# Project Luther Summary
# Predicting High School Track Results

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## Project Design

This project was motivated by the large quantity of data available on track and field meets on the web site www.athletic.net. The web site has lists of athletes competing in all events as well as detailed information for each athlete. For this project the focus was on Washington State high school athletes. The web site has full high school data for athletes graduating between 2006 and 2017.

The goal was to predict future performance of an athlete based on past performance. Data was pulled from the web site for girls and boys competing in the 400 meter and 1600 meter events. For each of the 4 high school years (9th, 10th, 11th and 12th grades) the personal record (PR) for these events were compiled. Only athletes who had competition results for all four years were included in the data set. More data points were collected for the 1600 race because for most of these races any number of athletes can enter the event. For the 400m races the entrants are limited due to a limited number of lanes on the track.

The data set included:

| | # girls | # boys | Total | # Schools |
|---|---|---|---|---|
| 400 meters | 382 | 444 | 826 | 186 |
| 1600 meters | 852 | 1204 | 2056 | 198 |

## Data

For each athlete the following data was collected.

| Variable | Type | Description | Use in Model |
|---|---|---|---|
| Athlete's Name | str | Record descriptor | N |
| Athlete's ID number | int | Record descriptor from athletic.net | N |

| | | | |
|---|---|---|---|
| Graduation Year | int | Year the athlete graduated from high school | Y |
| Athlete's School | Int | Each school will be given an integer number | N |
| Athletic District | int | 9 Districts in the state of Washington | Y |
| 9th Grade PR (Personal Record) | float | Best competition time for this school year | Y |
| 10th Grade PR (Personal Record) | float | | Y |
| 11th Grade PR (Personal Record) | float | | Y |
| 12th Grade PR (Personal Record) | float | | Target |

The athlete's athletic district and graduation year is an indication of the competition they would have during their races. There were approximately 200 schools represented in this dataset so this feature was struck from the analysis in favor of the athletic district.

## Models

Race times from 9th, 10th and 11th grade were used to predict the 12th grade times.

An investigation of model complexity was performed to determine what level of complexity was required to get a good prediction.

Algebraic

A simple examination of the data shows that plotting the ratio of growth from 10th grade to 11th grade over the growth from 11th grade to 12th grade is almost 1.

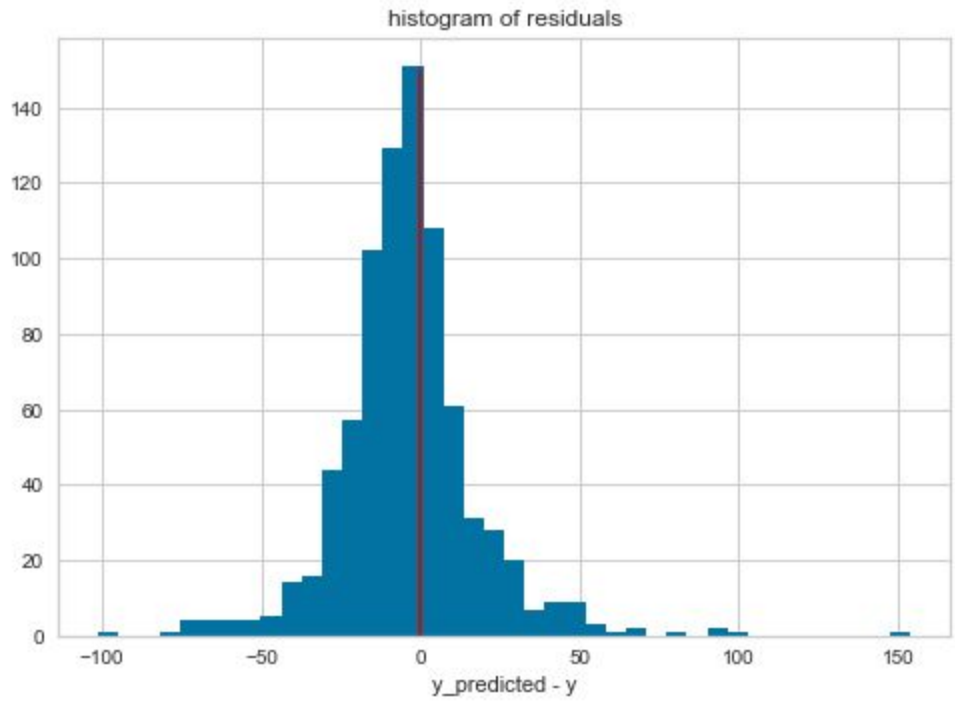
$$\frac{t_{12}}{t_{11}} / \frac{t_{11}}{t_{10}} \approx 1$$

From this knowledge a simple algebraic model can be tested to predict the 12th grade times. This model assumes this ratio of times is equal to 1. Or in other words:

$$t_{12}(predicted) = \frac{t_{11}^2}{t_{10}}$$

This model produces the following results

| | RMSE 400 meters race<br>Mean time = 58.4 sec | RMSE 1600 meters race<br>Mean time = 317.0 sec |
|---|---|---|
| Algebraic model | 3.7 sec (6.3% of ave) | 21.6 sec (6.8% of ave) |



