Last Judgement Report

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1 Problem Statement and Motivation

In this work I show how auto-regressive integrated moving average (ARIMA) and vector auto-regression (VAR) can model the trajectory of a meteorite on its way of colliding with the Earth. I give an estimate of the expected point of impact and a recommendation of the area that should be evacuated. Also I estimate the total number of people that will most likely be affected and show how more accurate radar measurements can change the expected impacted region.

2 Dataset

The available data for this problem comes from a time series of radar position estimates x-y-z (z being the altitude) of the meteorite. The coordinates are given in kilometers and the time is given in seconds passed after the first measurement.

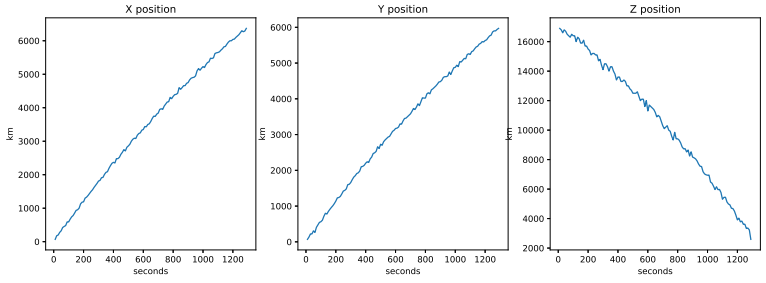

Fig. 1. The position over time for each dimension.

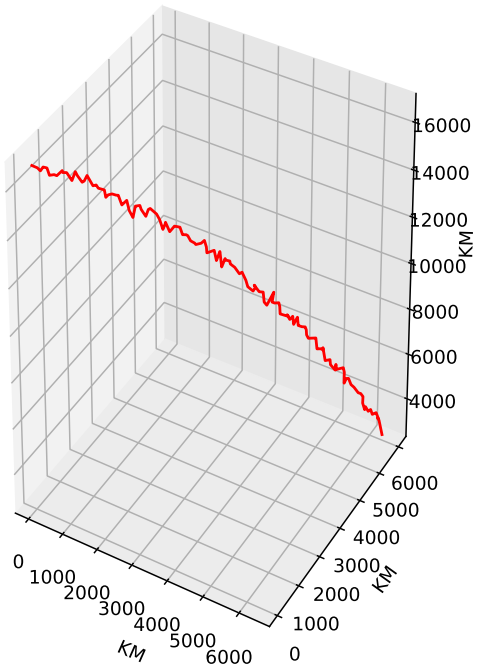

Fig. 2. The trajectory of the meteorite projected in 3D.

There is also a dataset of buildings close to the potential impact region. The important information of this dataset are the coordinates of each building and the amount of people living in there.

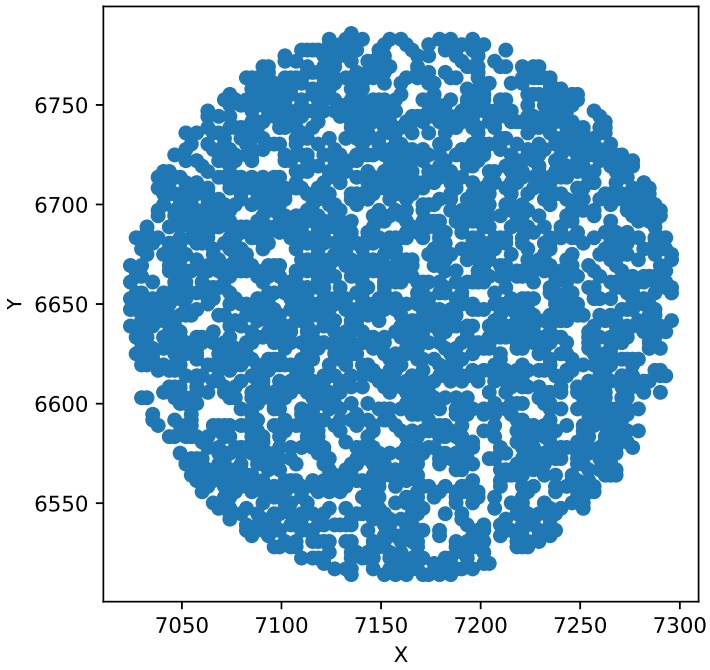

Fig. 3. The buildings are scattered in a circle shaped area with a radius of around 125.

