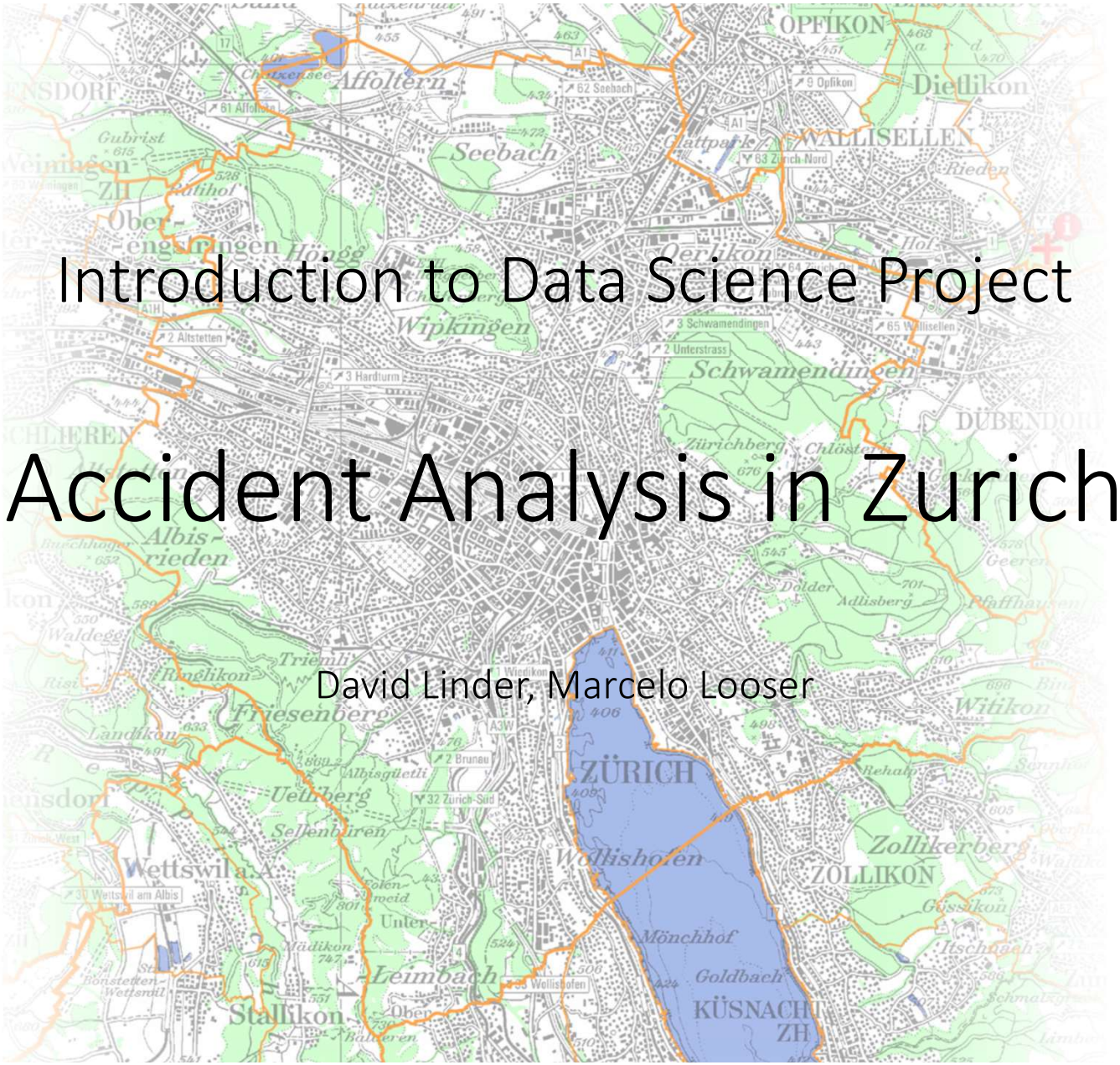
Introduction to Data Science Project

Accident Analysis in Zurich

David Linder, Marcelo Looser



Content

- Introduction
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- Classification
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- Questions

Introduction

- Questions that we tried to answer:
  - Which features in the data set are significant when accidents occur, correlations?
  - Can we classify certain features in dependence of a subset of other features?
  - Can we find the underlying probability distribution 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 destinct 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
1	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
3	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
4	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
5	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	9FC221265A3BE0F0E0430A865E33E0F0	at2	Auffahrunfall	accident par tamponnement	Incidente di tamponamento	Accident with rear-end collision
9	9FC221265BADE0F0E0430A865E33E0F0	at1	Überholunfall 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	9FD6BC1FBAD4D0FEE0430A865E33D0FE	at7	Parkierunfall	accident en parquant	Incidente nel parcheggiare	Accident when parking

	G	H	I	J	K	L	M	N	O	P
1	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
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Data preparation, accident data

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

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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	2011	1	Januar	janvier	Gennaio	January
3	route secondaire	Strada secondaria	Minor road	2682382	1246980	ZH	261	2011	1	Januar	janvier	Gennaio	January
4	autre	Altro	Other	2682791	1247749	ZH	261	2011	1	Januar	janvier	Gennaio	January
5	route secondaire	Strada secondaria	Minor road	2681199	1247102	ZH	261	2011	1	Januar	janvier	Gennaio	January
6	route secondaire	Strada secondaria	Minor road	2682479	1250690	ZH	261	2011	1	Januar	janvier	Gennaio	January
7	route secondaire	Strada secondaria	Minor road	2683365	1253681	ZH	261	2011	1	Januar	janvier	Gennaio	January
8	route secondaire	Strada secondaria	Minor road	2681841	1249487	ZH	261	2011	1	Januar	janvier	Gennaio	January
9	route secondaire	Strada secondaria	Minor road	2683299	1247929	ZH	261	2011	1	Januar	janvier	Gennaio	January
10	route secondaire	Strada secondaria	Minor road	2682866	1247664	ZH	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

