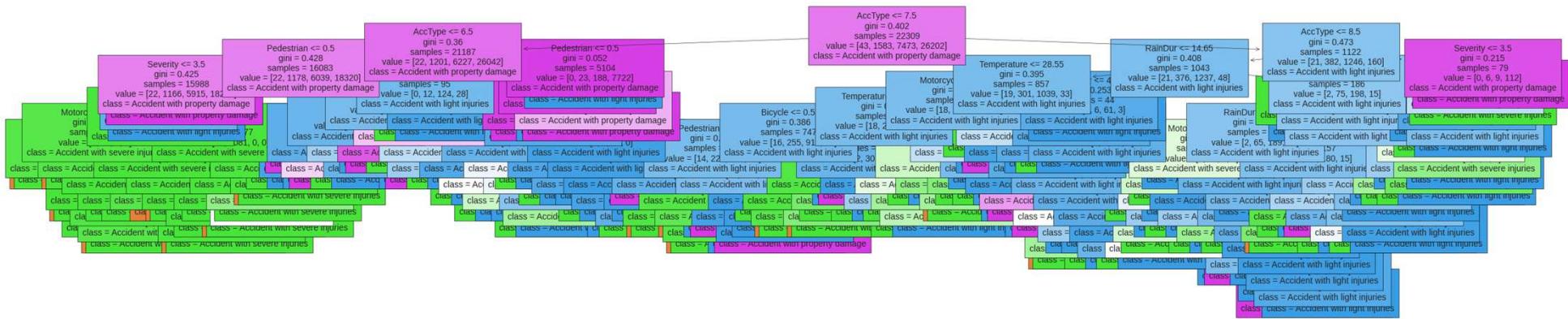
References

- The git repository can be found here: https://github.com/massstab/ESC403_project.git
- Also the raw data and instructions how to tidy up the data and the codebook with the explanation of all labels can be found there.
- The main accidents dataset can be found here: <https://opendata.swiss/de/dataset/polizeilich-registrierte-verkehrsunfalle-auf-dem-stadtgebiet-zurich-seit-2011/resource/3bf3f12a-bf09-4e69-8cde-0df9e268d54b>
- The meteo data can be found here: https://data.stadt-zuerich.ch/dataset/ugz_meteodataen_stundenmittelwerte
- The count of the pedestrian/cars/bike data can be found here: https://data.stadt-zuerich.ch/dataset/ted_taz_verkehrszaehlungen_werte_fussgaenger_velo
- The used Zurich maps were taken from: <https://maps.zh.ch/>

Appendix

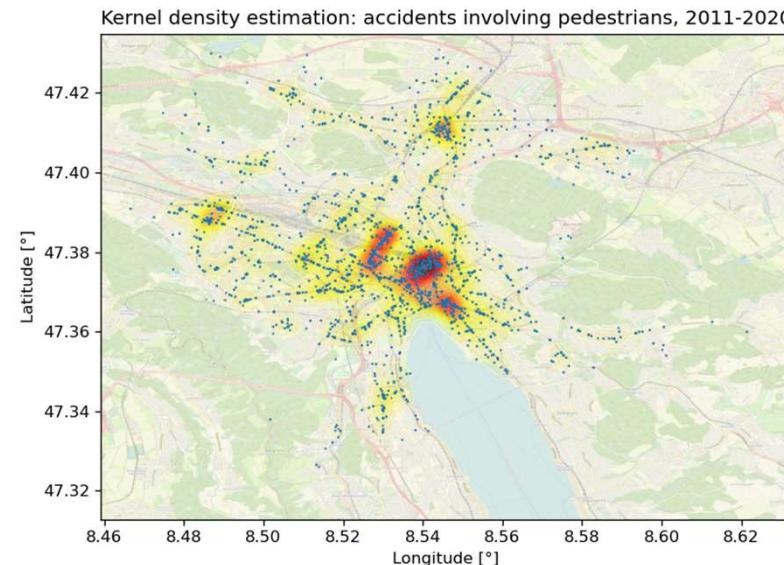
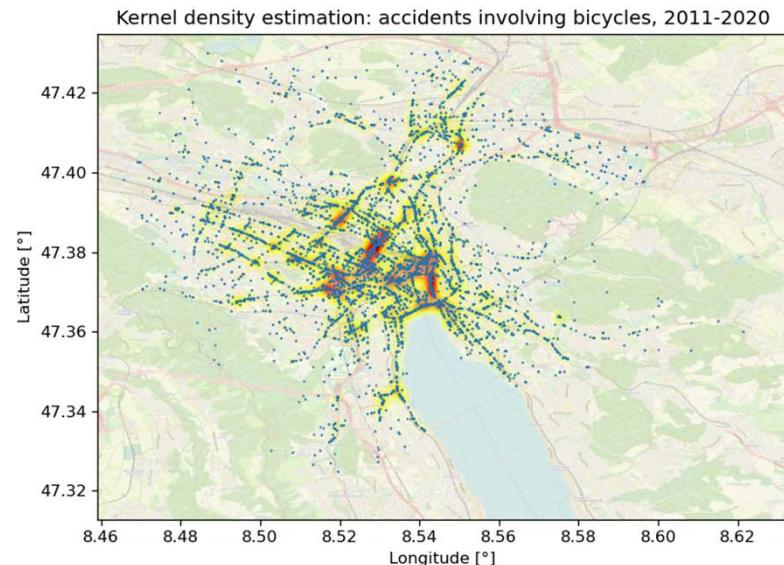


