Housekeeping

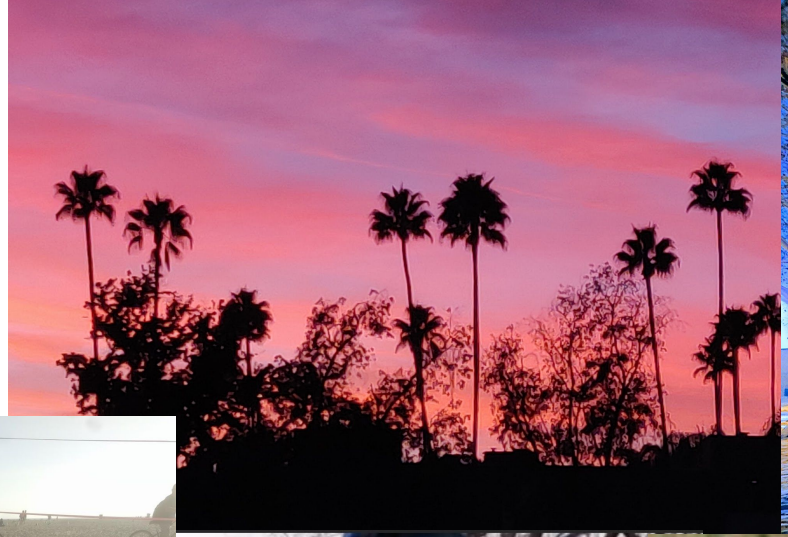
If you are waiting, please:

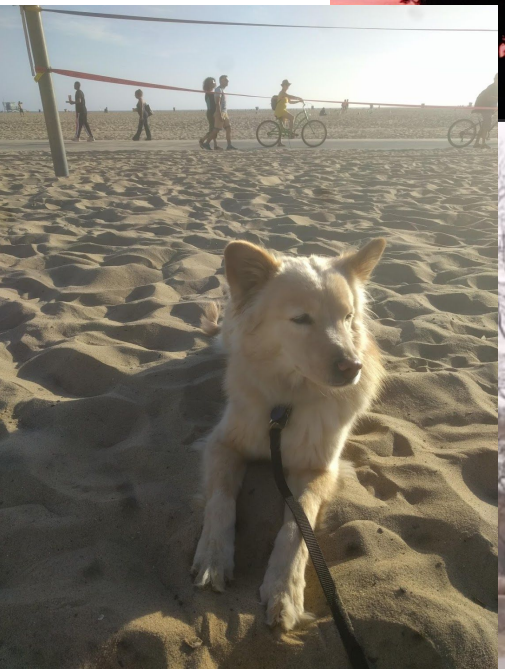
- Please “git clone” or download this repo:
  https://github.com/alextrickey/adz_demo.git
- From an R terminal outside of RStudio, run:
  install.packages(“forecast”)

Data Science Applications in Ad Tech

Alex Trickey PhD
2020-02-24

About Me





I Also Do Data Science

Provide fit prediction and style matching services to online clothing retailers

Ad Optimization (Today's Topic)

Data and analytics consulting for large media and entertainment companies

PhD Quantitative Psychology

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What Is Ad Tech?

