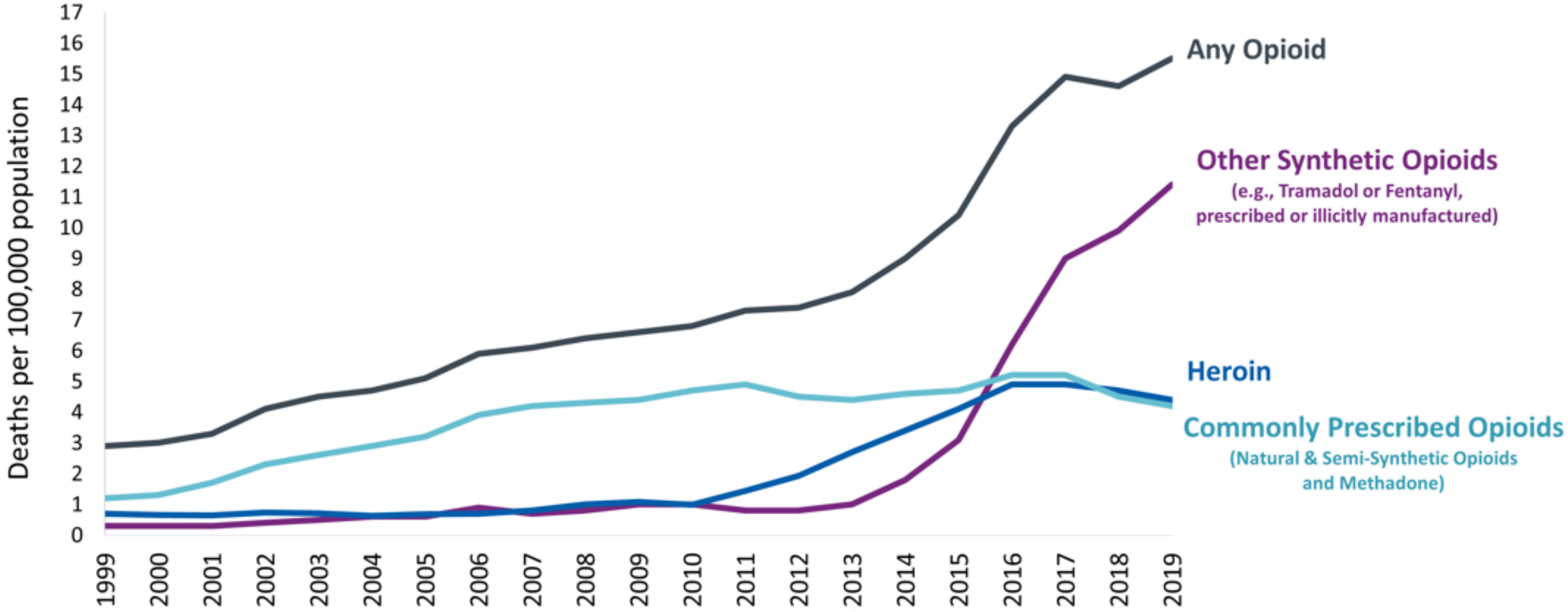
AI Ethics: Explainability of Machine Learning

CS229: Machine Learning
Carlos Guestrin
Stanford University

Three Waves of the Rise in Opioid Overdose Deaths

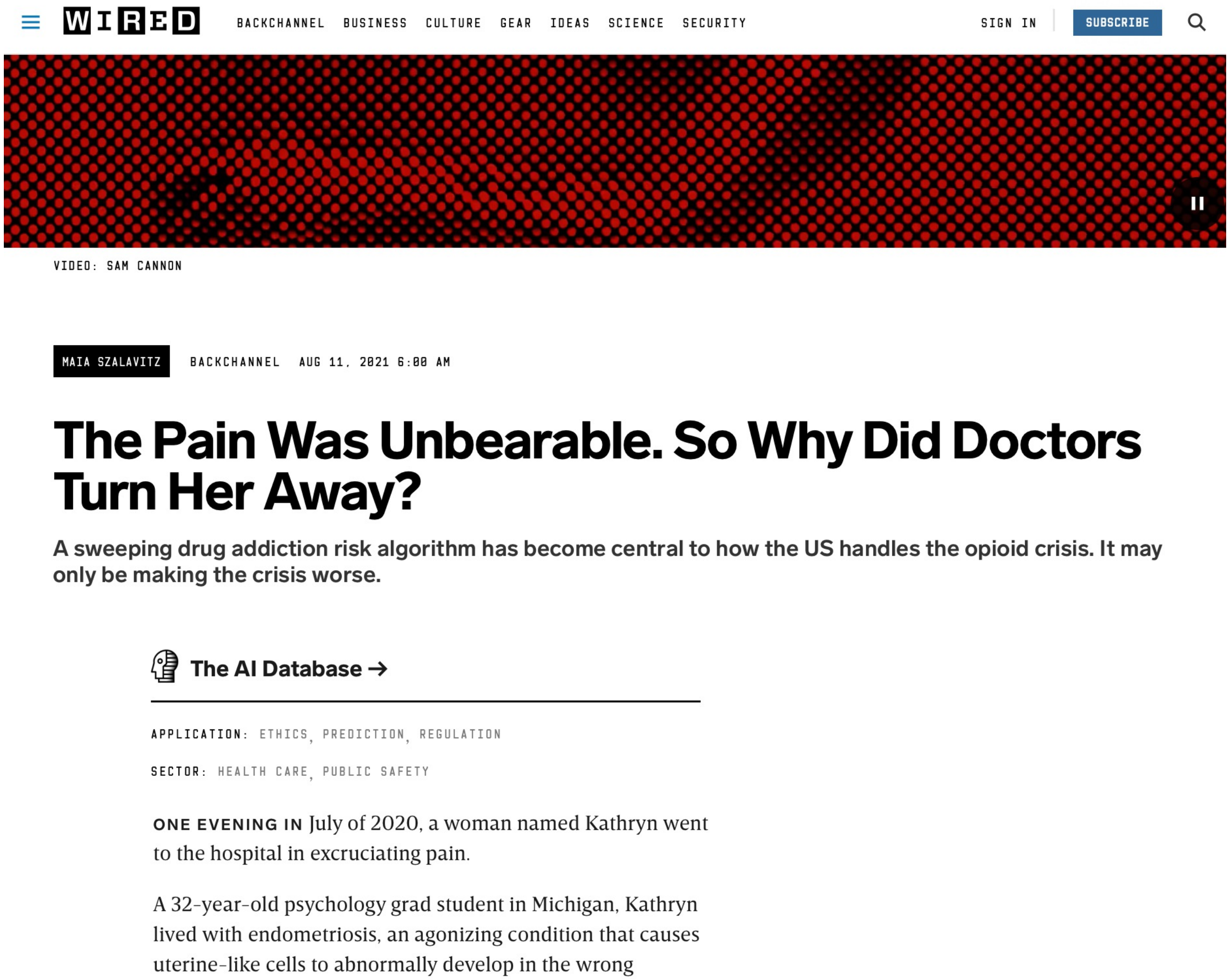


Wave 1: Rise in Prescription Opioid Overdose Deaths Started in 1999

Wave 2: Rise in Heroin Overdose Deaths Started in 2010

Wave 3: Rise in Synthetic Opioid Overdose Deaths Started in 2013

SOURCE: National Vital Statistics System Mortality File.



VIDEO: SAM CANNON

MAIA SZALAVITZ BACKCHANNEL AUG 11, 2021 6:00 AM

The Pain Was Unbearable. So Why Did Doctors Turn Her Away?

