Data 8 Connector: Sports Analytics

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4/17/2018 - Regression Modeling

Linear Fit/Regression

A linear fit encodes the linear relationship between two variables

Correlation is closely linked to linear fits

- ➔ Small errors and higher slope → stronger correlation

Correlation quantifies the association, linear fit gives the functional relationship

We used linear fits for

- ➔ Estimating relationship between runs/points and wins
- ➔ Measuring performance of batting metrics
- ➔ Explanatory power of Four Factor model

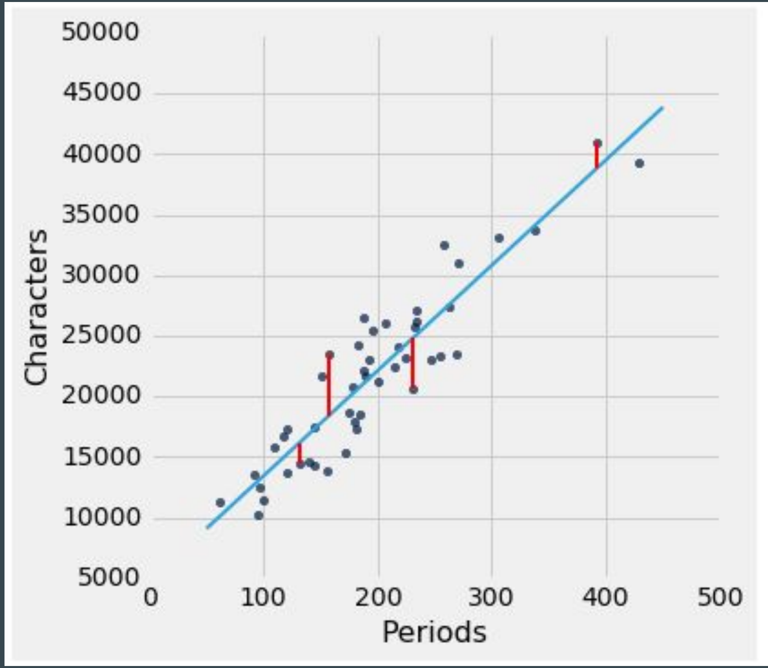
Method of Least Squares

How do we obtain the regression fit?

Method of least squares

Sec 15.3 of Inferential Thinking

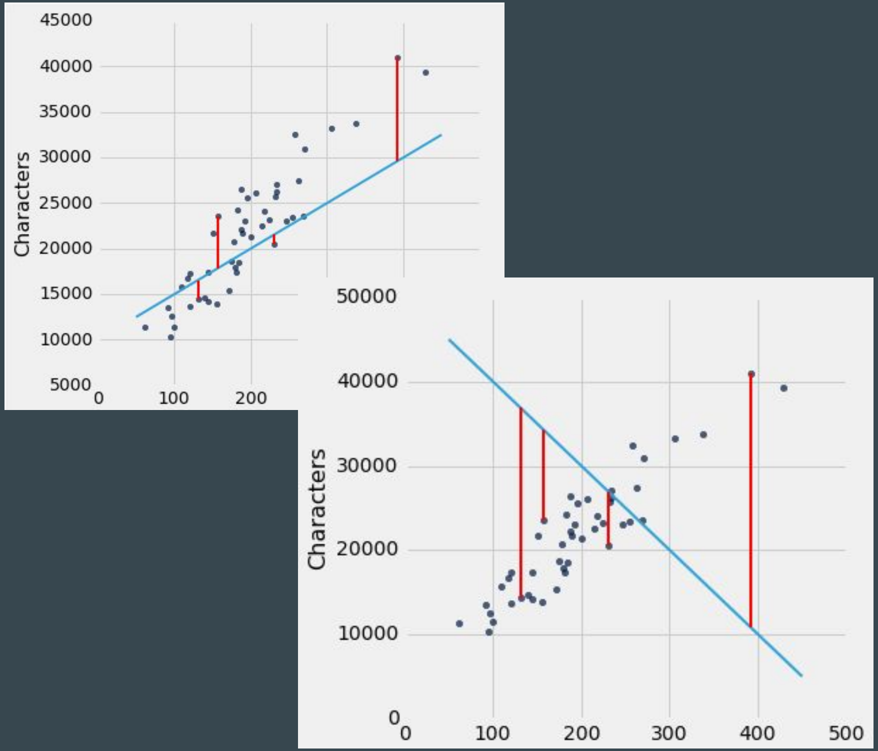
Our goal is to find a line that minimizes the Mean Squared Error (red lines)