Advertising technology

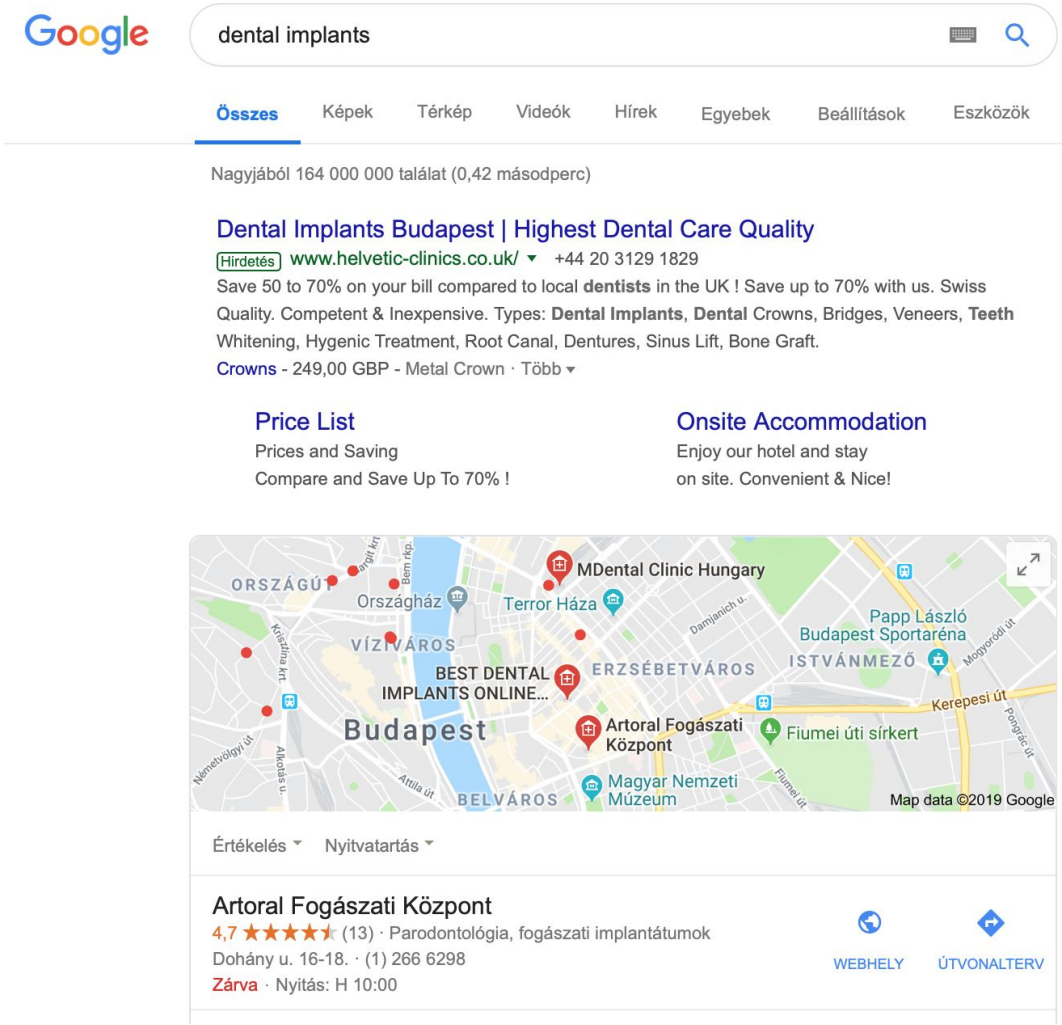
The set of tools, analyses, algorithms, strategies, etc used to target and serve ads on the internet

What kinds of companies are in the “Ad Tech” space?

Search Engines: Google, Yahoo, Bing

Ad Trading, Tools and Optimization: Critio, MediaMath, AdRoll, The Trade Desk, Rubicon, etc.

Media and Merchandising: Facebook, Amazon, BuzzFeed, etc.



Ads Are Everywhere

Are You Guacamole or Hummus?

BY ZOE SAMUEL

Larissa

How can we…

- get more **traffic**?
- modify **engagement**?

Data Science Questions In Ad Tech

ZOO

Search

ANIMALS CARS, TRUCKS & ENGINES TV, FILM & MUSIC ALL ABOUT YOU! LOVE & SEX SPORTS TRIVIA GENERAL TRIVIA THE WORLD

made well, they are absolutely delicious!

Read More

Scroll to Begin Quiz ↓

Válaszd például a Samsung Galaxy A50 készüléket

1. How easily irritated are you?

Not at all! | Like an open sore

I have my moments! | I have the patience of a saint.

WHAT DO YOU KNOW ABOUT CAR ENGINES?

Take this quiz to find out!

Our goal at Zoo.com is to keep you entertained in this crazy life we all live.