A sweeping drug addiction risk algorithm has become central to how the US handles the opioid crisis. It may only be making the crisis worse.

The AI Database →

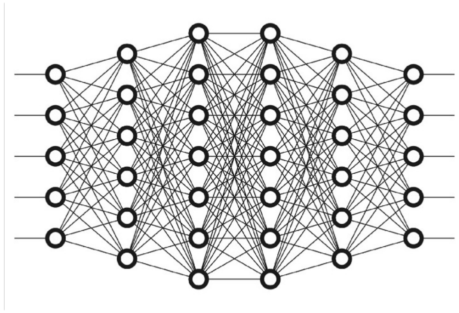
APPLICATION: ETHICS, PREDICTION, REGULATION

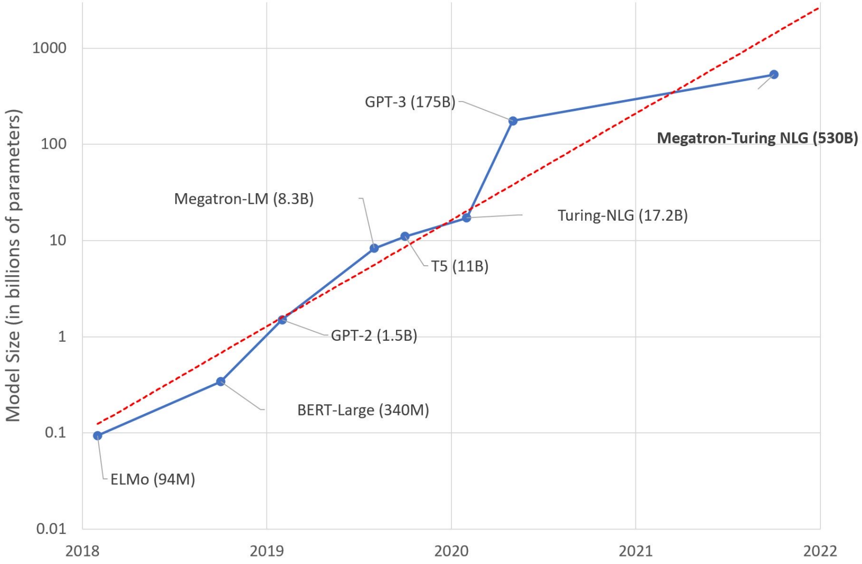
SECTOR: HEALTH CARE, PUBLIC SAFETY

ONE EVENING IN July of 2020, a woman named Kathryn went to the hospital in excruciating pain.

A 32-year-old psychology grad student in Michigan, Kathryn lived with endometriosis, an agonizing condition that causes uterine-like cells to abnormally develop in the wrong

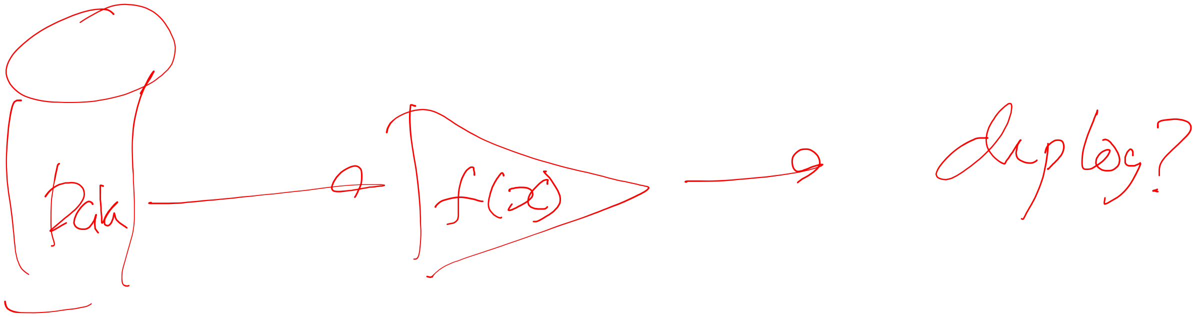
ML Models More and More Complex





When is a model ready to deploy?

Hard to understand when models are working (for the right reasons) and not working!!

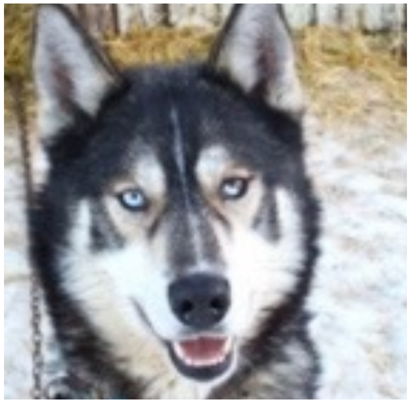


Isn’t test accuracy enough?

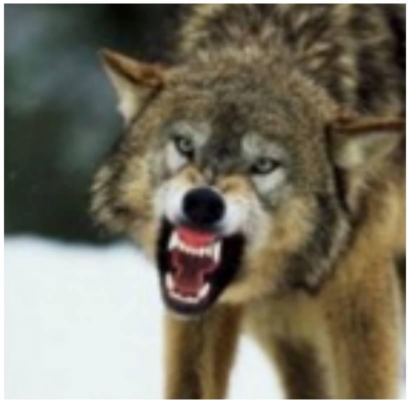
A User Study on Test Accuracy

“Why should I trust you?”: Explaining the Predictions of Any Classifier. Ribeiro, Singh & G. KDD 16

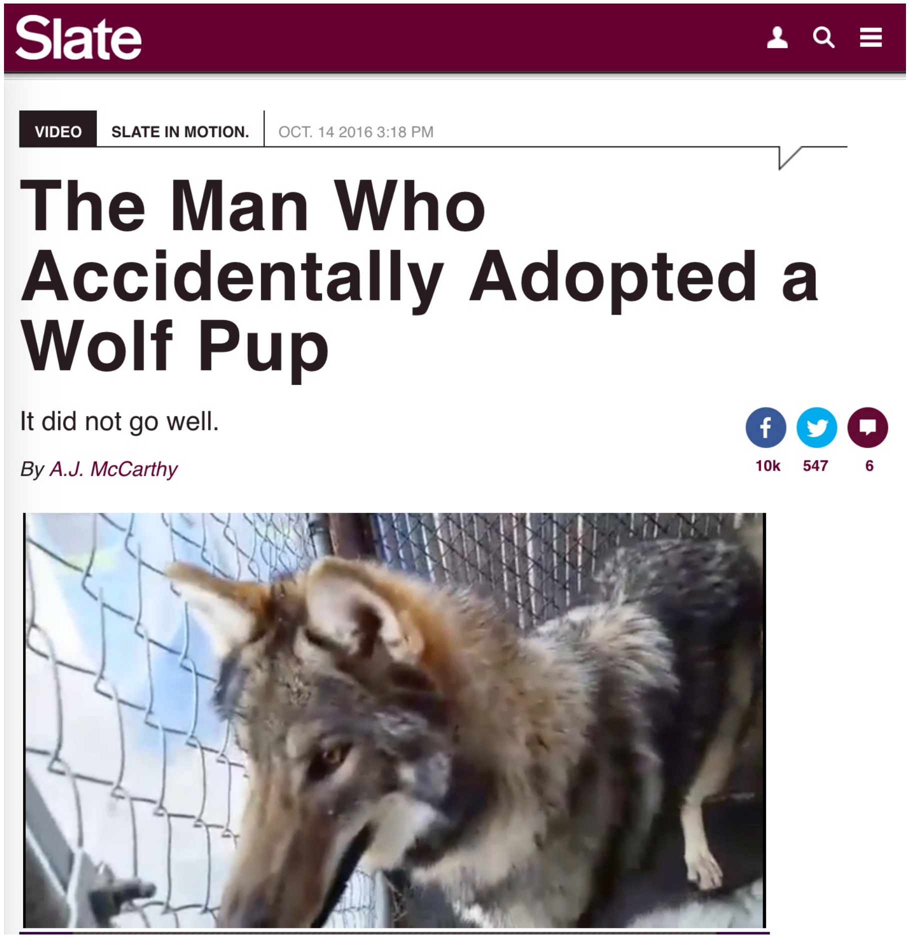
Train a neural network to predict wolf v. husky



Husky



Wolf



Slate

VIDEO SLATE IN MOTION. OCT. 14 2016 3:18 PM

The Man Who Accidentally Adopted a Wolf Pup

It did not go well.