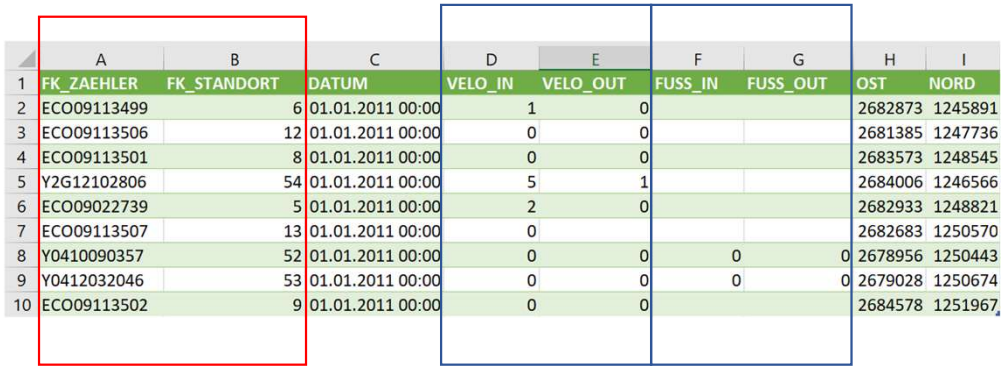
Data preparation, counts of cars on the road

- 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
1	MSID	MSName	ZSID	ZSName	Achse	HNr	Hoehe	EKoord	NKoord	Richtung	Knun	Kname	An	D1I	D2ID	D3ID	D4ID	MessungDatZeit	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 accidents within a radius of 200m.

Data preparation, merging

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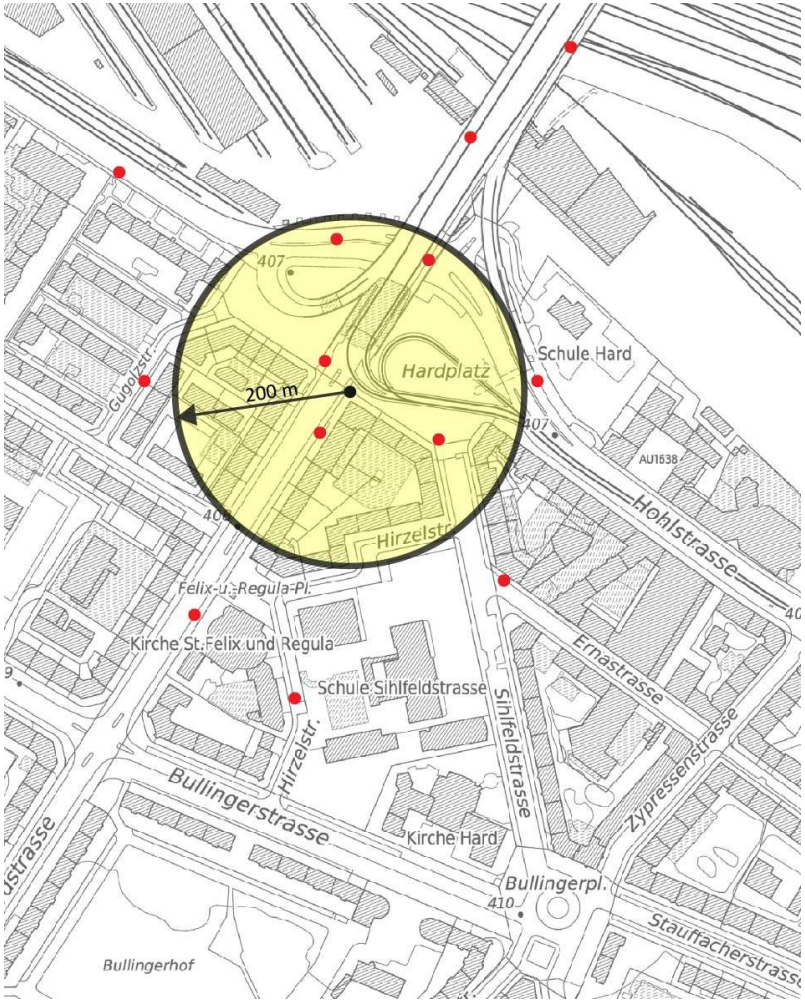


