ProP (Projectile Prediction)

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1. Introduction

   I work for an organization that conducts experimental testing for a variety of customers. A part of testing consists of determining powder loads for the tests to ensure the target is impacted at the test parameter velocity; this effort can take a couple days. Currently, the method of honing in on the required loads is guessing on the gun powder load (GPL) required, test, adjust, and repeat. There is research that suggests the many factors that influence gun powder results (e.g., humidity, temperature, times the round has been used). Furthermore, not every program test setup is exposed the same dependent variables; this prevents the user using all previous test data to make new assumptions.

2. Methodology

   The software that was developed to predict the GPL does not use physics-based model but instead, statistical and machine learning based approaches. The problem that arises is when looking at the test data that spans over 20 years, it is difficult to determine what is meaningful and what is not. This software allows the user to input all data that they might think is relevant and by using machine learning, it can be decided what is and is not contributing to the GPL.

3. Implementation

   This software is envisioned to not only be utilized by engineers but also by the team in the field conducting the tests. To ensure that this software can be used by a multitude of users, the interface needed to be simplistic in its nature. This was accomplished in that the software only requires a single input by the user and provides a file that can then be implemented in their own way. To do this, the user call the software and inputs the name of the Excel file that will be used for machine learning and for predicting the GPL of the interested scenarios.

   The input of data is required to be Excel for this software. This decision was made due to the fact that users of the software rely heavily on Excel for most data analysis and making the input file Excel based is something that the user is familiar with.

For machine learning, Lasso with Elastic Net created by SciKit was implemented for the machine learning of the data that the user provides of the previously conducted tests. This method takes multiple parameters for a single result and weights them according to the influence they have on the result. This method was chosen in attempt to take the plethora of parameters involved within a test and produce a system that can determine effectively the right parameters to include and the accuracy of the final results. The data that is provided is organized in classes categorized by parameters. In other words, the test data is stored as an object with each item in the object representing a parameter that was recorded for the test results.

To complete all actions within the software, the packages relied on are Pandas, NumPy, Pytest, PyYAML, and xlrd.

4. Results: show sample results based on the functionality of your code. Keep in mind some of the plotting practices we talked about.

   The input of the data is within the excel file split into two separate sheets. The first sheet is comprised of the data that was collected to represent the system of interest with the powder load used in the first column of the data as shown in Figure 1. The data does not have a limit on the number of parameters observed or the number of tests recorded. The second sheet will consist of the system that needs to be predicted. The parameters of this unknown system need to contain the same parameters that are included on the first sheet except for the powder GPL. An example of this is given in Figure 2. The results of the predictions made based on the machine learning used is shown in Figure 3.

Powder load	Velocity Recorded	Weight of Threat	Humidity	Sabot Orientation	Distance to Target	Temperature
2916	4964	75	64	1	15	73
2986	5985	75	9	1	15	20
2742	7181	75	72	0	15	90
2336	5157	75	0	1	15	26
2018	6091	75	4	1	15	47
5424	6992	75	77	0	23	55
5358	5014	75	70	1	23	82
5324	6185	75	6	0	23	20
4228	6891	75	19	0	23	26
5050	5079	75	0	0	23	49
6071	5849	75	67	1	65	80
6506	6899	75	18	0	65	10
6607	5124	75	15	1	65	40
6546	6052	75	65	0	65	65
7221	7020	75	4	0	65	31
2097	4851	150	9	0	15	45
2209	5825	150	73	0	15	62
2838	7046	150	18	1	15	11
2709	4999	150	69	0	15	75

Figure 1 Sheet One of System Data

Powder load	Velocity Needed	Weight of Threat	Humidity	Sabot Orientation	Distance to Target	Temperature
1	5000	75	19	0	15	16
1	6000	75	76	1	15	60
1	7000	75	10	1	15	29
1	5000	75	62	1	15	81
1	6000	75	9	0	15	23
1	7000	75	65	1	23	51
1	5000	75	74	0	23	88
1	6000	75	77	1	23	62
1	7000	75	14	1	23	46
1	5000	75	74	1	23	65
1	6000	75	19	0	65	12
1	7000	75	62	0	65	87
1	5000	75	12	0	65	33
1	6000	75	15	1	65	47
1	7000	75	77	0	65	57
1	5000	150	76	0	15	63
1	6000	150	7	0	15	38
1	7000	150	9	0	15	26
1	5000	150	1	1	15	23

Figure 2 Predicted System

Powder load	Velocity Needed	Weight of Threat	Humidity	Sabot Orientation	Distance to Target	Temperature
3159.126	5000	75	72	0	15	79
3271.31	6000	75	61	1	15	58
3341.303	7000	75	79	1	15	84
3155.542	5000	75	75	0	15	76
3333.047	6000	75	3	0	15	37
3991.099	7000	75	2	0	23	16
3728.072	5000	75	69	0	23	64
3827.115	6000	75	69	1	23	88
3980.347	7000	75	11	0	23	11
3815.658	5000	75	2	1	23	44
6870.525	6000	75	6	1	65	21
6951.268	7000	75	15	1	65	45
6774.251	5000	75	10	1	65	29
6797.274	6000	75	61	0	65	90
6889.15	7000	75	67	1	65	89
3171.57	5000	150	18	0	15	24
3197.363	6000	150	73	0	15	72
3370.471	7000	150	11	1	15	42
3179.932	5000	150	11	0	15	35

Figure 3 Predicted GPL

5. Conclusions

This software does manage to complete the original proposal put forth for this class and has room to still improve. In the immediate future, it is planned to present to the user the accuracy of the machine learning based on the data provided. This will give an indication of how accurate the produced data is and if more data or more parameters need to be provided to produce a more accurate result. Furthermore, it is planned to have the software include a feature selection. This will go through the data that is provided and determine if there are any parameters that do not contribute to the result within a certain percentage. This will allow the user to determine which parameters are of interest and can perhaps provide a larger data set with fewer parameters required for the machine learning. The first item that will be changed for this software is the increase of functions within the script. The software includes only a handful of functions in its current state. Because of this, it was virtually impossible to generate test conditions to be tested for any software updates. The code needs to be simplified into functions that have clear parameters that can be measured and verified. Other than this component, the software is complete and meets the expectations for the class and encompasses all the conditions listed in the initial proposal.

6. References

Levi Coey (2019, June 12). Projectile_Prediction (Version v1.0.1). Zenodo. http://doi.org/10.5281/zenodo.3244456