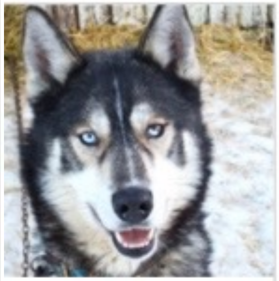
By A.J. McCarthy

Train a neural network to predict wolf v. husky

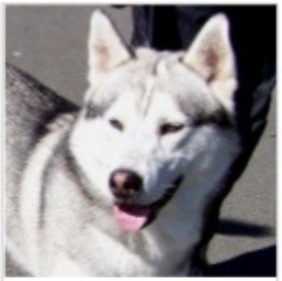
Predicted: wolf
True: wolf

Predicted: husky
True: husky

Predicted: wolf
True: wolf



Predicted: wolf
True: husky

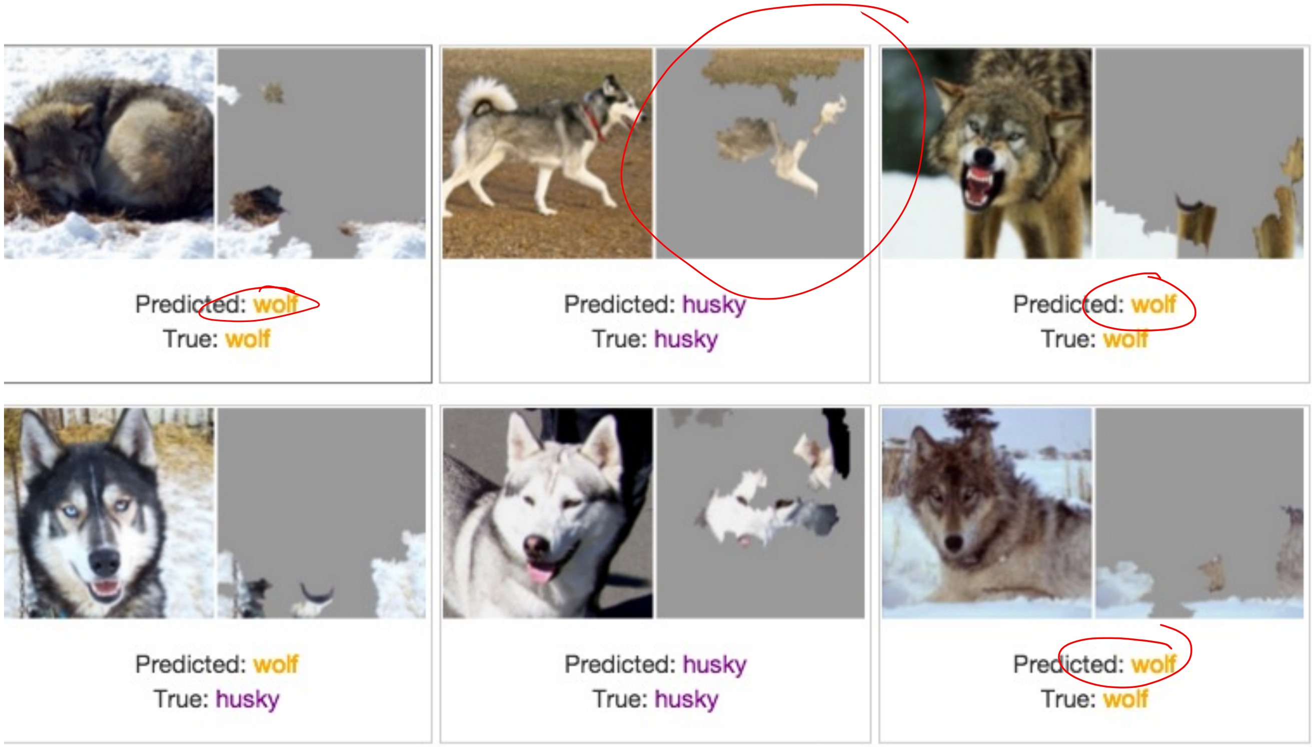


Predicted: husky
True: husky

Predicted: wolf
True: wolf

achieves desired accuracy

Explanations for neural network prediction



Snow detector

Test accuracy may not capture critical issues

- Bad data
- Biases
- Poor performance in critical cases
- …

Examining Models

Debugging is One Reason to Examine Models

- Examining models:
  - Why a model makes particular predictions
  - What alternative predictions are possible
  - How robust/stable are predictions
  - What data supports predictions
- Examining models for debugging: discover bad, unexpected or unstable behavior
  - Typically not discovered by accuracy in train/test data