Data preparation

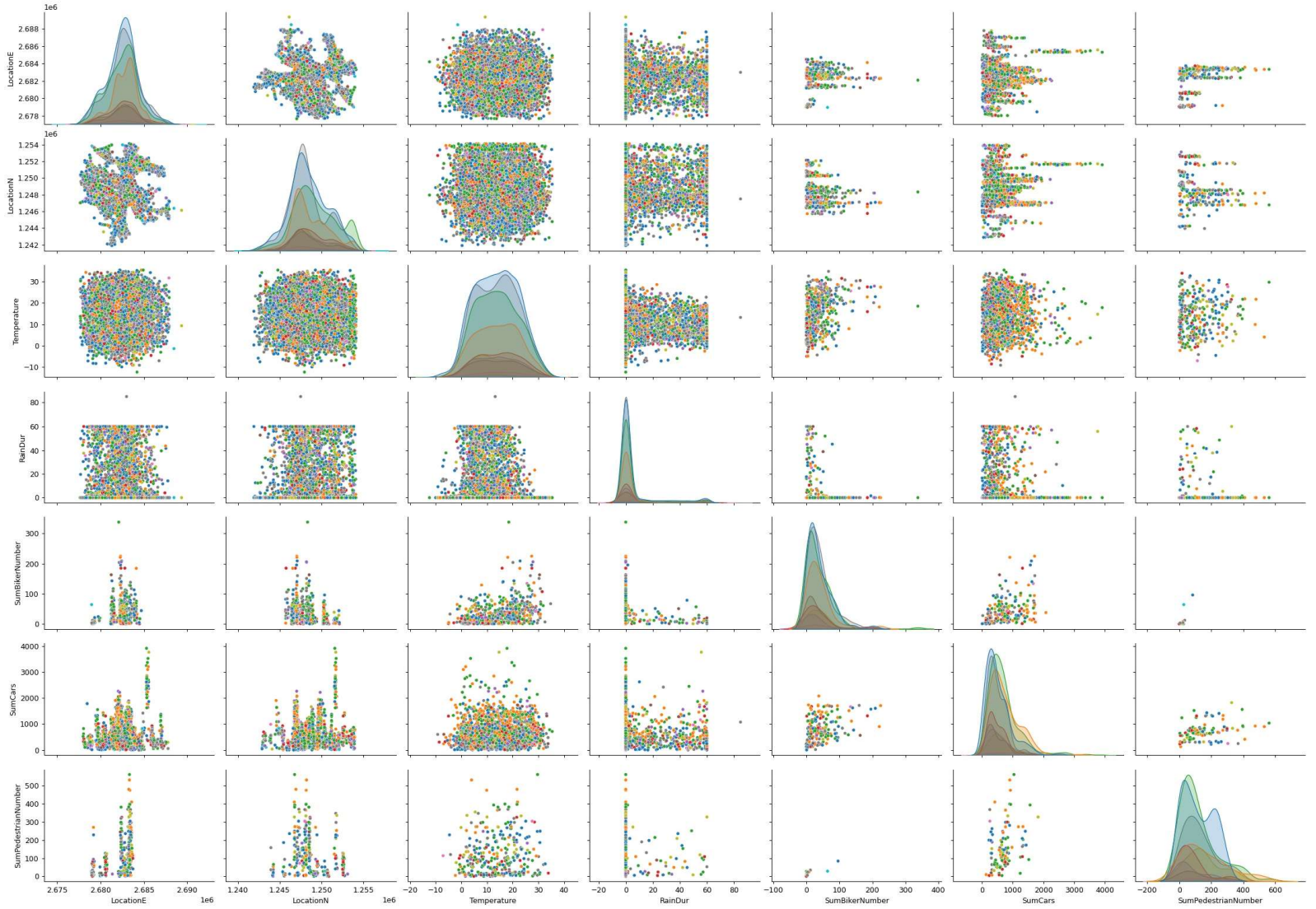
- The merged and cleand data sets are now ready to undergo some analysis.

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.

SumPedestrian SumCar SumBicycle RainDur Temperature LocationN LocationE



Exploratory analysis

0: Accident with skidding or self-accident

1: Accident when overtaking or changing lanes

2: Accident with rear-end collision

3: Accident when turning left or right

4: Accident when turning-into main road

5: Accident when crossing the lane(s)

6: Accident with head-on collision

7: Accident when parking

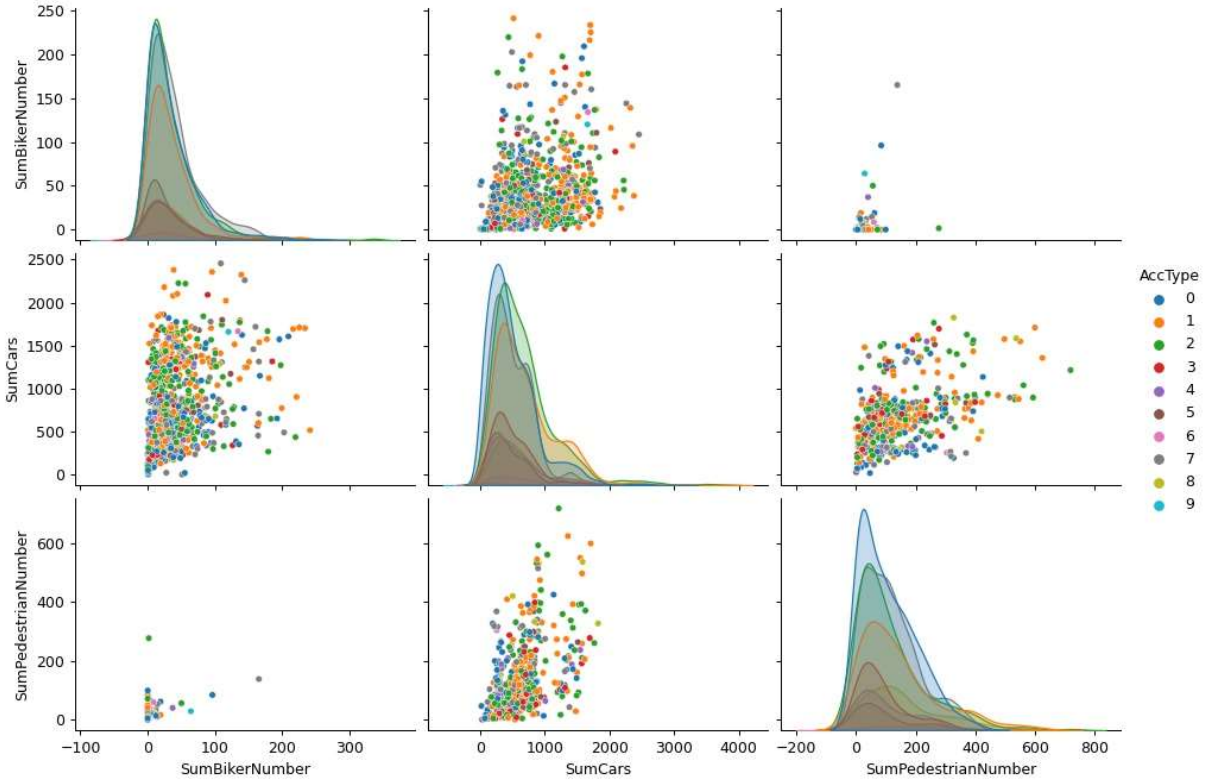
8: Accident involving pedestrian(s)

