How formula 1 crashes are influenced by various factors

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Abstract

This paper shows how crashes in formula 1 are influenced by certain properties of the circuits that's been driven on.

1 Introduction

In formula 1 crashes are more a rule than an exception. In the grand prix' [LINK] in 2017 only, half of the races had incidents in the section including the first turn. [LINK] We would like to find out if cars are more likely to crash if the circuit has a certain set of characteristics.

In previous research, various properties of racing are already taken into account, such as regulations and safety measurements on technical level of a car to improve the safety of a driver [LINK]. We hope to find particular causes in the properties of a track, to improve which can be used to reach this same goal.

In order to do this a model for the behaviour of drivers/cars is created and used to simulate races on various tracks under a few circumstances.

2 Methods

To obtain a view on how the amount of crashes is influenced by the (brake) distance for turn one and the (maximum) speed that could be obtained before it, Monte Carlo simulations are being used. Each simulation represents a start of a grand prix, in which every car attempts to pass the first turn. These cars, with an average length of five metres, and a width of two, start at a grid with two sides. Every other car starts left, or right, based on the first (pole) position, with 8 metres in between (LINK). For our simulation we divided the total width of the circuit in five lanes, to make it possible to take over cars. There are 20 cars in each race.

In the simulations, every track of the 2017 formula 1 calendar is being tested, 20 in total. To get results which mimic the real world, behaviour of drivers/cars is imitated through the following rules;

- The order of the cars on the grid is based on the achieved start grids from this season so far (17 configurations, till Japan). They are randomly used, to neglect incidental bad qualifications for drivers. Driver switches during the season are included.

- The focus in our model lies in moving forward. As long as the point of where a car should brake isn't reached, the car accelerates. The numbers being used to calculate the amount of metres that are added every second, are based on a few cars, and define the range for all cars.

- When the 'braking zone' is (nearly) reached, the negative acceleration is being calculated with the current speed of the car and the metres that are needed to brake for this turn on average (LINK).

Next to improving the distance driven, there will be attempted to move to an optimal position on the track. What's optimal for a car at a certain moment differs. Ideally, if a car is faster than the car in front of him, it will try to take over. Take overs will be done with the "optimal row"1 in consideration.

When a car is in front of another car which is considered faster, it will try to defend its position by moving towards the row the car in the back is driving, in order to 'block' it.

Driving into the braking zone also means that an optimal position should be chosen to drive into the turn.

Sometimes when a car is faster, has the plan to defend or to improve its position, other cars are blocking this, or the car needs to go off the track to obtain the result. In this case the current position on track will be maintained.

1. The opposite side of the turn is considered as being optimal. By driving there, you could maintain the top speed/accelerate as long as possible.

2.1 Crashes

To validate our hypothesis we need to define crashes. Checks for crash occurences will be executed till the second in which the car has passed the point of the turn.

A check validates if something happend between the current car, and the car in front of it. By doing this, it's possible to check if the manouvre which just was executed, either braking, switching or just accelerating could be performed succesfully.

Crashes can only happen between cars that are in the same row. If a crash is near, an additional switch of rows may be performed to avoid a crash. If the distance between the current car and the car in front is less than zero, it means there was a crash.

3 Results

The results are based on simulations which are ran 10,000 times for each track. The total sum of crashes is 121,747.

country	turn	mtr	brake	speed	crashes
Australia	R-L	381	100	150	7837
China	R-L	324.7	50	170	7664
Bahrain	R-L	476.4	100	70	7792
Russia	R-R	205.2	-	300	2103
Spain	R-L	690.5	100	130	7211
Monaco	R-R	111	75	103	7477
Canada	R-L	258	125	154	6334
Azerbaijan	L-R	206	50	116	7926
Austria	R-L	318	200	122	673
GB	R-L	270	-	281	991
Hungary	R-L	576	100	85	7550
Belgium	R-L	251	150	77	2887
Italy	R-L	615	125	80	7393
Singapore	L-L	274	50	126	8724
Malaysia	R-L	620	100	74	8849
Japan	R-L	373	10	152	1262
USA	L-R	364	100	86	8217
Mexico	R-L	890	200	107	6279
Brazil	L-R	334	50	109	5129
UAE	L-R	305	50	150	9449

Table 1: Overview of grand prix, with circuit data. All the circuits are listed in table 4, with all the necessary data. In the last column we can see the numbers of crashes based om our simulation model. The number of crashes seems divided equally for most of the circuits. Some of them have significant lower crashes, e.g. Austria, with only 673 crashes.