Examining Models to Detect Algorithmic Bias

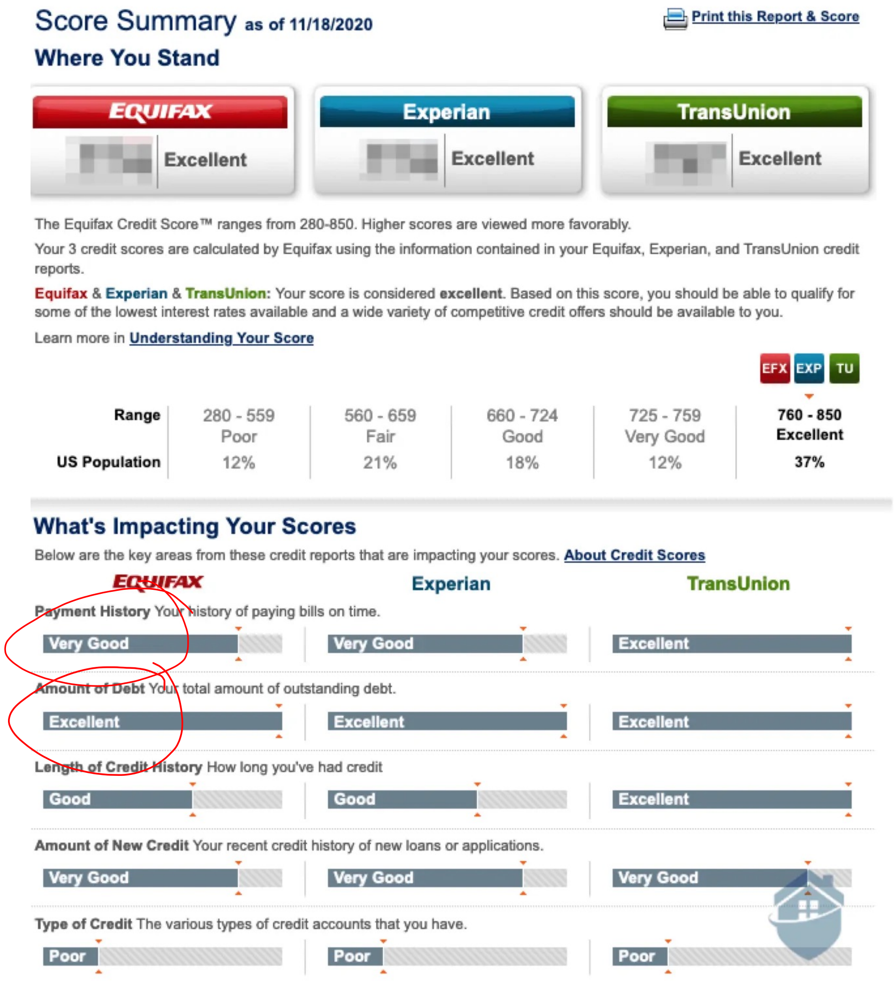
- Evaluate multiple fairness criteria

- Verify how/if decisions depend on sensitive features

- Discover what groups are privileged/disadvantaged by predictions

Examine Models for Recourse

- In opioid overdose risk case, patient deemed risky had no way to discover why
  - Or how to fix bad data
- Understanding why could enable individuals to:
  - Address data issues
  - Change their actions to change outcomes



Score Summary as of 11/18/2020

Print this Report & Score

Where You Stand

EQUIFAX	Experian	TransUnion
[redacted] Excellent	[redacted] Excellent	[redacted] Excellent

The Equifax Credit Score™ ranges from 280-850. Higher scores are viewed more favorably.

Your 3 credit scores are calculated by Equifax using the information contained in your Equifax, Experian, and TransUnion credit reports.

Equifax & Experian & TransUnion: Your score is considered **excellent**. Based on this score, you should be able to qualify for some of the lowest interest rates available and a wide variety of competitive credit offers should be available to you.

Learn more in Understanding Your Score

					EFX EXP TU
Range	280 - 559 Poor	560 - 659 Fair	660 - 724 Good	725 - 759 Very Good	**760 - 850** **Excellent**
US Population	12%	21%	18%	12%	**37%**

What's Impacting Your Scores

Below are the key areas from these credit reports that are impacting your scores. About Credit Scores

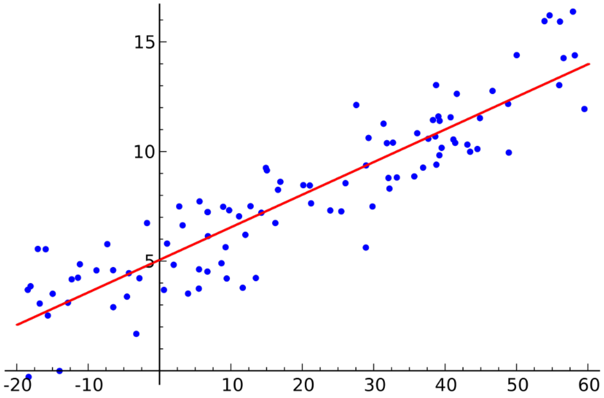
	EQUIFAX	Experian	TransUnion
Payment History Your history of paying bills on time.	Very Good	Very Good	Excellent
Amount of Debt Your total amount of outstanding debt.	Excellent	Excellent	Excellent
Length of Credit History How long you've had credit	Good	Good	Excellent
Amount of New Credit Your recent credit history of new loans or applications.	Very Good	Very Good	Very Good
Type of Credit The various types of credit accounts that you have.	Poor	Poor	Poor

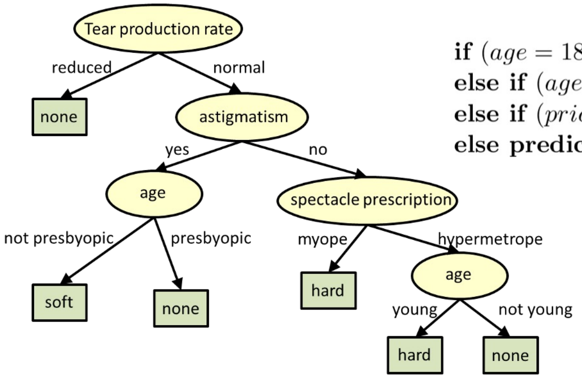
Interpretable Models vs Post-hoc Explanations

Interpretability in ML

Giving humans a ***mental model*** *of the machine's model behavior*

Learning Interpretable Models (c.f., Lethan & Rudin 2015)

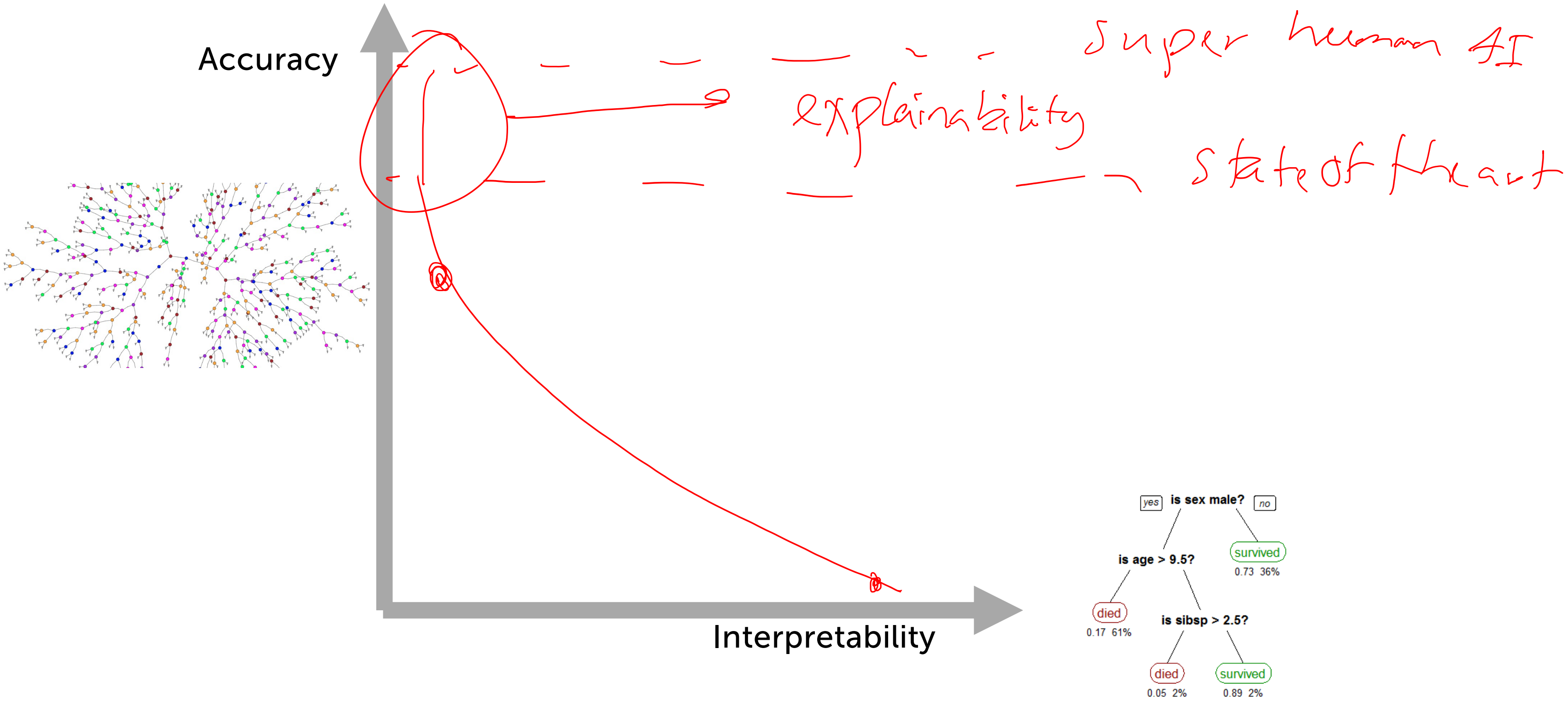




if $(age = 18-20)$ **and** $(sex = male)$ **then predict** yes
else if $(age = 21-23)$ **and** $(priors = 2-3)$ **then predict** yes
else if $(priors > 3)$ **then predict** yes
else predict no