We want you to look inward and explore new and interesting things about yourself. We want you to look outward and marvel at the world around you. We want you to laugh at past memories that helped shape the person you've become. We want to dream with you about all your future holds. Our hope is our quizzes and articles inspire you to do just that.

Life is a zoo! Embrace it on Zoo.com.

Válts okostelefont a készülékcsere programban

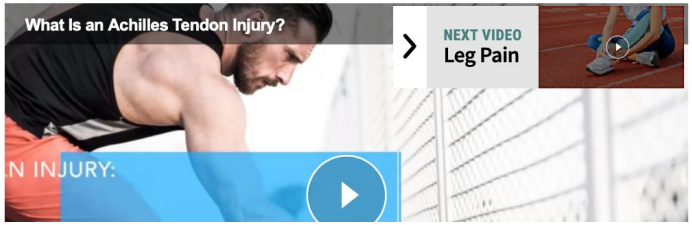
Válts okostelefont a

WebMD SIGN IN SUBSCRIBE SEARCH

ADVERTISEMENT
108 országból tarthatja ügyfeleivel a kapcsolatot
Személyi és utazási célra, a Vodafone és partnerhálózatain.
A mi korlátlan Business Red World csomagunkkal
vodafone business

Fitness & Exercise > Guide >

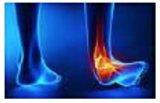
What Is an Achilles Tendon Injury?



SPONSORED ADS

1 Affordable Senior Dental Implants
2 Dental Implant Prices
3 Pain Relief Medications
4 Home Remedies for Heel Pain
5 Apple Cider Vinegar Diet
6 Treatments for Hip Pain

TODAY ON WEBMD


What's Causing Your Leg Pain?
Tendinitis, muscle cramp & more.

Want to Try Yoga?
What to know about benefits, types, and more.

Hydration Quiz
How much water do you need?

Build a Better Butt
Workouts for slim and shapely ıtes.

Which ads…

- have the highest **value**?
- are the **clickiest**?

Data Science Questions In Ad Tech

Useful Terms

Impressions = Number of Times the Ad was Displayed

Clicks = Number of Times the Ad was Clicked

Click-Through-Rate (**CTR**) = Clicks / Impressions

Revenue Per Click (**RPC**) = Revenue / Clicks

Revenue Per Impression (**RPI**) = Revenue / Impressions

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Problem 1

How do different types of ads perform next to the rabbit?

Suppose we have 3 types to choose from:

- dog food
- cat toys
- phone service

Getting a Pet Rabbit? 4 Things to Know First

BY JESSLYN SHIELDS MAY 9, 2019

Rabbits are cute and cuddly, but they require veterinary care just as a dog or cat does. RALPH ORLOWSKI/GETTY IMAGES

Imagine having a pet bunny to snuggle on the couch while you watch Netflix, or maybe to hop around in your yard, posing for the cameras with your children on Easter morning. All that sounds pretty adorable, if you're into that kind of thing. And yet, like any pet, rabbits are also a much bigger commitment than you might realize. So, what do you need to know before picking up a rabbit and commencing couch

Explore the Available data

Open up **problem_set.r** and start an R session.

Take a few minutes to explore:

A. Load the data from “data/hourly_ad_category_data.csv”.

B. Are there any problems with the data?

C. Try to summarize the data with statistics and/or a visualization.

D. How do the three ads compare?

Think Before Modeling

Now that we know what data is at our disposal, let's think about it:

- Which of our metrics might be best to model/optimize?

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Time Series

What is special about time-series?

Source:
https://www.dailyfx.com/forex/fundamental/article/special_report/2018/11/30/Brexit-Impact-on-GBP-How-the-Pound-Might-Move-After-Parliamentary-Vote.html

Time Series

What is special about time-series?
- Order matters
- Autocorrelation
- Trends
- Seasonality

Source:
https://www.dailyfx.com/forex/fundamental/article/special_report/2018/11/30/Brexit-Impact-on-GBP-How-the-Pound-Might-Move-After-Parliamentary-Vote.html

What Kinds of Models Are Time Series Models?

What kinds of methods can be used to model time series?