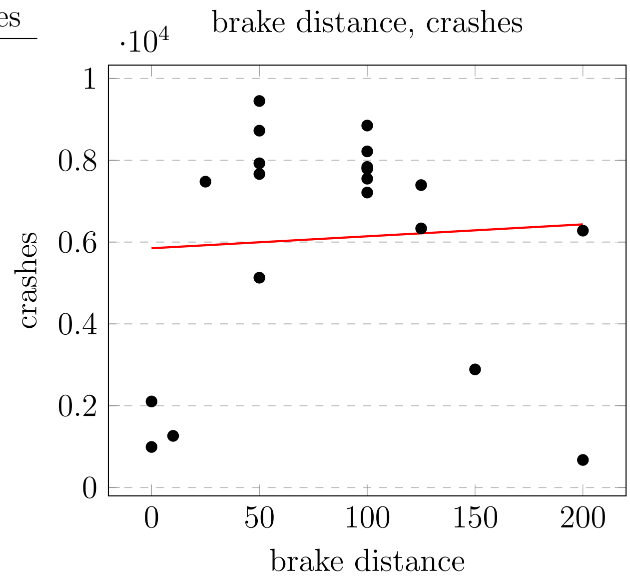


Figure 1: Crashes on scale of brake distance

In figure 1 every single dot means the numbers of crashes based on the brake distance. In this figure we see a stable trend. It seems that the brake distance doesn't affect the number of crashes.

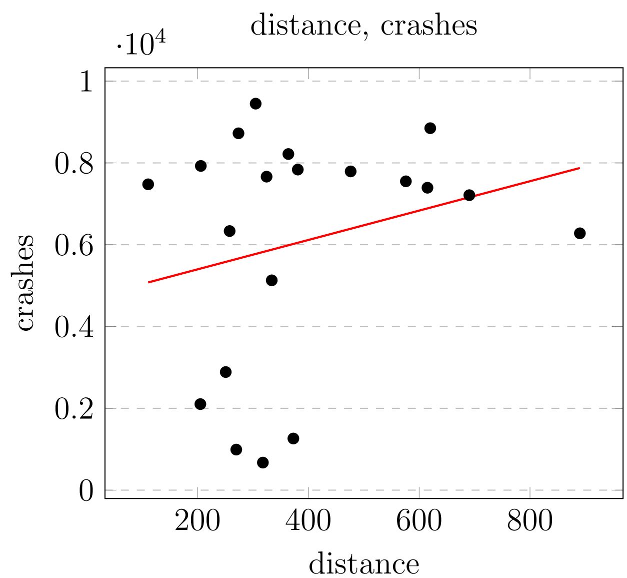


Figure 2: Crashes on scale of turn distance

According to figure 2, we see that the number of crashes increase when the distance rises. There are numerous causes for this, high speed could be one.

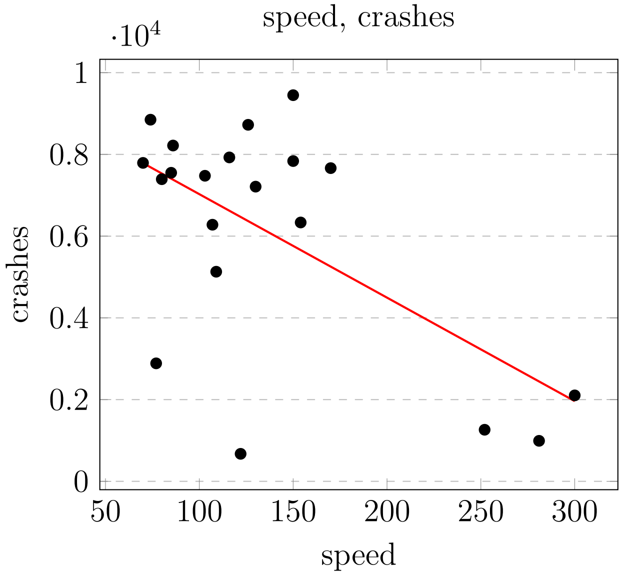


Figure 3: Crashes on scale of turn speed

When a driver can take a turn without braking much, the number of crashes will decrease. Figure 3 is a nice description of this behaviour and it seems logical. Imagine that you have a large turn coming ahead, then you and the drivers in front of you don't have to brake suddenly.