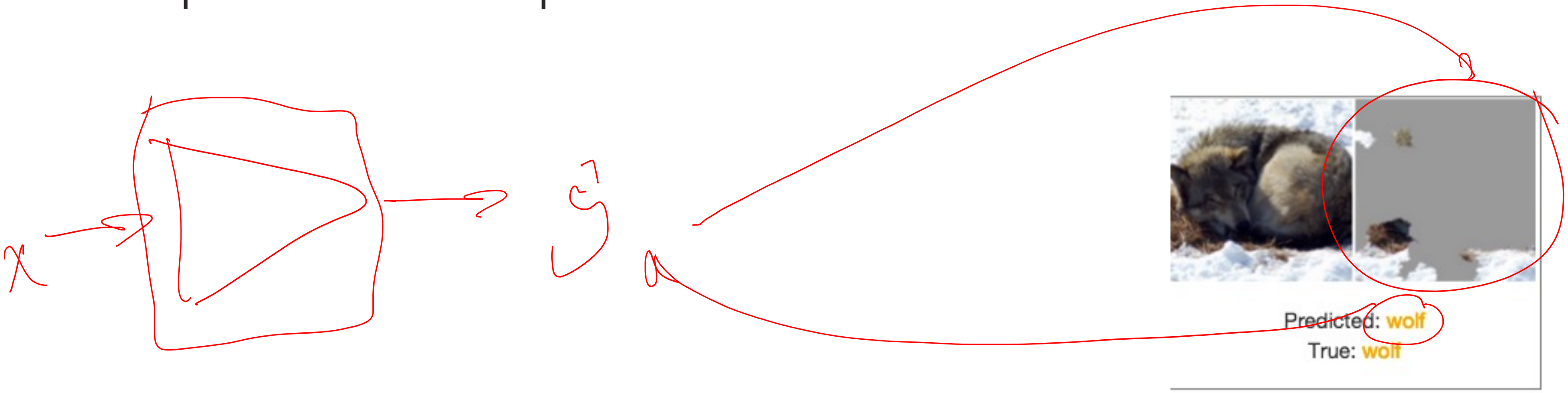
Image credit: Lakkaraju, Adebayo, Singh NeurIPS 2020 Tutorial

Accuracy vs Interpretability



Post-hoc Explanations

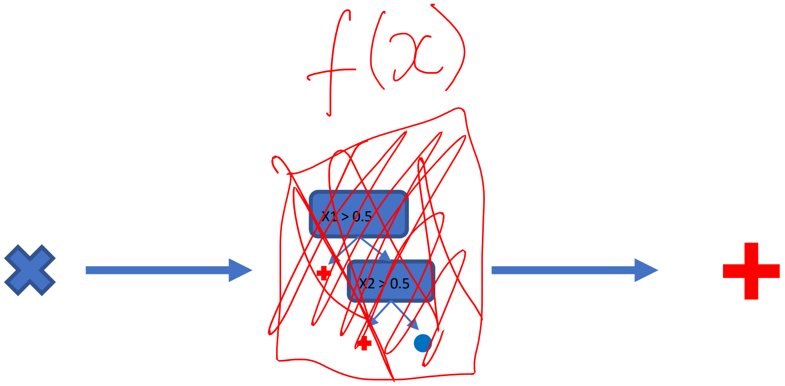
- Given a (huge, complex) model, provide human explanations for predictions



LIME: Local, Interpretable Model-Agnostic Explanations

"Why should I trust you?": Explaining the Predictions of Any Classifier. Ribeiro, Singh & G. KDD 16