- Classical Time Series Models
- Fourier / Spectral Analysis
- Signal Processing
- Neural Networks / Deep Learning
- Structural / Hierarchical Models
- And many more: https://en.wikipedia.org/wiki/Time_series#Tools

We should choose based on the problem we are trying to solve.

Stationary Vs Non-stationary Time Series

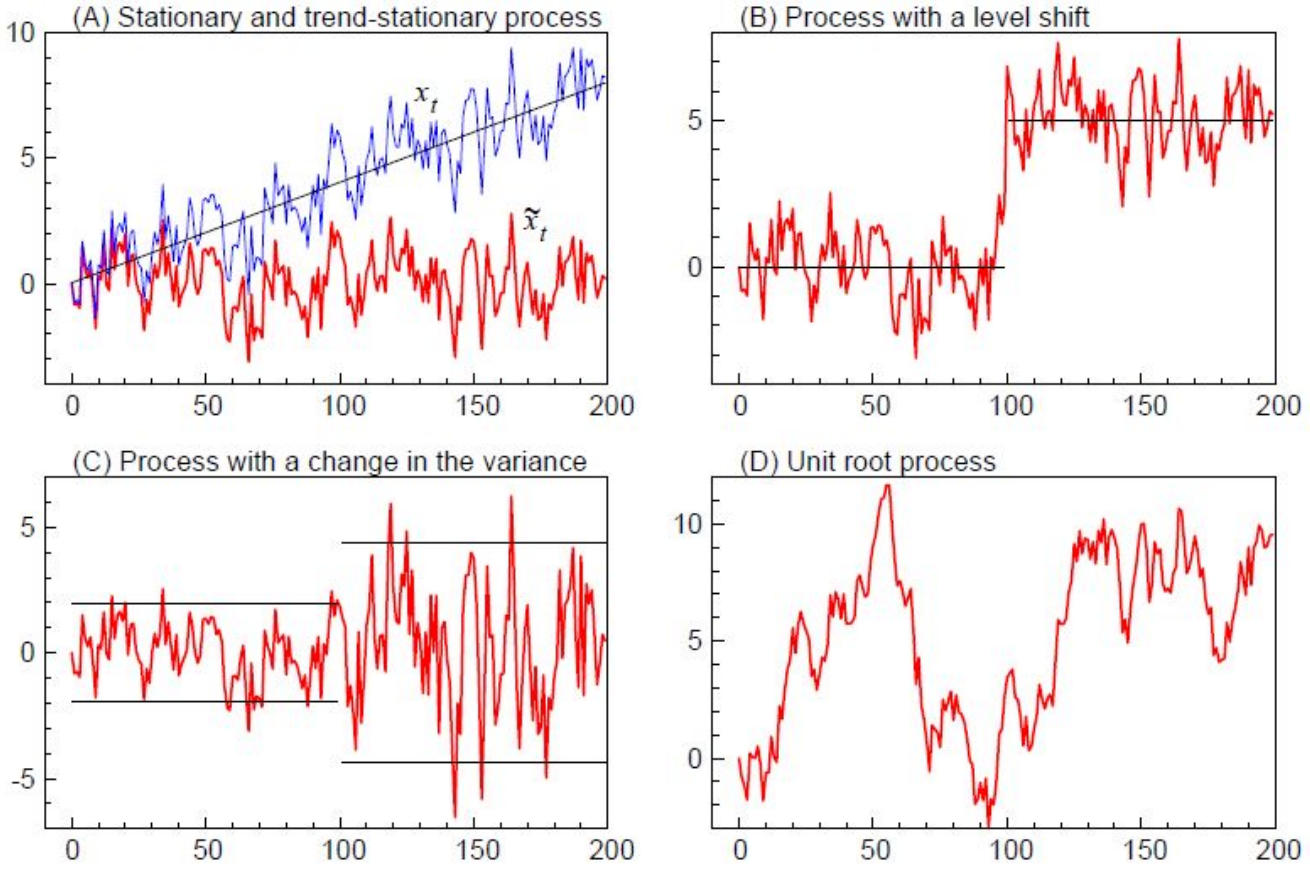

Figure 1: *Simulated examples of non-stationary time series.*

Source: https://stats.stackexchange.com/questions/4142/using-the-distance-of-p-value-from-alpha