9: Accident involving animal(s)

LocationE LocationN Temperature RainDur SumBicycle SumCar SumPedestrian

Exploratory analysis

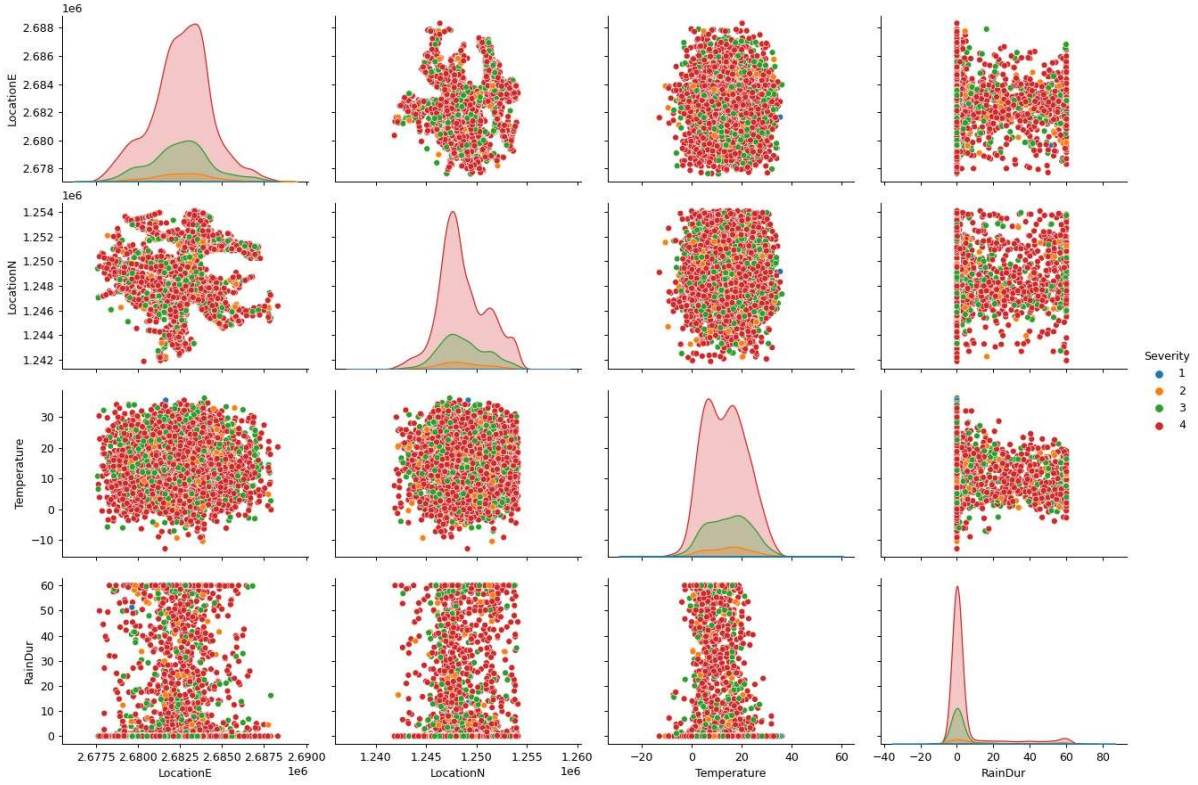
- There is no clear clustering visible.
- We se some trends in the scatter plot, but only trivial ones.



Exploratory analysis

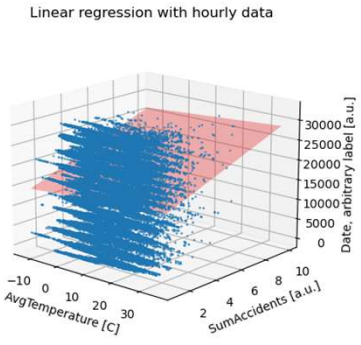
Severity classes:
1: Accident with fatalities
2: Accident with severe injuries
3: Accident with light injuries
4: Accident with property damage

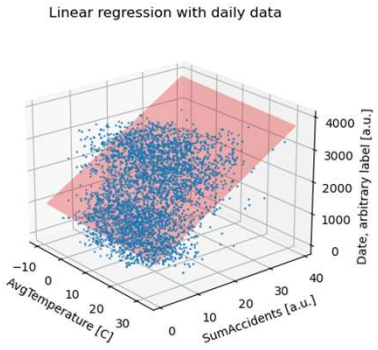
- There is no clear cluster-ing visible.
- The class 4 seems to be dominant.