Model agnostic→ Ignore any internal structure



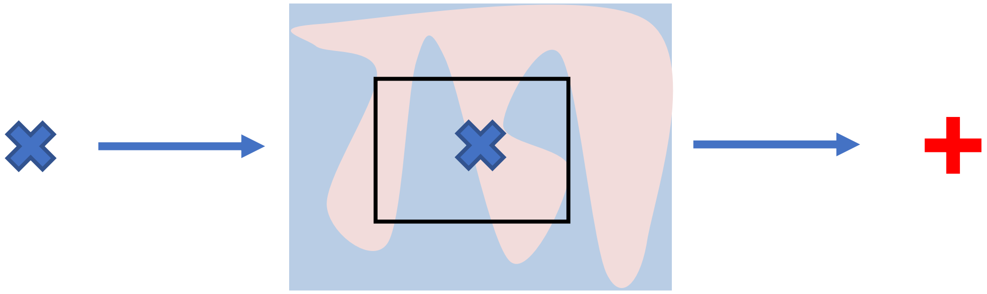
compare diffent function class

state-of-the-art

future proof

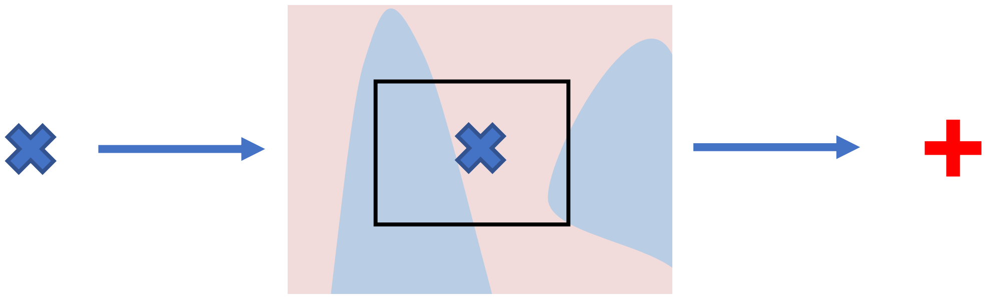
Explaining predictions

Global decision may be very complicat



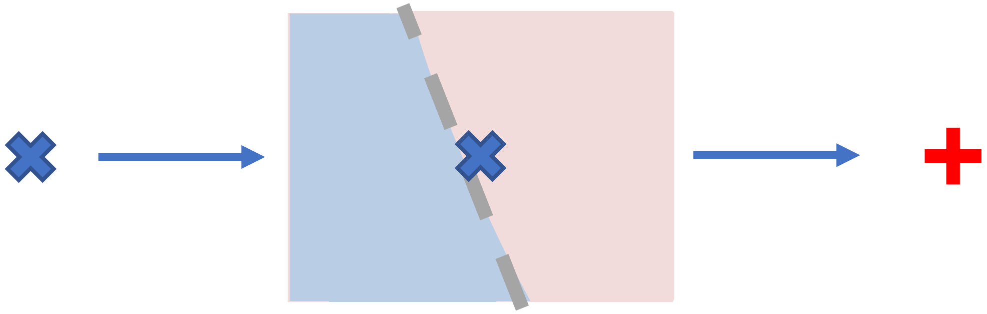
Explaining predictions

Locally, decision looks simpler…



Explaining predictions

Very locally, decision looks linear



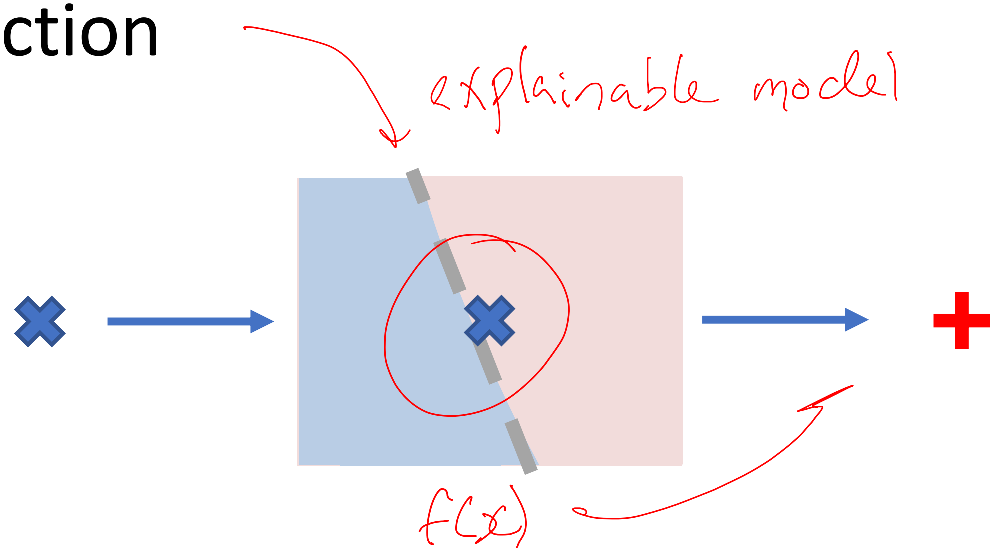
Locally

“Why should I trust you?”: Explaining the Predictions of Any Classifier. Ribeiro, Singh & G. KDD 16

Explaining predictions

Very locally, decision looks linear

LIME: Learn locally sparse linear model around each prediction

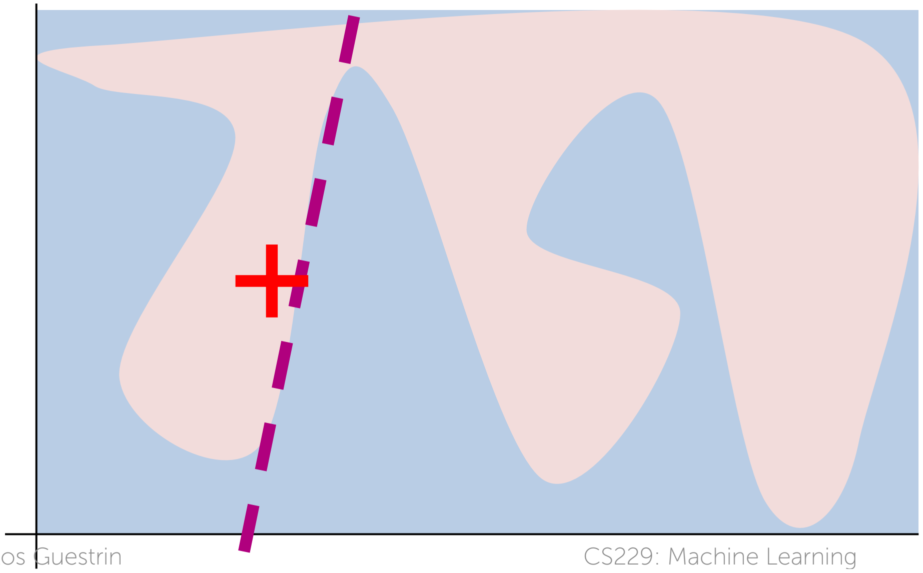


"Why should I trust you?": Explaining the Predictions of Any Classifier. Ribeiro, Singh & G. KDD 16

LIME – Key Ideas

1. Pick a model class interpretable by humans

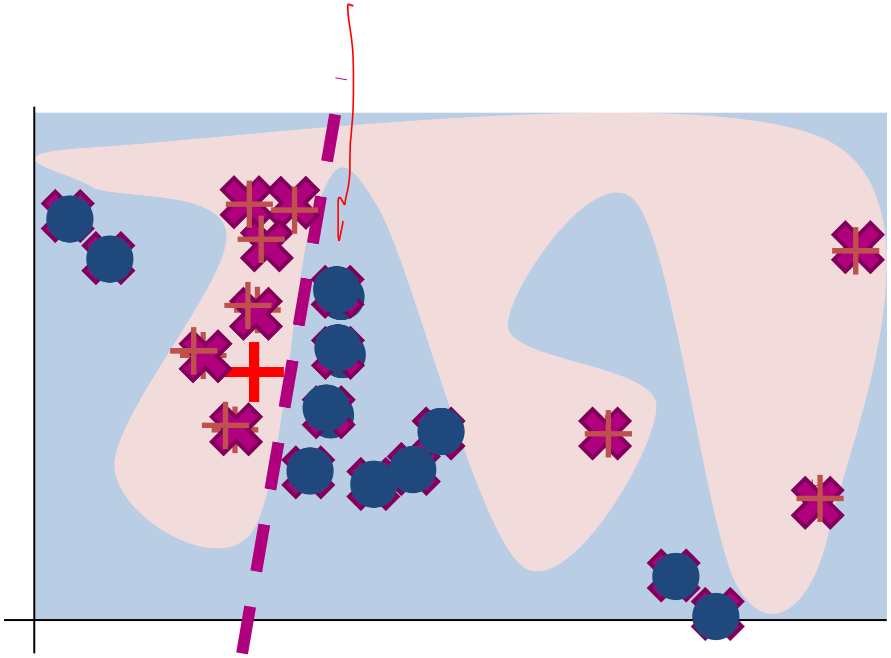
2. Locally approximate global (blackbox) model
   - Simple model globally bad, but locally good



Sparse linear Explanations

1. Sample points around x_i
2. Use complex model to predict labels for each sample
3. Weigh samples according to distance to x_i
4. Learn new simple model on weighted samples
5. Use simple model to explain

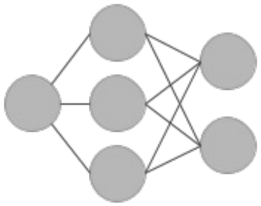
label with $f(x)$



Interpretable representations

x (embeddings)

0.5	0.3	1.3	4.4	1.1	...



Model

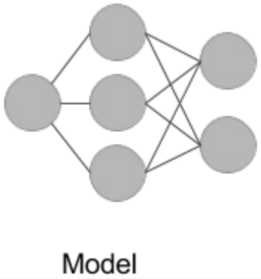
x' (words)

This is a horrible movie.