Models of Stationary Data

Autoregressive Models (AR)

- Current value depends on preceding values
- E.g. Stock prices, temperature

$$X_t = 0.9\ X_{t-1} + error$$

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- Current value depends on previous errors
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$$X_t = \mu + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$$

$X_t = -0.5\ error_{t-1} + error_t$

Models of Stationary Data

Autoregressive Models (AR)

- Current v
- E.g. Stoc

$$+ \sum_{i=1}^{p} \varphi_i X_{t-i} + \varepsilon_t$$

X_t = 0.9

Both of these models assume the data are stationary.

The main differences between them are the degree and quality of the correlation between current and past events and how the systems respond to sudden changes (shocks).

Moving Averag

- Current value depends on previous errors
- E.g. Demand for a product

$$X_t = \mu + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$$

X_t = -0.5 $error_{t-1}$ + $error_t$

Models of Stationary Data

Autoregressive Models (AR)

- Current value depends on preceding values
- E.g. Stock prices, temperature

$$X_t = c + \sum_{i=1}^{p} \varphi_i X_{t-i} + \varepsilon_t$$

$X_t = 0.9\ X_{t-1} + error$

AR + MA = ARMA: $X_t = c + \varepsilon_t + \sum_{i=1}^{p} \varphi_i X_{t-i} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$

Moving Average Model (MA)

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Models of Non-Stationary Data

ARIMA

- ARMA with “differencing” transformations to make it stationary.
- Differencing:
  - Literally subtracting the previous value from the next one:

$$y'_t = y_t - y_{t-1}$$

  - Can be repeated multiple times
  - Can also be used to account for seasonality:

$$y'_t = y_t - y_{t-m}$$

Models of Non-Stationary Data

BATS:

- **B**ox-Cox transforms the series prior to modeling
- **A**RMA errors
- **T**rend term with damping
- **S**easonal components

Models of Non-Stationary Data

TBATS:

- **T**rigonometric seasonal components via Fourier Series
- **BATS**

BATS and TBATS References

- White Paper: https://robjhyndman.com/papers/ComplexSeasonality.pdf
- Summary of Formulas and Python Implementation: https://medium.com/intive-developers/forecasting-time-series-with-multiple-seasonalities-using-tbats-in-python-398a00ac0e8a

How do we choose A Model?

Want to know: **Which will best predict future observations?**

- Rather than random sampling, we can split the data into historical (training) data and future (testing) data.
- Then we can compare performance on the test set.

Problem 2: Model Fitting and Forecasting

Let’s jump back into **problem_set.r** and walk through an example together.