Method of Least Squares

In trying to find the optimal fit, we'll avoid large errors and find good overall performance

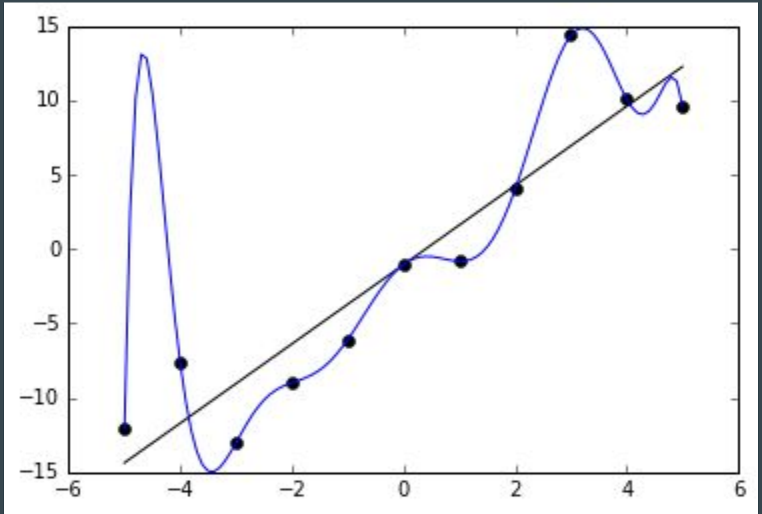
The goal is the magnitude of the errors is as small as possible



Method of Least Squares: Overfitting

After optimizing, the fit won't necessarily be flawless but we will avoid ridiculous results

As we'll see, optimizing can also backfire. We can fit the data too well leading to poor prediction on new observations



Multiple Regression

The relationship between an observation and inputs is given by:

$$\text{Observation} = \alpha + \beta_1 \cdot \text{Input}_1 + \cdots + \beta_k \cdot \text{Input}_k + \text{Error}$$

We want to quantify simultaneous impacts of variables

Realistically never enough observations to enumerate everything and compute EVs

- It worked for run values: not a lot of values, lots of data, isolated impact

Multiple Regression

Inputs can be continuous variables like height, weight, area, or anything else

We can also use discrete variables. A simple example would be a binary variable

Multiple Regression: Method of Least Squares

The relationship between an observation and inputs is given by:

$$\text{Observation} = \alpha + \beta_1 \cdot \text{Input}_1 + \cdots + \beta_k \cdot \text{Input}_k + \text{Error}$$

The method of least squares still applies

$$\text{minimize} \sum \text{Error}_i^2 = \text{minimize} \sum (\text{Observation}_i - \text{Prediction}_i)^2$$

$$\text{Prediction} = \alpha + \beta_1 \cdot \text{Input}_1 + \cdots + \beta_k \cdot \text{Input}_k$$

Multiple Regression: Interpretation

What is the prediction value?

Our expectation of the observed value given the input attributes

If we receive a new set of inputs (say we're Zillow and someone lists a house) we can use the regression model to form an expectation of the observation

Multiple Regression: Interpretation

What about the coefficients?

- The marginal effect of the variable

All things being equal, if we increase a variable by 1 unit, the coefficient quanties the change in expectation

We often use continuous variables like height or weight but can also use discrete variables

- A simple example would be a binary variable like “house has a jacuzzi”

Coefficient represents impact of the binary condition being true

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Multiple Regression

Let’s try it with a demo

Plus/Minus

Raw Plus/Minus is a statistic that routinely gets used but is quite terrible and useless

To compute plus/minus:

- Track the score change while a player is on the court
- If the score goes up by 10, the player is a +10
- If the score goes down by 5, the player is a -5

You can compute +/- for a game or aggregate it for a season

You could normalize it to per 100 possessions if you wanted

Plus/Minus

The most obvious issue with +/-: if you play with Lebron, you’re potentially going to get rated too high

Alternatively, if you play with someone bad, it’s likely you’ll be rated too low

It also does not address opponent strength: a +10 against the worst team is the same as a +10 against the best team

And if your team is good, it’ll outscore opponents so every player will look positive

Plus/Minus

One quick remedy that is used: on/off differential

- Track +/- for when a player is on versus off
- Compute the difference (per 100 possessions)

By computing the on/off measure, you are trying to isolate the player's effect

This is a common statistical technique:

- Compute differences between results from a binary condition is True and False

If there is enough diversity in all the other variables (other players on the court), you will be able to measure the size of the effect

Adjusted Plus/Minus

Given that there are so many simultaneous impacts of players, this seems like a perfect opportunity to use regression modeling

Adjusted +/- uses regression to estimate the impacts and compute a +/- player rating

This is known as a *top down metric*

Use end results (scores, wins) to estimate player performance

Top Down Metrics require methods like regression modeling

In contrast, *bottom up metrics* use collected microevents to build towards an evaluation: points, rebounds, singles, doubles, etc

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Adjusted Plus/Minus

We collect data on *stints* for an entire NBA season

A stint is a contiguous block of time where the same 10 players are on the court together

For each stint, we track who was on the court, the number of possessions, and the offense/defense performance

We model team performance as the sum contribution of each player on the court.

Adjusted Plus/Minus

Our goal is to build this model:

$$\begin{aligned}\text{HomeTeamNetRating}_t &= \text{HomeCourtAdv}\\ &+ \text{Sum(Home Player } i\text{'s rating if player } i \text{ is in the } t\text{-th stint)}\\ &- \text{Sum(Away Player } i\text{' rating if player } i \text{ is in the } t\text{-th stint).}\end{aligned}$$

Each variable corresponds to a player

0 if the player *was not* on the court during the stint

1 if the player *was* on the court during the stint

Adjusted Plus/Minus

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We end up with a table of 0s and 1s

Size is (Number of Stints) × (Number of Players + 1)

We include an extra variable representing the home court advantage

Each row will have exactly 11 non-zero values

Adjusted Plus/Minus: What can go wrong?

Regressions aren't perfect and can fail for a few simple reasons

First off, we probably should have bucketed players who didn't play much into a unified "scrub" player

A player who was in for one short stint and saw a net rating of +200 will have the regression optimized aggressively try to give him a big rating

The optimizer can easily and freely reduce the RMSE doing this so why not?

Adjusted Plus/Minus: What can go wrong?

Okay, so we dumped the “scrubs”. Would that fix things?

We’d get closer but still not good enough

Observed NBA Lineups do not behave like randomized controlled trials

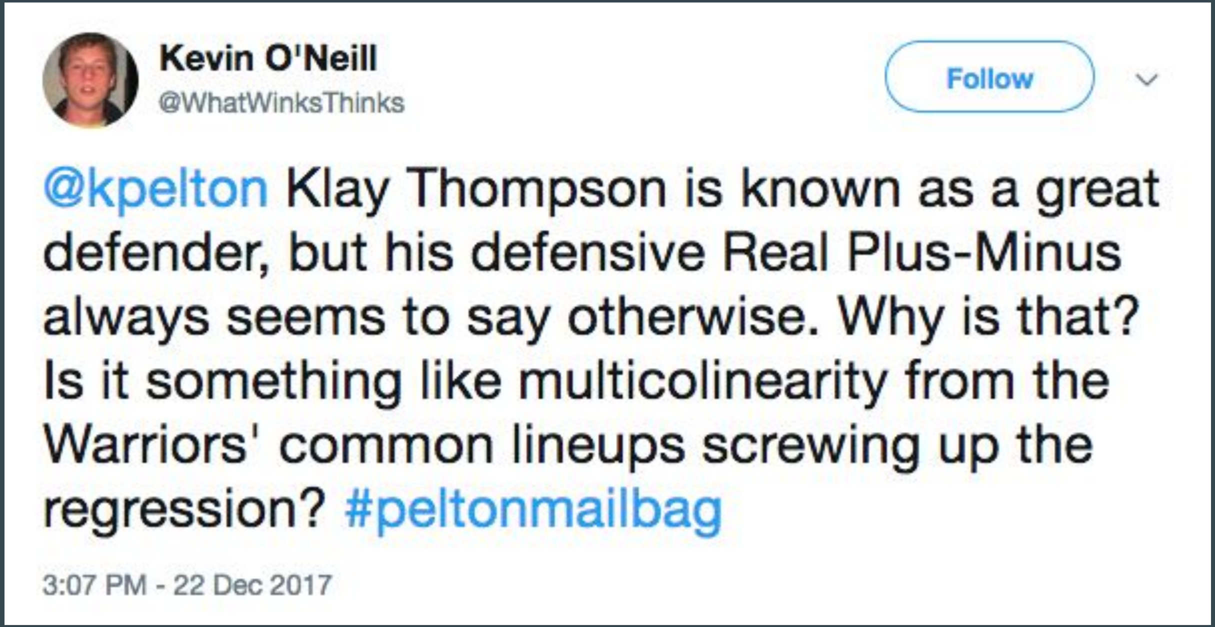
- Sometimes two players almost always play together.
- Or two players always switch for each other

In general: given 9 players on the court, we can do a really good job predicting the 10th

Adjusted Plus/Minus: What can go wrong?