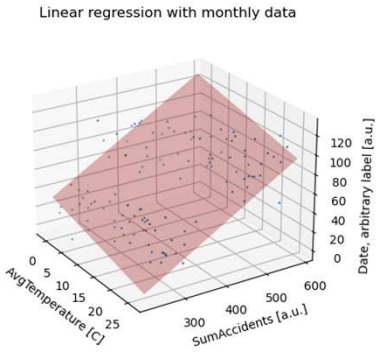


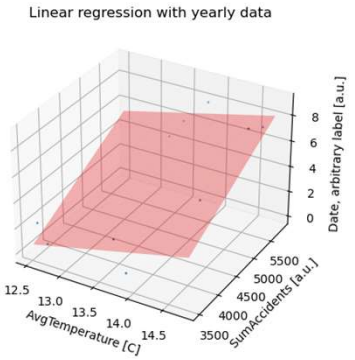
Exploratory analysis

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



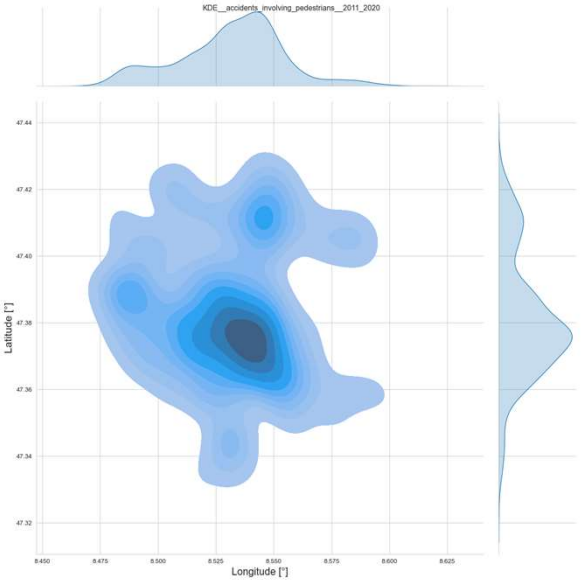


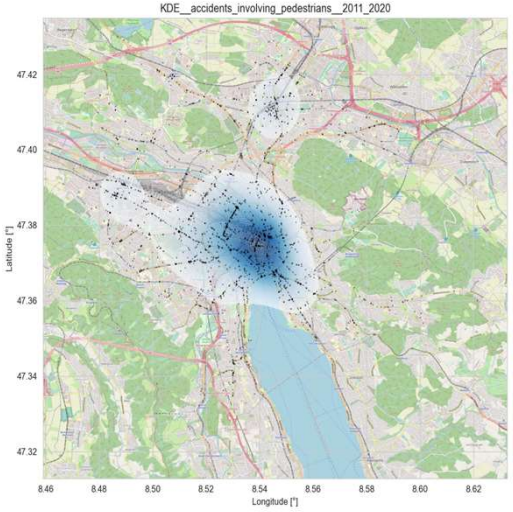




Exploratory analysis

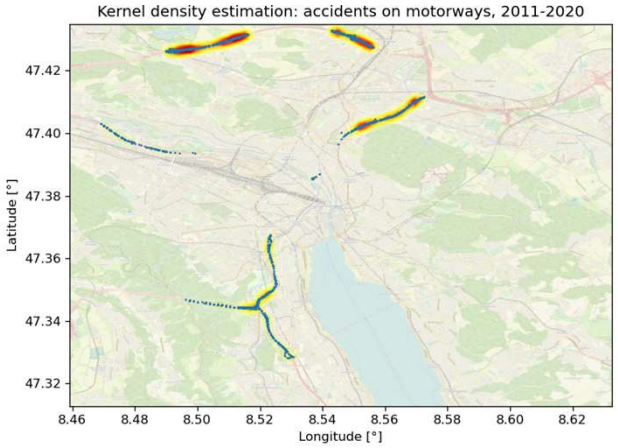
- To see the distribution of the data points in addition with a probability density estimation, we have ploted them on map of Zurich.
- We used seaborn, scipy and sklearn to do this. Note the once on the right are ploted via seaborn and scipy.
- For the exploratory part we only used the default parameters.

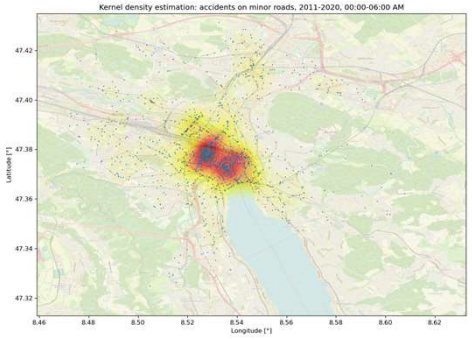


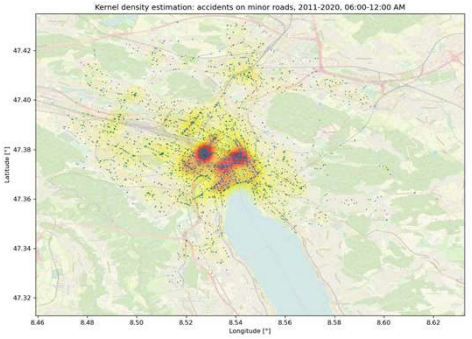


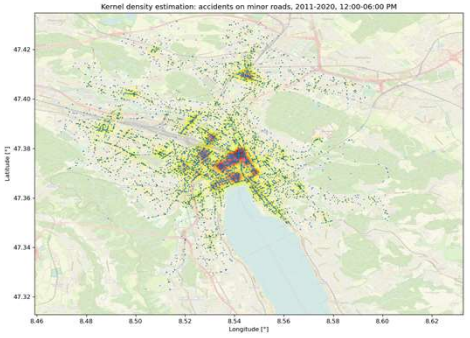
Exploratory analysis

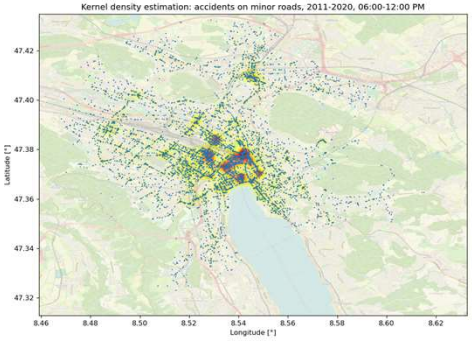
- We decided to use the sklearn implementation. Since we can use the implemented 2-fold cross validation to estimate the best bandwidth.