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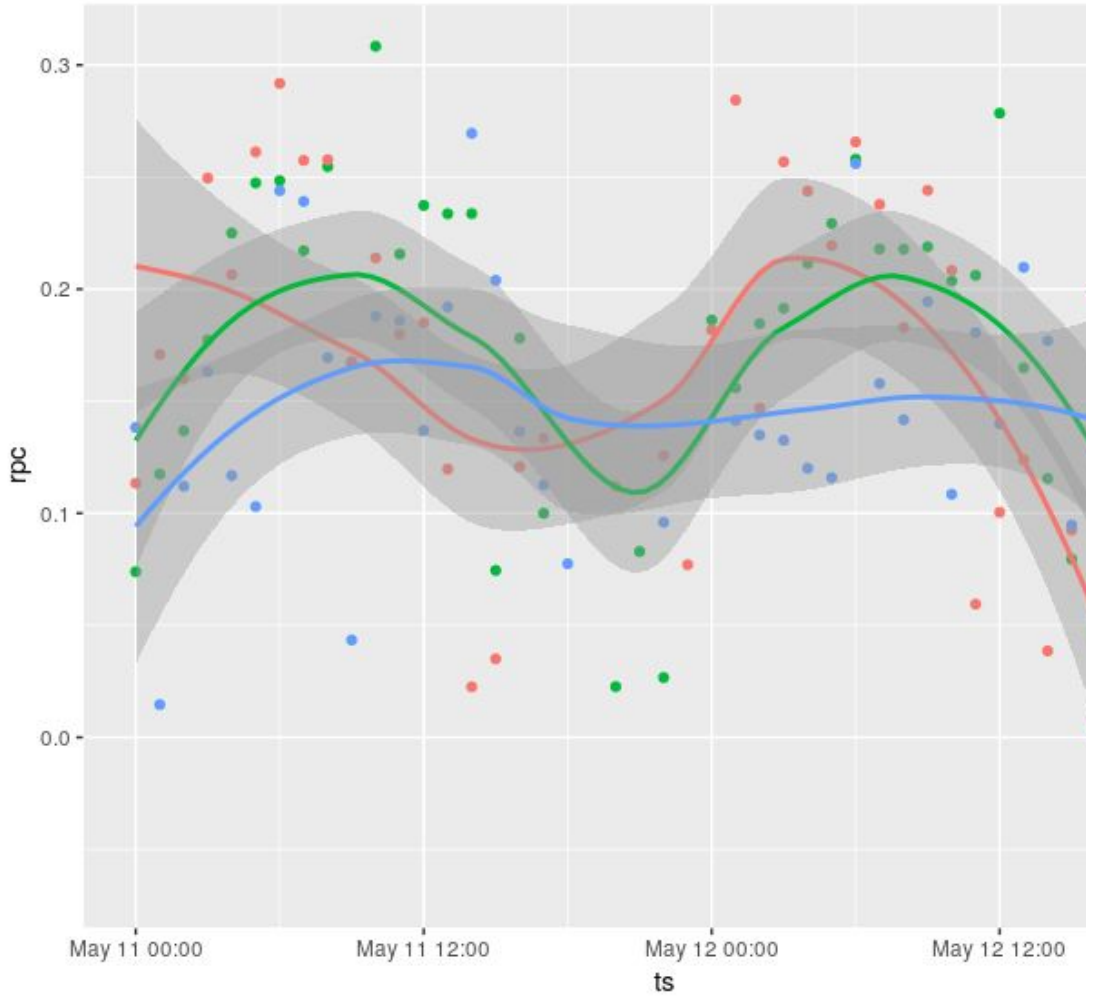
Let's Think about Optimization