Appendix



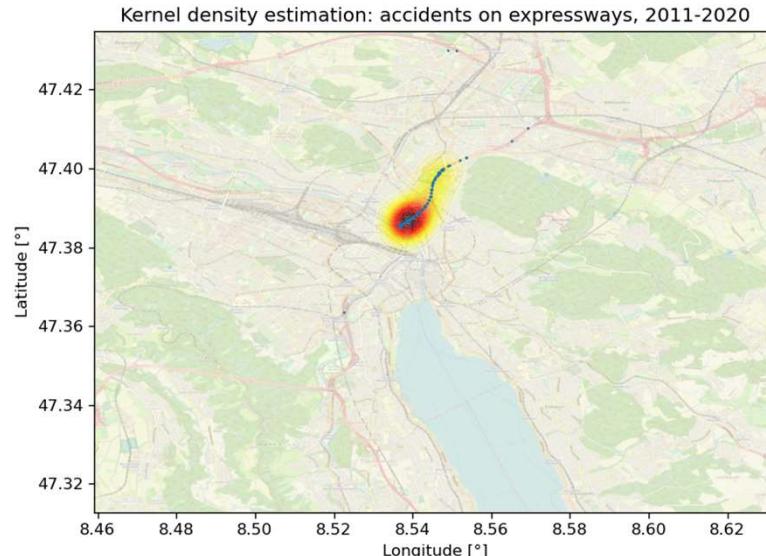
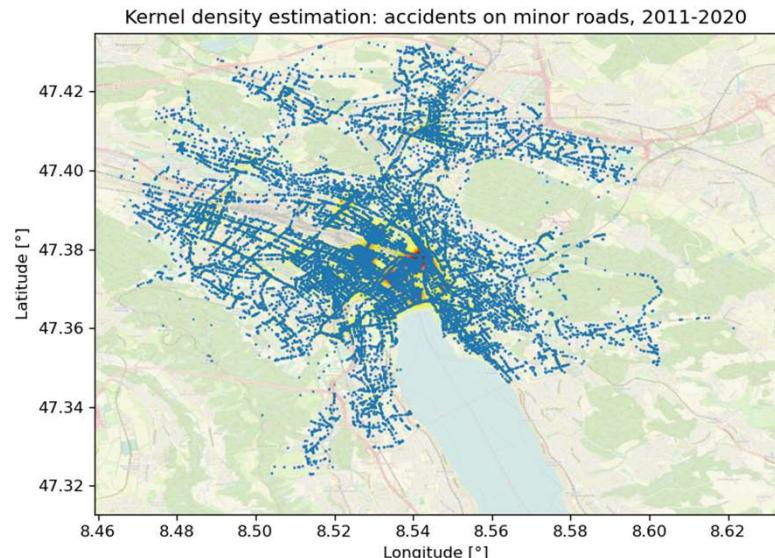
Appendix

- Small subset of made KDEs



Appendix

- Small subset of made KDEs



Appendix

- Small subset of made KDEs, best bandwidth estimation
- The bandwidth were chosen in a range of [0, 0.1] with 256 values

```
Kernel density estimation: accidents when overtaking or changing lanes, 2011-2020 bandwidth estimate: 0.0121212121212121  
Kernel density estimation: accidents with rear-end collision, 2011-2020 bandwidth estimate: 0.0020202020202020  
Kernel density estimation: accidents when turning left or right, 2011-2020 bandwidth estimate: 0.00101010101010101  
Kernel density estimation: accidents when turning-into main road, 2011-2020 bandwidth estimate: 0.00101010101010101  
  
....  
KDE_AccPedestrians_2011-2020_exploratory , bandwidth estimate: 0.0020202020202020  
KDE_AccBicycles_2011-2020_exploratory , bandwidth estimate: 0.00101010101010101  
KDE_AccMotorcycles_2011-2020_exploratory , bandwidth estimate: 0.00101010101010101  
KDE_AccOnMotorways_2011-2020_exploratory , bandwidth estimate: 0.00101010101010101  
KDE_AccOnExpressways_2011-2020_exploratory , bandwidth estimate: 0.0030303030303030303  
KDE_AccOnPrincipalRoads_2011-2020_exploratory , bandwidth estimate: 0.00101010101010101  
KDE_AccOnMinorRoads_2011-2020_exploratory , bandwidth estimate: 0.00101010101010101  
KDE_AccOnMotorwaySideInstallation_2011-2020_exploratory , bandwidth estimate: 0.01616161616161616  
KDE_AccOnOtherRoads_2011-2020_exploratory , bandwidth estimate: 0.0020202020202020
```

Appendix