3 Modeling Approach

We frame this task as a time series problem and model it with the auto-regressive integrated moving average (ARIMA). It has been shown that auto-regressive models can be successfully employed to predict object motion when information of physical forces is missing.[1][2]

First I inspect the velocity of the meteorite by taking the first difference. A KPSS test with p values of 0.01/0.01/0.013 (x-y-z) indicate that the velocity series is not stationary. Differencing the series another time to take the acceleration turns the series stationary.

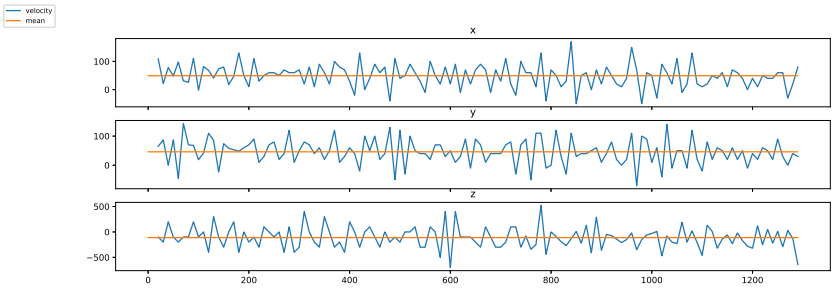

Fig. 4. The time series after taking the first difference.

On the other hand, the lag-1 auto-correlation is already negative for the velocity and thus it is better to choose to not further difference the time series for the ARIMA model. It is possibly to inspect the partial auto-correlation function and the auto-correlation function to determine the amount of AR and MA terms based on the lag beyond which each function has a sharp cutoff. But instead I do a grid-search of different ARIMA parameters based on the Akaike information criterion (AIC) to select the model. The "pmdarima" python library provides an integrated method for this.

[1] Ashraf Elnagar and Kamal Gupta. "Motion prediction of moving objects based on autoregressive model". In: *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 28.6 (1998), pp. 803–810.

[2] Desmond Chik, Jochen Trumpf, and Nicol N Schraudolph. "Using an adaptive VAR model for motion prediction in 3D hand tracking". In: *2008 8th IEEE International Conference on Automatic Face & Gesture Recognition*. IEEE. 2008, pp. 1–8.

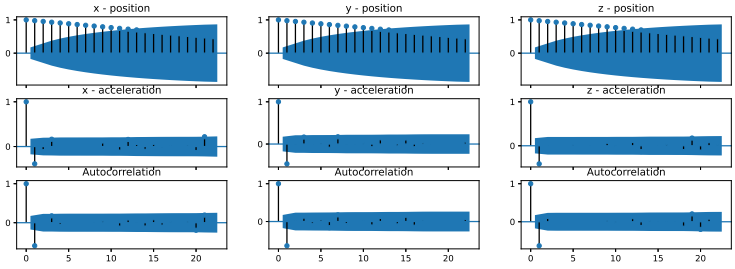

Fig. 5. The auto-correlation function of the original series and the first/second difference.

- auto correlation - cross column correlation

3.1 References and how to handle them

This is not intended to be a scientific paper, so it's fine you don't have scientific references, but feel free to use some for your practice.

If you use websites as references, then it's preferable to use footnotes, like this [3].

A sample reference list with entries for journal articles **ref˙article1**, an LNCS chapter **ref˙lncs1**, a book **ref˙book1**, proceedings without editors **ref˙proc1**, and a homepage **ref˙url1**. Multiple citations are grouped **ref˙article1**; **ref˙lncs1**; **ref˙book1**, **ref˙article1**; **ref˙book1**; **ref˙proc1**; **ref˙url1**.

4 Results and Interpretation

Briefly summarize any changes in your approach or implementation plans you have made along the way.

Next, show your results. How well does your model and/or implementation perform? Do you answer the questions posed properly? Did you meet the goals? Finally, give some interpretation. What do your results mean?

5 Conclusion

Summarize your work (briefly), the strengths and short-comings of your results, and speculate on how you might address these short-comings if given more time (or more data).

[3] this is a footnote

References

Chik, Desmond, Jochen Trumpf, and Nicol N Schraudolph. "Using an adaptive VAR model for motion prediction in 3D hand tracking". In: *2008 8th IEEE International Conference on Automatic Face & Gesture Recognition*. IEEE. 2008, pp. 1–8.

Elnagar, Ashraf and Kamal Gupta. "Motion prediction of moving objects based on autoregressive model". In: *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 28.6 (1998), pp. 803–810.