- In an ideal world, we'd get to randomly shuffle players around
  - Of course, this ignores coaches and learning to play together
- So this lack of good randomization in lineups leads to a well-known issue:
  - Multicollinearity

Adjusted Plus/Minus: What can go wrong?


Kevin O'Neill
@WhatWinksThinks
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@kpelton Klay Thompson is known as a great defender, but his defensive Real Plus-Minus always seems to say otherwise. Why is that? Is it something like multicolinearity from the Warriors' common lineups screwing up the regression? #peltonmailbag

3:07 PM - 22 Dec 2017

http://www.espn.com/nba/story/_/id/21921522/kevin-pelton-weekly-mailbag-including-wizards-playing-to-competition

Adjusted Plus/Minus: Multicollinearity

I was hesitant to use this term since it’s overly technical and jargony

However, Kevin Pelton does a good job of explaining:

> Readers shouldn't be scared off by the word multicollinearity, which in this context means that adjusted plus-minus has a difficult time determining which player to credit for a team's success or failure when they tend to play together frequently. I don't think that's a big issue for the Warriors because of games their stars miss due to injury and the fact that Steve Kerr tends to mix his starters and reserves. Multicollinearity is a bigger issue when coaches tend to exclusively play their starters and reserves together, or there are specific players who play only when the other is off the court.

Adjusted Plus/Minus: Multicollinearity

So how do we address multicollinearity? The solution:

Simultaneously minimize least squares but also *penalize aggressive fitting*

If the optimization wants to assign a big value to someone, it better have a lot of evidence behind it, ie. the reduction in the least squares needs to offset the penalty imposed.

The penalty is on the sum of squares of the coefficients

- We pick a penalty parameter to quantify the strength of this penalty
- There are methods that can suggest a good value.

Regularized Adjusted Plus/Minus (xRAPM)

When we fit the the penalized regression, we get Jerry Engelmann's statistic called *Regularized Adjusted Plus Minus* or xRAPM

Regularization is the same thing as penalization, just a term out of mathematics

Engelmann typically uses multiple years of data but we will do pretty well with one

xRAPM is the cousin/basis for ESPN's Real Plus/Minus statistic

RAPM Demo

RAPM: Picking the Penalty Parameter

So how do we pick the penalty parameter?

Without the penalty, our model overfits and will not perform well in prediction on new data

We don't have new data though...

We can actually split our data into two components

- On one component, the training component, we fit the model
- On the other component, the testing component, we evaluate the model

RAPM: Picking the Penalty Parameter

Evaluating on the test component gives us an idea of how well the model performs

How do we split the data?

Randomly. And as many times as we have time for.

If we collect enough test results from these random splits, we can approximately know how our model performs in prediction

So how does this work with the penalty?

RAPM: Picking the Penalty Parameter

1. Fix the penalty parameter
2. Randomly split the data a bunch of times
3. Fit the penalized model on the data splits
4. Get the test results for each of the models and average
5. Vary the penalty parameter to see which one has the best test results

This is known as *Cross-Validation*

You cross-validate the model against data you do have so you can gauge how it will perform in prediction

Regression and Plus/Minus

RAPM is not the only game in town

APM: Adjusted Plus/Minus

Uses the basic regression. Our version was junk but with a bit of data cleaning this could be fixed

RAPM: Regularized Adjusted Plus/Minus

Uses penalization to help stabilize the regression. More automatic than data cleaning

SPM: Statistical Plus/Minus (might be outdated/dead)

Regress APM onto box score data (points, reb, etc). This is a two-stage process. The second stage stabilizes the results from APM

BPM: Box Plus/Minus (Basketball Reference)

Regress RAPM onto box score data. A two-stage process like SPM

Regression and Plus/Minus

And of course

RPM: Real Plus/Minus (ESPN)

Proprietary but supposedly uses all sorts of information like aging and coaches and box score data

One last comment:

You don’t even have to do Plus/Minus for scoring. You can put in rebounding and obtain the marginal effect for rebounding