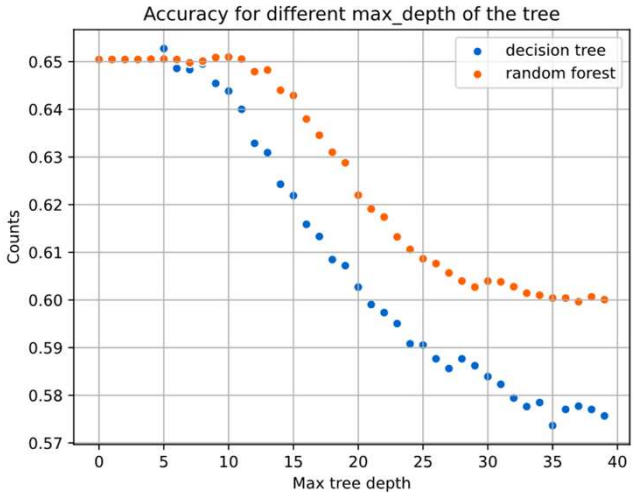


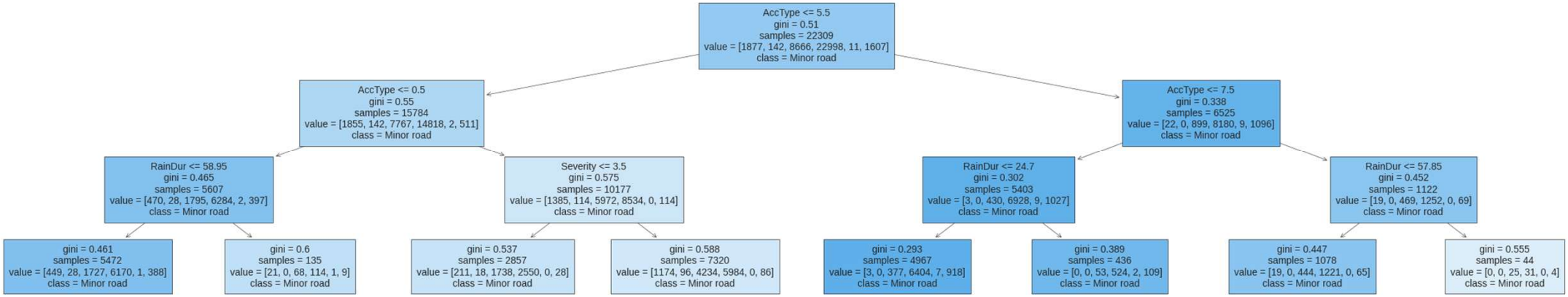
Classifications

- 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']