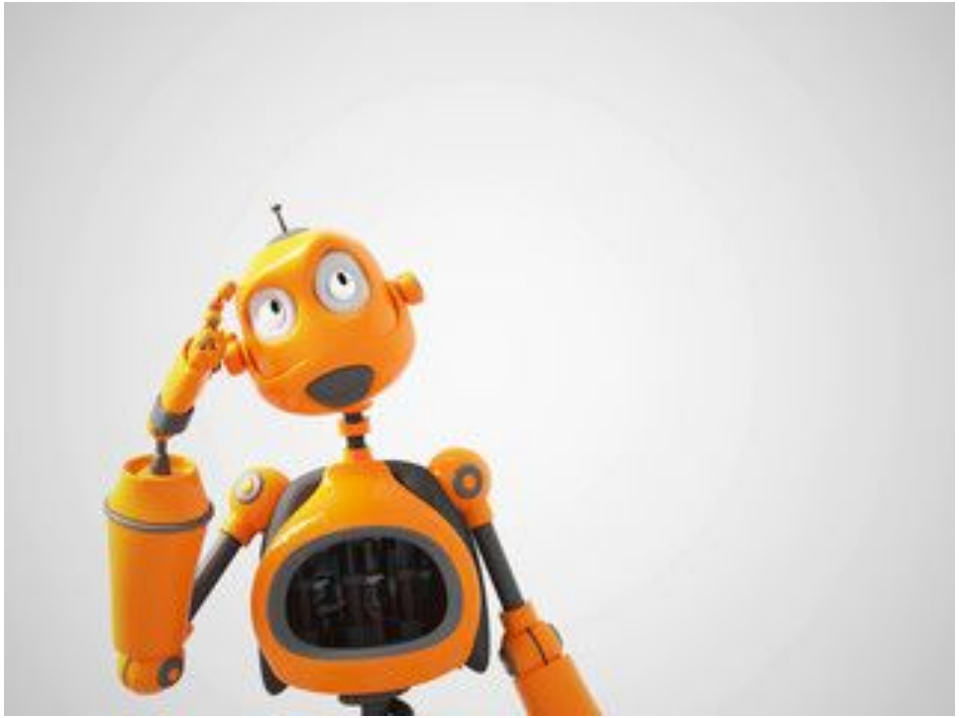
Explore-Exploit Dilemma

Exploit - We want to take advantage of solutions that we know are more optimal than others.

Explore - However, if do not sufficiently investigate other options we may end up exploiting a suboptimal solution.

Dilemma - How should we balance between these?

Reinforcement Learning



“Reinforcement learning (**RL**) is an area of machine learning concerned with how software agents ought to take ***actions*** in an ***environment*** so as to maximize some notion of cumulative ***reward***.”

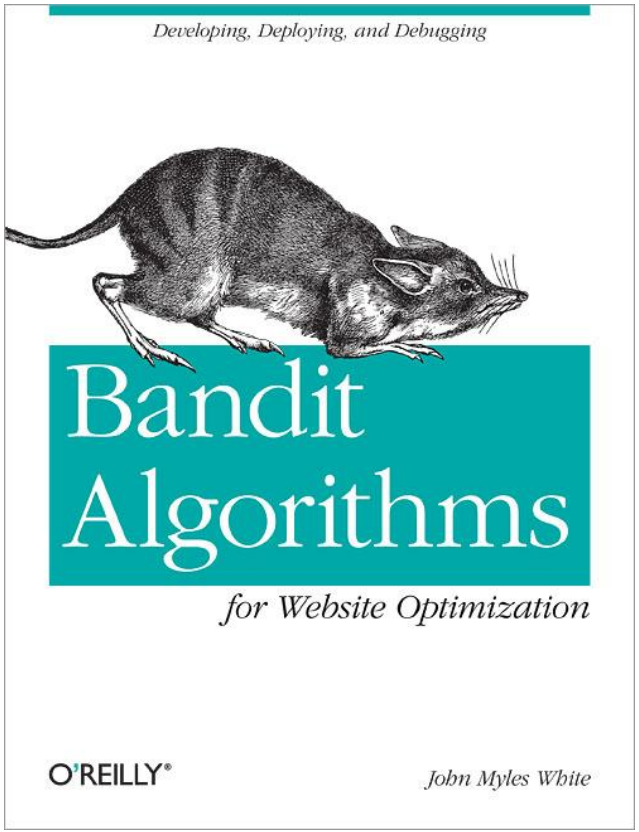
- Wikipedia Definition

Sources: https://en.wikipedia.org/wiki/Reinforcement_learning, https://www.fotolia.com/tag/pondering

Bandit Algorithms

Bandits are a simple class of RL agents.

They can help manage the explore-exploit dilemma by giving more weight to good options and less to bad options as information is acquired.



Some Gotchas

These algorithms will shape the data.

Goodhart's Law -- When a measure becomes a target it ceases to be a good measure.

Some Gotchas

These algorithms will shape the data.

Goodhart's Law -- When a measure becomes a target it ceases to be a good measure.

To avoid this, maintain an unbiased baseline, so you and your models will not be misled.

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Problem 3

Suppose, we selected an optimization strategy using our ts model.

We rolled it out on 10% of the traffic.

It’s been running for one day.

Problem 3

Suppose, we selected an optimization strategy using our ts model.

We rolled it out on 20% of the traffic.