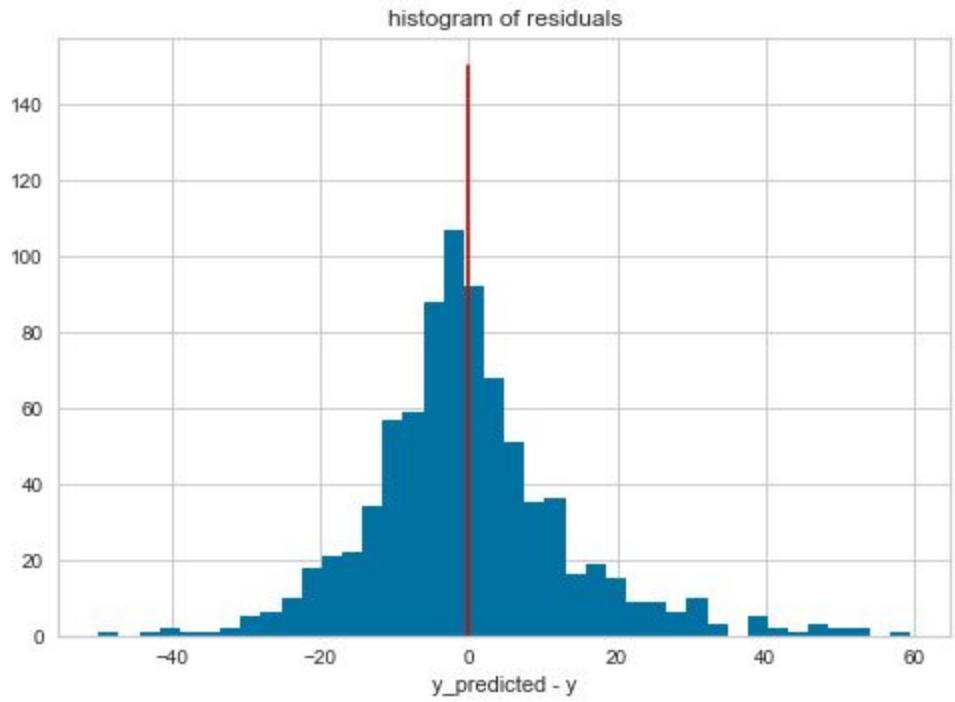

This is pretty good but from the above plot of the residuals we are predicting lower times with this model then the data shows.

Linear Regression

A simple linear regression model was fit to the data. One-hot encoding was used to account for the different districts.

From the above plot you can see that the residuals are more evenly distributed and the model is producing better results.

| | RMSE 400 meters race<br>Mean time = 58.4 sec | RMSE 1600 meters race<br>Mean time = 317.0 sec |
|---|---|---|
| Algebraic model | 3.70 (6.3% of ave) | 21.64 (6.8% of ave) |
| Linear Regression | 2.18 (3.7% of ave) | 13.54 (4.3% of ave) |




Further examination with this linear regression model shows that significantly less data then is available is required to train this model. Data from only 150-200 athletes is required, significantly less than as available in the dataset. Knowing this, a reduction in the geographic area or number of years of data would produce similarly accurate results

Significance of Features

LASSO regularization was used to determine the importance of the importance of the features in the linear regression model. In the table below are listed the features in the dataset. The most important feature for both the 400m and the 1600m races is the time in the 11th grade. For the 400m race this is followed by the time in the 10th grade and then by the sex of the athlete. For the 1600m race this is followed by the graduation year. When the model was ran with just these features marked with green check marks the accuracy did not change significantly.

| Race | Importance of Features | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Districts | | | | | | PR for grade | | | Sex | Grad Year |
| | 1 | 2 | 3 | 4 | 5 | 6 | 9th | 10th | 11th | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 Meter | X | X | X | X | X | X | X | ✓ | ✓ | ✓ | X |
| 1600 Meter | X | X | X | X | X | X | X | X | ✓ | ✓ | ✓ |

Other models

Two other models were tried. In the hope of picking up more of the taper off of times during the 12th grade year, higher order terms were added to the model. Two features were added, one with the square of the 12th grade PR and the other with the square of the 11th grade PR. This addition to the model did not improve the accuracy of the prediction. The other model was a mixed effects regression which showed similar results as the linear regression.

| | RMSE 400 meters race<br>Mean time = 58.4 sec | RMSE 1600 meters race<br>Mean time = 317.0 sec |
|---|---|---|
| Algebraic model | 3.7 sec (6.3% of ave) | 21.6 (6.8% of ave) |
| Linear Regression | 2.2 sec (3.7% of ave) | 13.5 (4.3% of ave) |
| Adding Higher Order terms to Linear Regression | 2.3 sec | 13.4 sec |
| Mixed Effects Model | 2.1 sec | 13.6 sec |

## Conclusions and Future Extensions

The accuracy of these linear models was quite good and a definite improvement over a simple algebraic model. But there was a limit to what the models could predict. This should be improved by adding more features to the model. The full event list for each athlete is available on www.athletic.net. It would be interesting to add more details about the athlete's competitions within each school year. It would also be interesting to add information on which other events in which the athlete competed.

The model required relatively few features and data points (athletes) to provide an accurate prediction. For future work it should be noted that the dataset need not be this big.

This approach could easily be extended to an investigation of field events as well as to running events.

A very relevant use of this type of predictive model of future performance is for athletic recruiting, for example colleges recruiting from high schools.  The work here shows merit and indicates the potential of extension to the prediction of college performance based on high school performance.

## Appendix

Tools used for this analysis

- Pandas
- Numpy
- Statsmodels
- Patsy
- Scikit Learn
- Beautiful Soup
- Yellowbrick
- Matplotlib