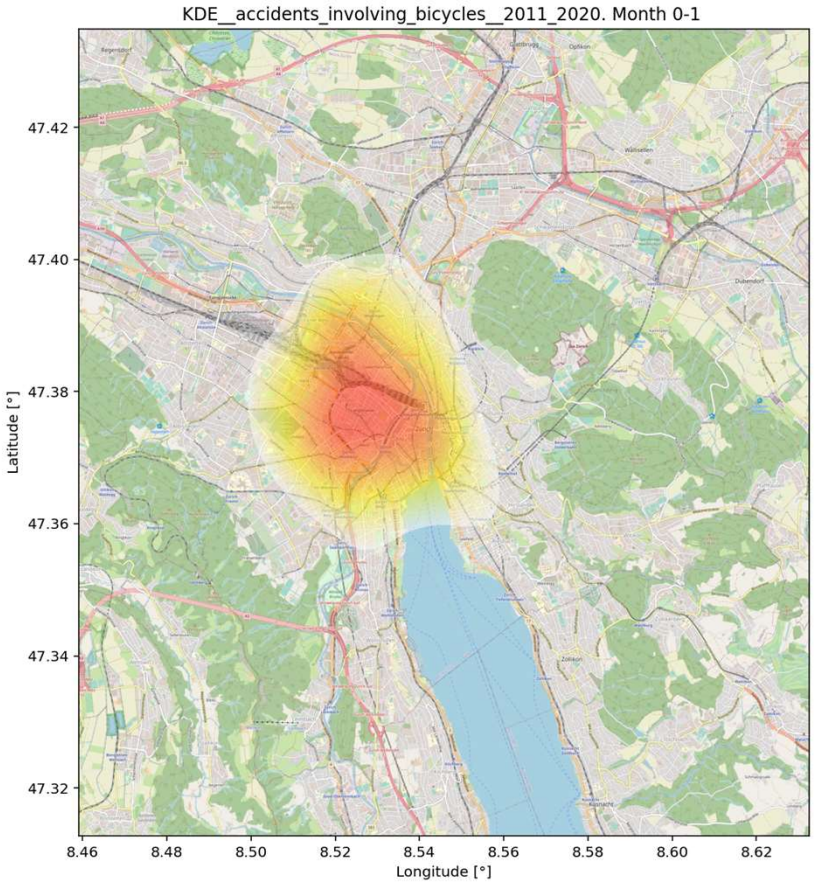
```
model = tf.keras.Sequential([
    feature_layer,
    layers.Dense(128, activation='relu'),
    layers.Dense(128, activation='relu'),
    layers.Dropout(.3),
    layers.Dense(num_units, activation='softmax')
])
optimizer = optimizers.Adam(learning_rate=0.01)
model.compile(optimizer=optimizer,
   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

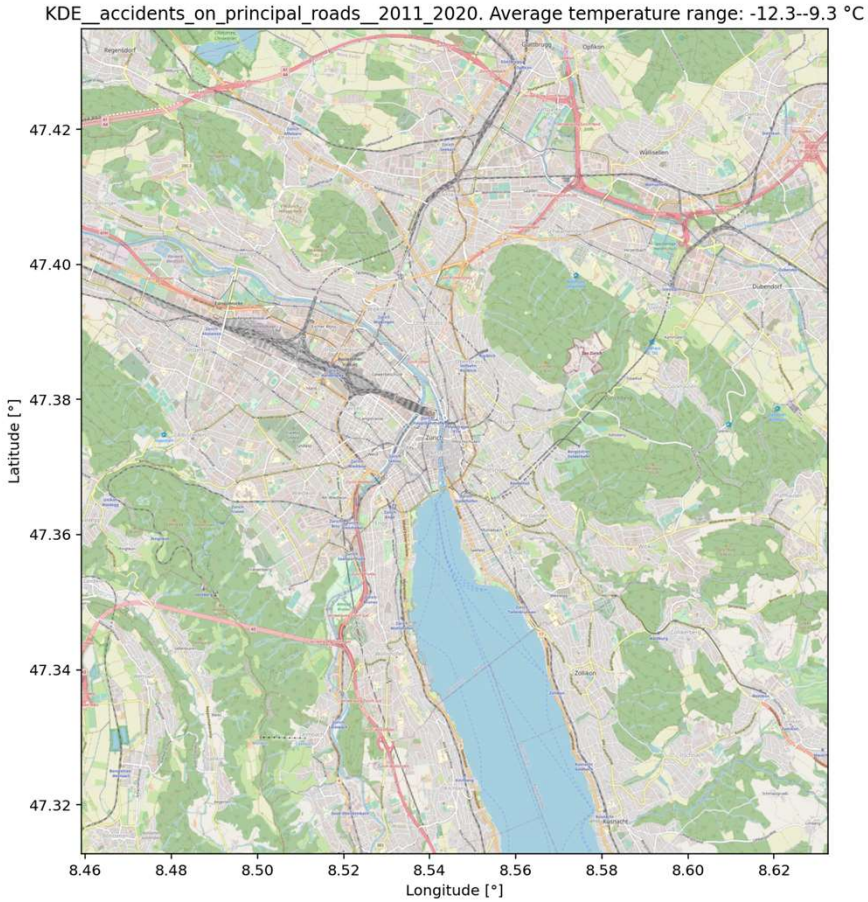
Kernel density estimation

- 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 ?

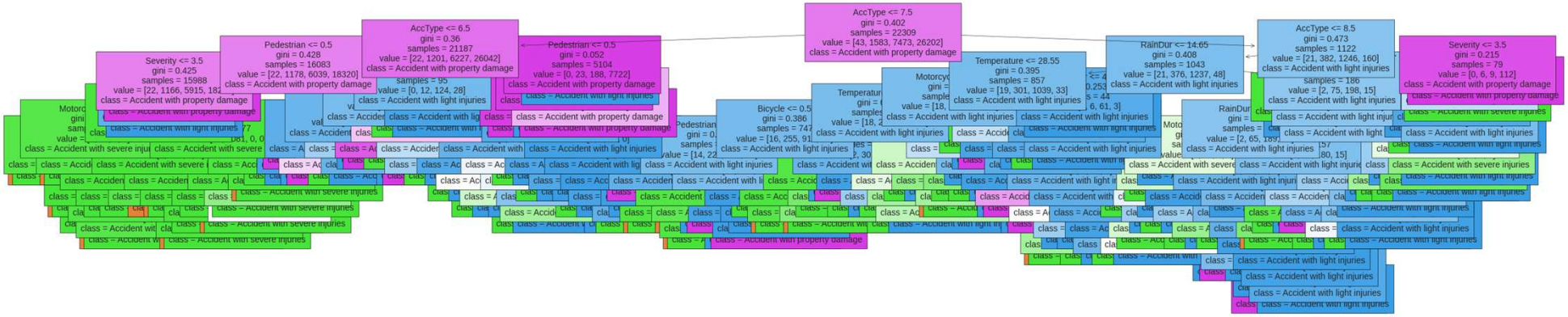
References

- 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_meteodaten_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

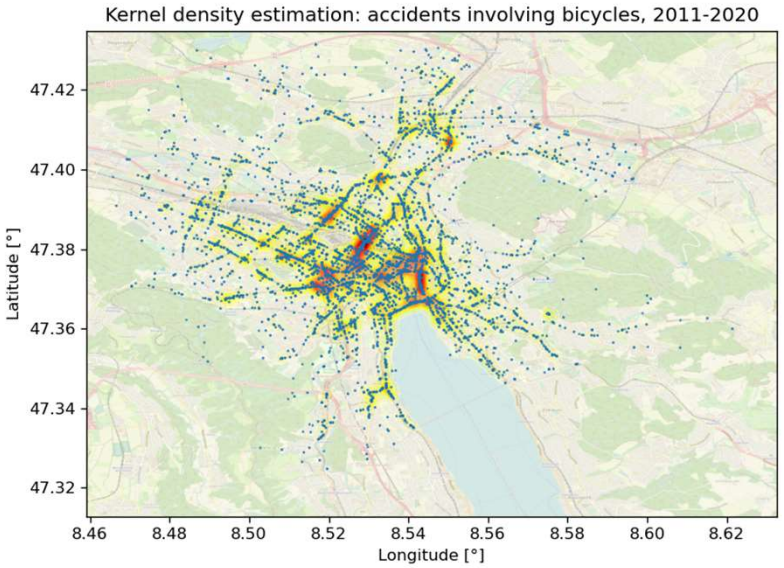

LocationE
LocationN
Temperature
RainDur
SumBikerNumber
SumCars
SumPedestrianNumber
RoadType
0
1
2
3
4
5

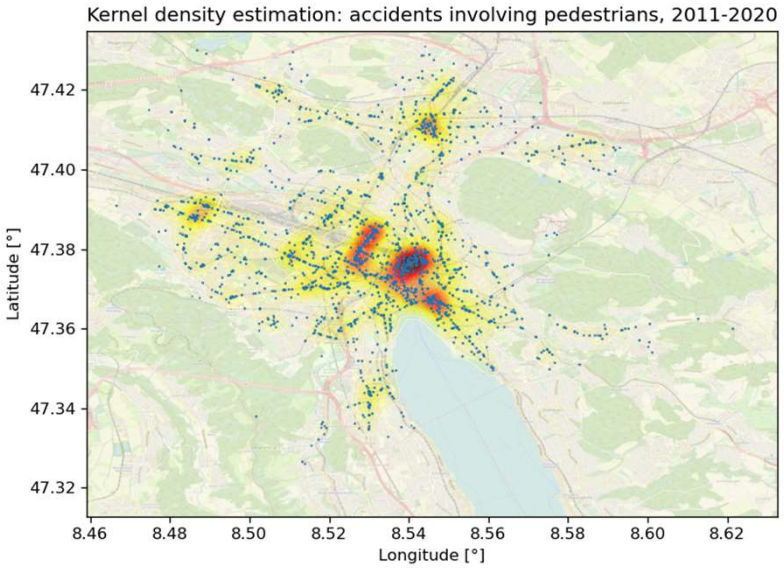
Appendix


AccType <= 7.5
gini = 0.402
samples = 22309
value = [43, 1583, 7473, 26202]
class = Accident with property damage
Pedestrian <= 0.5
gini = 0.428
samples = 16083
value = [22, 1178, 6039, 18320]
class = Accident with property damage
AccType <= 6.5
gini = 0.36
samples = 21187
value = [22, 1201, 6227, 26042]
class = Accident with property damage
Pedestrian <= 0.5
gini = 0.052
samples = 5104
value = [0, 23, 188, 7722]