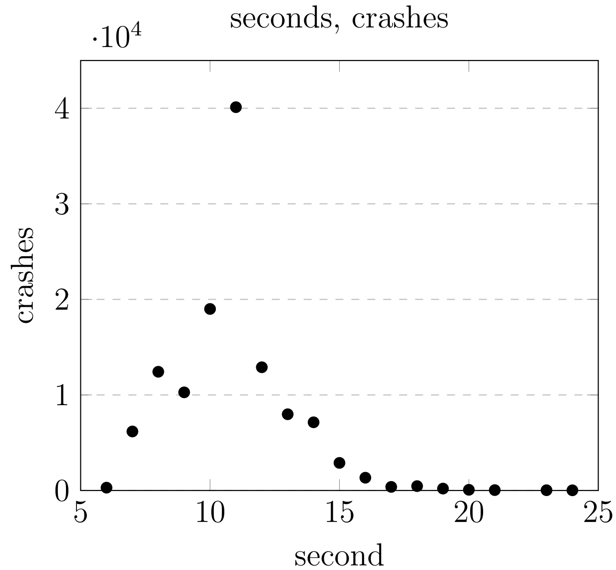
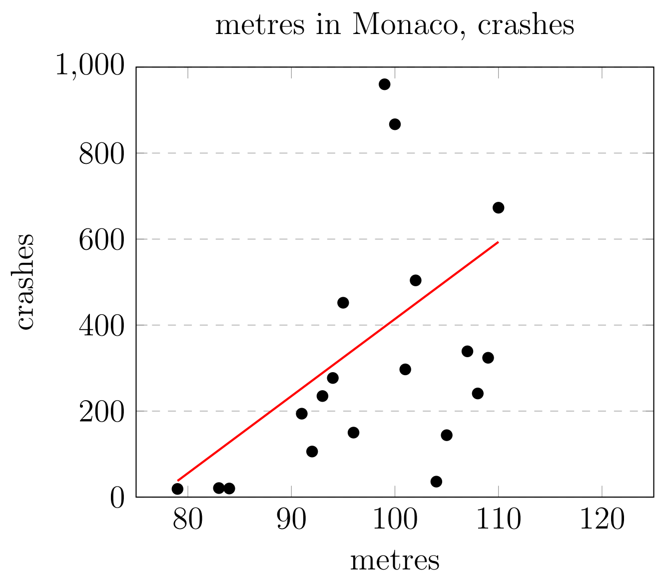
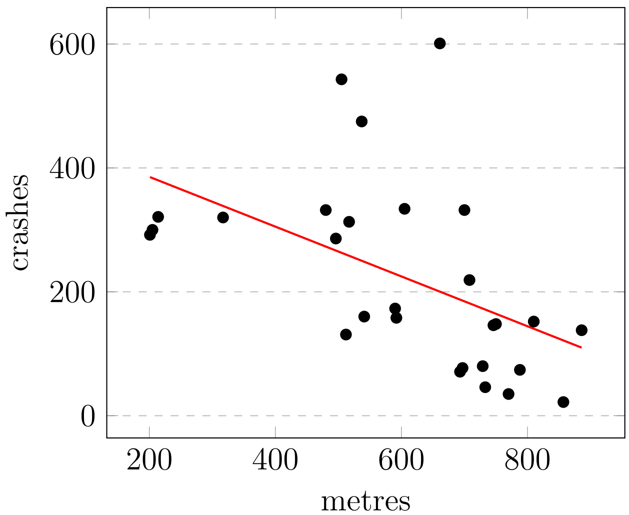


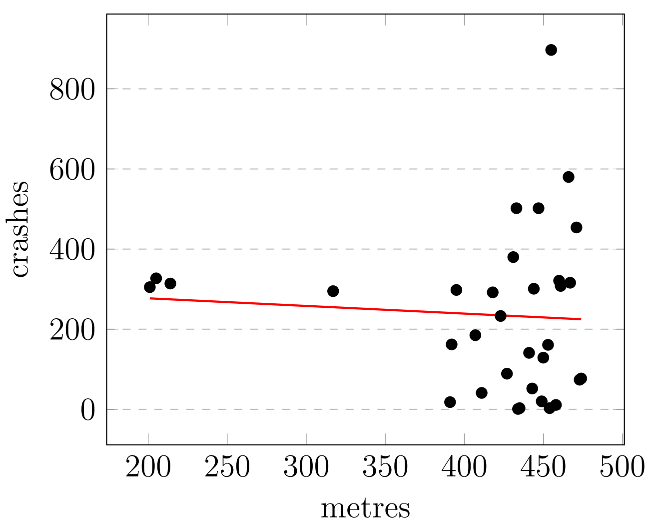
Figure 4: Crashes on scale of seconds



metres in Mexico, crashes



metres in Bahrain, crashes



(205,327)(214,314)(317,295)(391,18)(392,162)(395,298)(407,185)(411,41)(418,292)(423,233)(427,89)(431,380)(43

4 Discussion

(Meaning of your results w.r.t. others) Avoid vague subjective statements (like I find .., or .... highly significant...., etc.) Rather use "The figure shows ...."

MC traffic simulation, `https://link.springer.com/article/10.1007/s11709-009-0032-3`

Nagel Schrekenberg, traffic simulation? `https://people.sc.fsu.edu/~jburkardt/classes/isc_2009/monte_carlo_simulation.pdf`

Sort of something we do? Except we want to crash.. and these model try to avoid collision..

5 Conclusion

What did you learn, why did you do it, how does it advance science - done, what is left for future work? - done

Our goal of this paper is to predict the outcome of a Formula 1 race on a small part of a track. We want to find unsafe conditions, to improve the safety of the track and make it safer for the driver. However, during the eximination of our results, we figured that the crash of cars occur completely at random. We did not find a significant factor that show how or when a crash will hapen. By improving our model, with futher research, and try to mimic the real world F1 races with extra conditions like driver response or the width of the corner. Nobody can react as fast as a computer and the corners are most of the time smaller than the straight part. So you have to position yourself, react to other drivers, before entering the cornern. Also the acceleration is currently linear, which under normal circumstances is not linear. There are a lot of other factors that we have not take in account.

Appendix

The supplementary online material of our statistic hypothesis test and source code can be found on Jordi's Github page: `https://github.com/LiveNL/F1/SOM.pdf`

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References

[1] The Pennsylvania State University. *Chi-Square Tests*. Oct. 2017. URL: `https://onlinecourses.science.psu.edu/statprogram/node/158`.