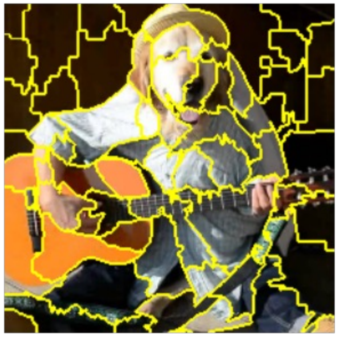
Human

Interpretable representation: images

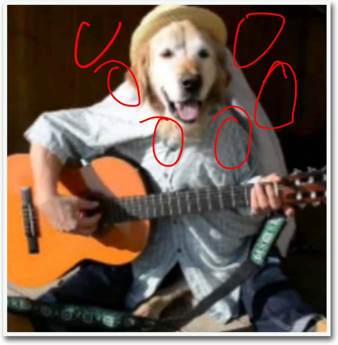
x (3 color channels / pixel)

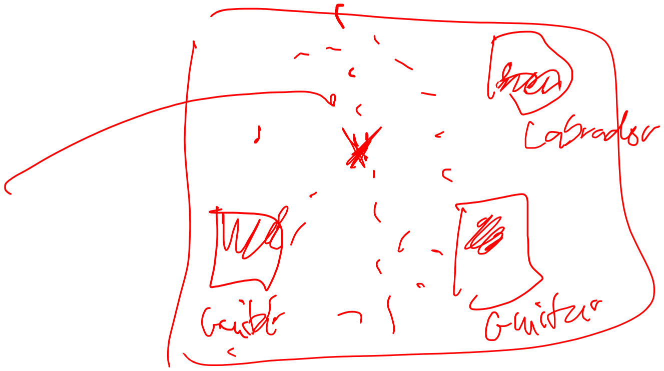


x' (contiguous superpixels)

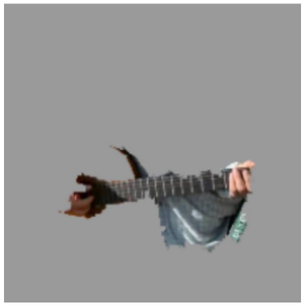


Explaining prediction of Inception Neural Network

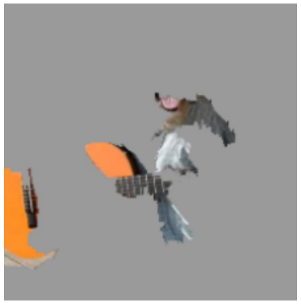




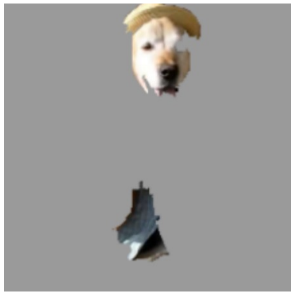
P( ) = 0.32



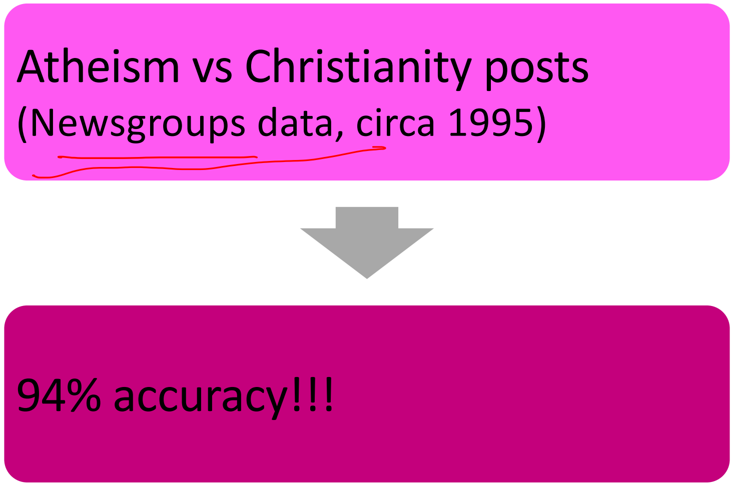
P( ) = 0.24



P( ) = 0.21



Achieving target metric may not be enough



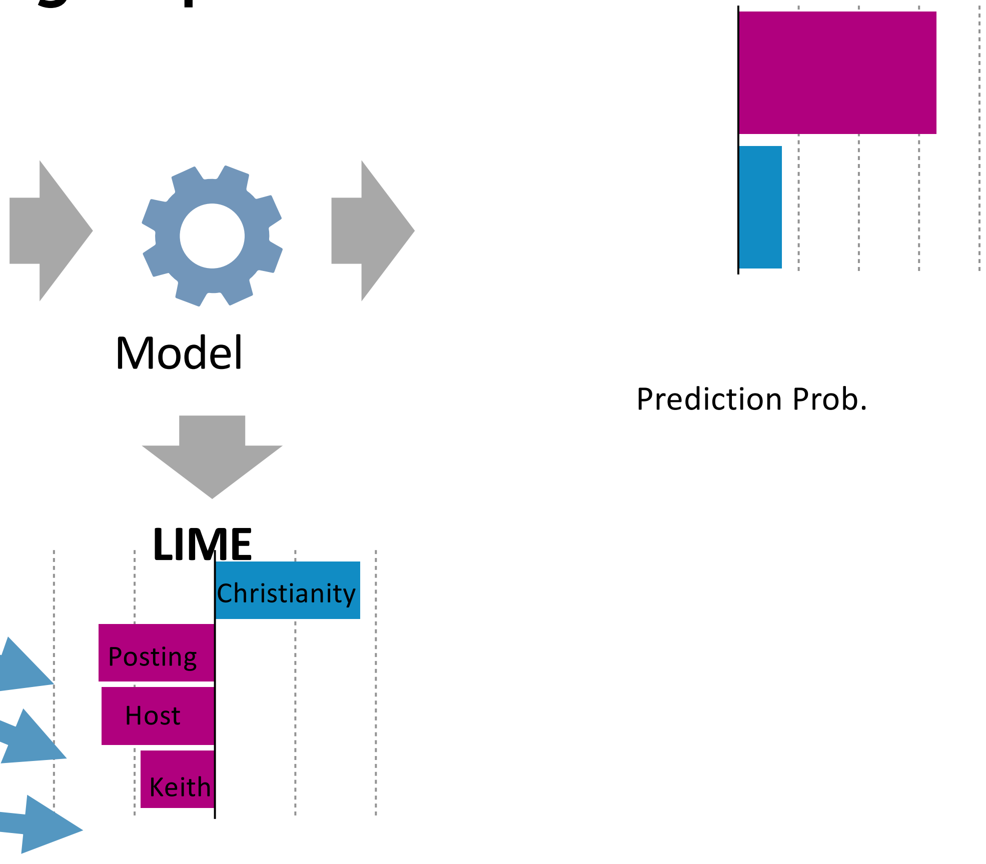
Atheism vs Christianity posts
(Newsgroups data, circa 1995)

94% accuracy!!!