class = Accident with property damage
Severity <= 3.5
gini = 0.425
samples = 15988
value = [22, 1166, 5915, 182
class = Accident with property damage
Temperature <= 28.55
gini = 0.395
samples = 857
value = [19, 301, 1039, 33]
class = Accident with light injuries
RainDur <= 14.65
gini = 0.408
samples = 1043
value = [21, 376, 1237, 48]
class = Accident with light injuries
AccType <= 8.5
gini = 0.473
samples = 1122
value = [21, 382, 1246, 160]
class = Accident with light injuries
Severity <= 3.5
gini = 0.215
samples = 79
value = [0, 6, 9, 112]
class = Accident with property damage
Bicycle <= 0.5
gini = 0.386
samples = 747
value = [16, 255, 91
class = Accident with light injuries
value = [0, 12, 124, 28]
class = Accident with light injuries
value = [14, 22
class = Accident with light injuries
value = [2, 75, 198, 15]
class = Accident with light injuries

Appendix

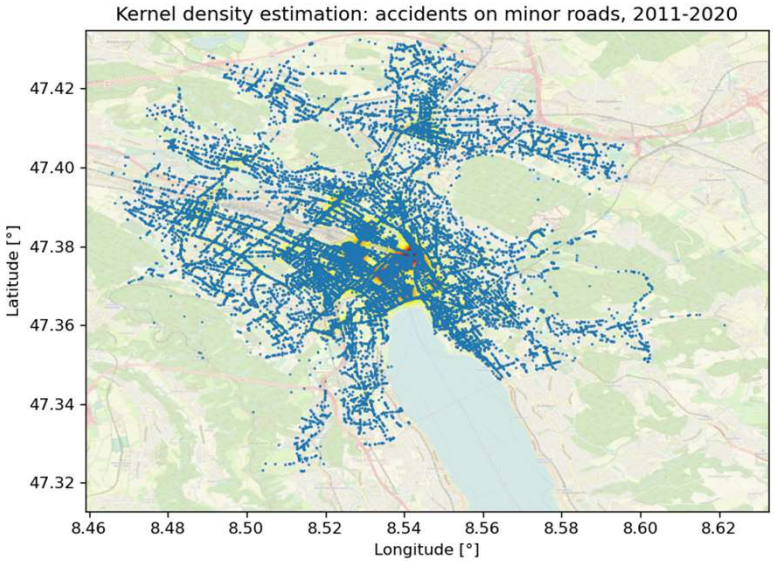
- Small subset of made KDEs

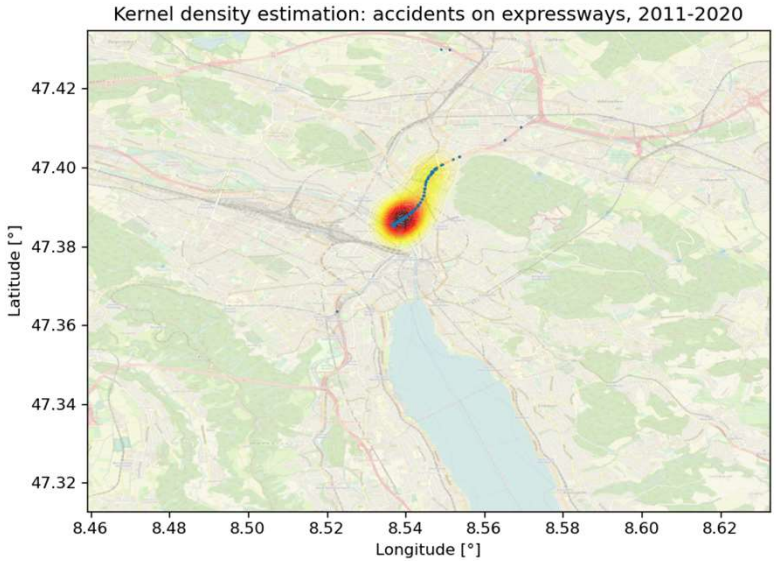




Appendix

- 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: 0.012121212121212121
Kernel density estimation: accidents with rear-end collision, 2011-2020 bandwidth estimate: 0.00202020202020202
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: 0.00202020202020202
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: 0.00202020202020202
```