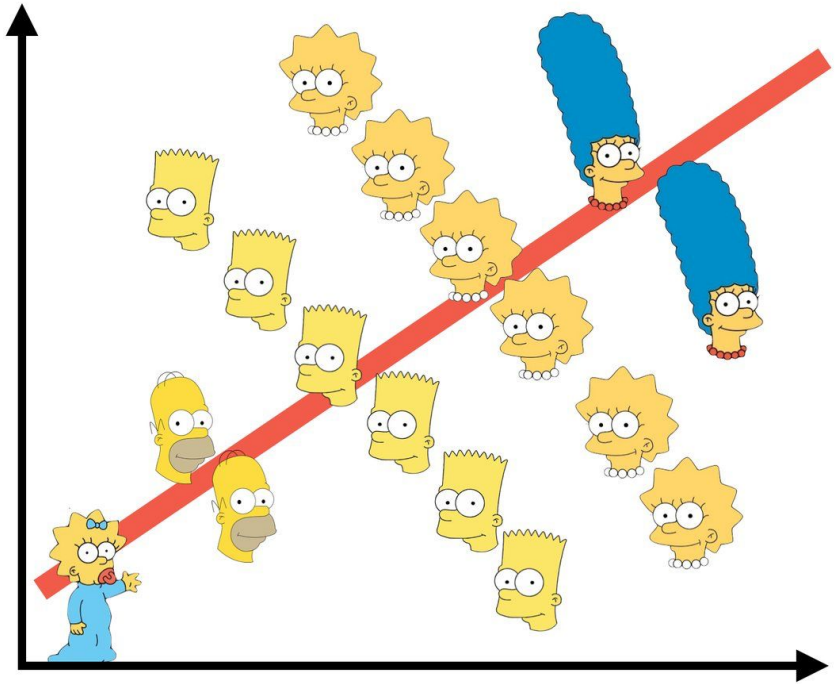
It’s been running for one day.

Enter DJ Janos:

Are we making money?

Source: https://vimeo.com/3109723

Gotchas

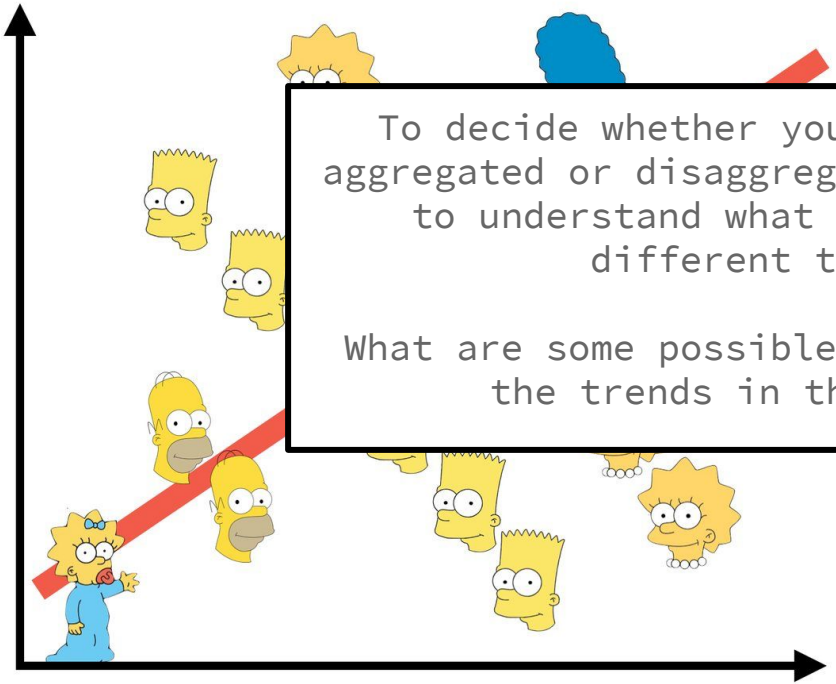


“Simpson's paradox is a phenomenon in probability and statistics, in which a trend appears in several different groups of data but disappears or reverses when these groups are combined.”

- Wikipedia Definition

Source: https://www.analyticsindiamag.com/understanding-simpsons-paradox-and-its-impact-on-data-analytics/

Gotchas



To decide whether you should use the aggregated or disaggregated data you have to understand what is **causing** the different trends.

What are some possible explanations for the trends in the Ad Data?

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Thanks!
Questions???