LIME applied to 20 newsgroups

From: Keith Jones
Subject: Christianity is the answer
NTTP-Posting-Host: x.x.com

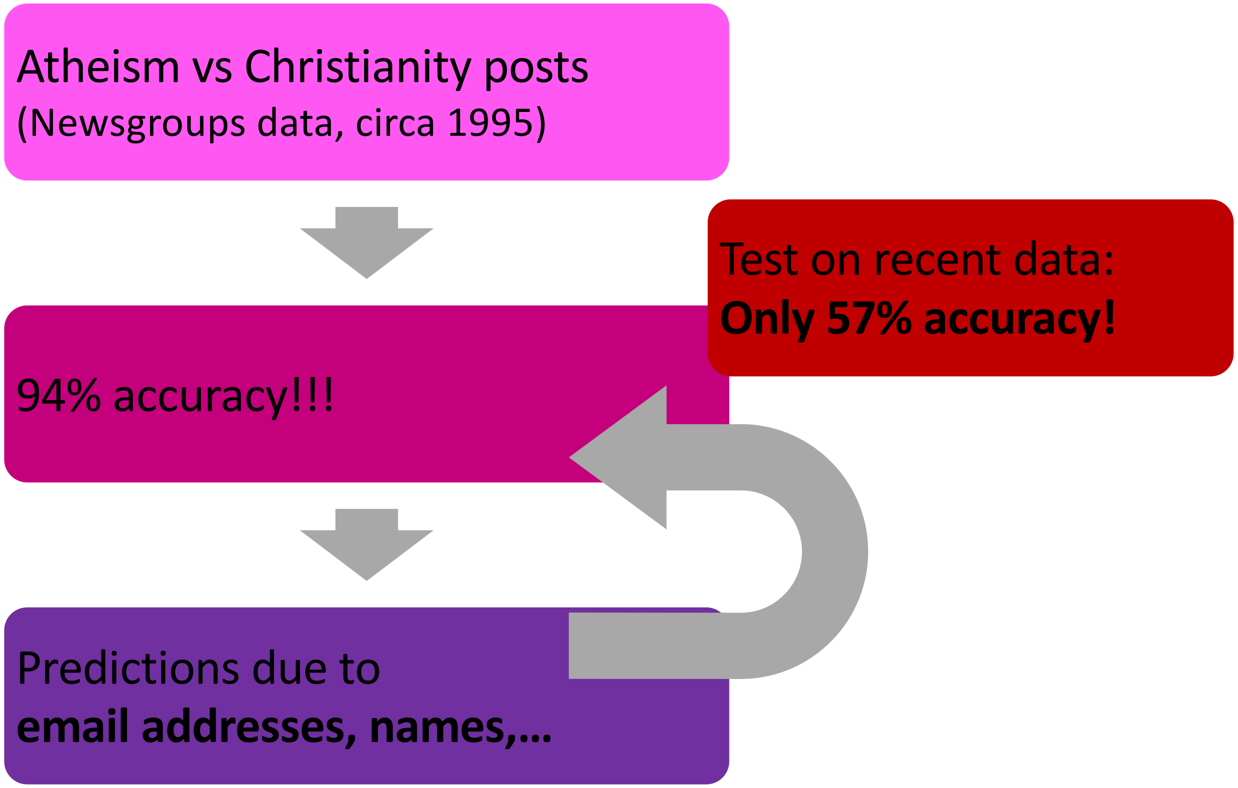
I think Christianity is the one true religion.
If you'd like to know more, send me a note



Appear in 21% of training examples, almost always in Atheism

Appears in 11% of training examples, **always** in atheism

Achieving target metric may not be enough



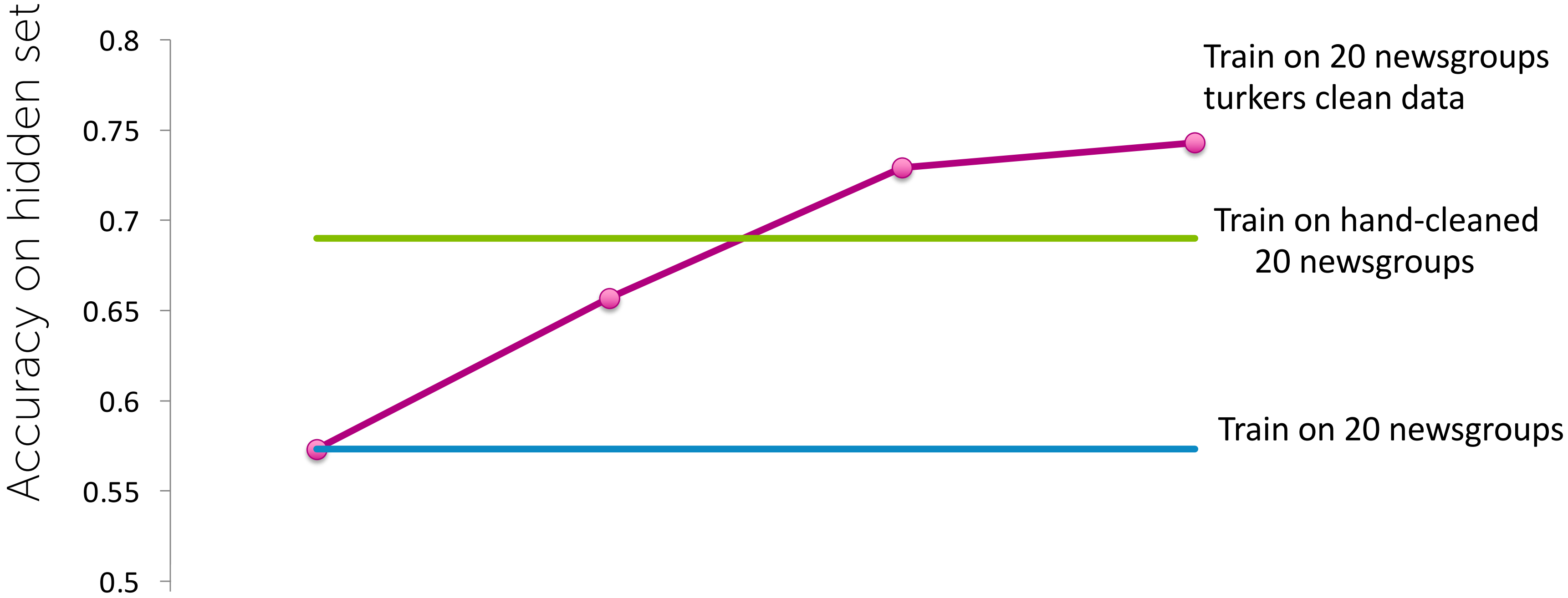
Atheism vs Christianity posts
(Newsgroups data, circa 1995)

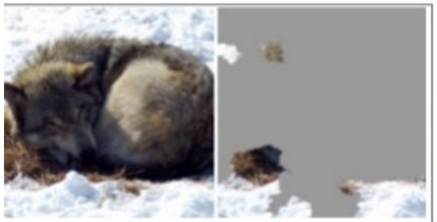
94% accuracy!!!

Predictions due to
email addresses, names,...

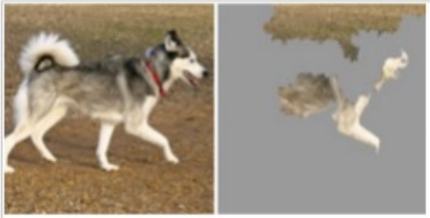
Test on recent data:
Only 57% accuracy!

Fixing bad classifiers

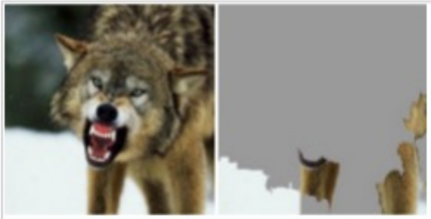




Predicted: wolf
True: wolf



Predicted: husky
True: husky



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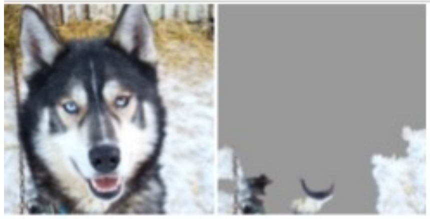
True: wolf



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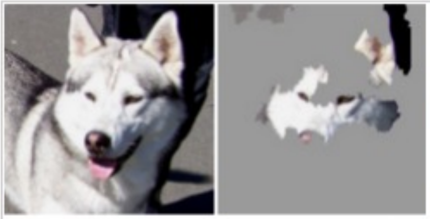

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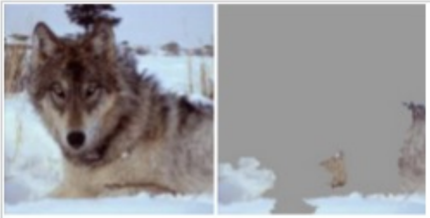
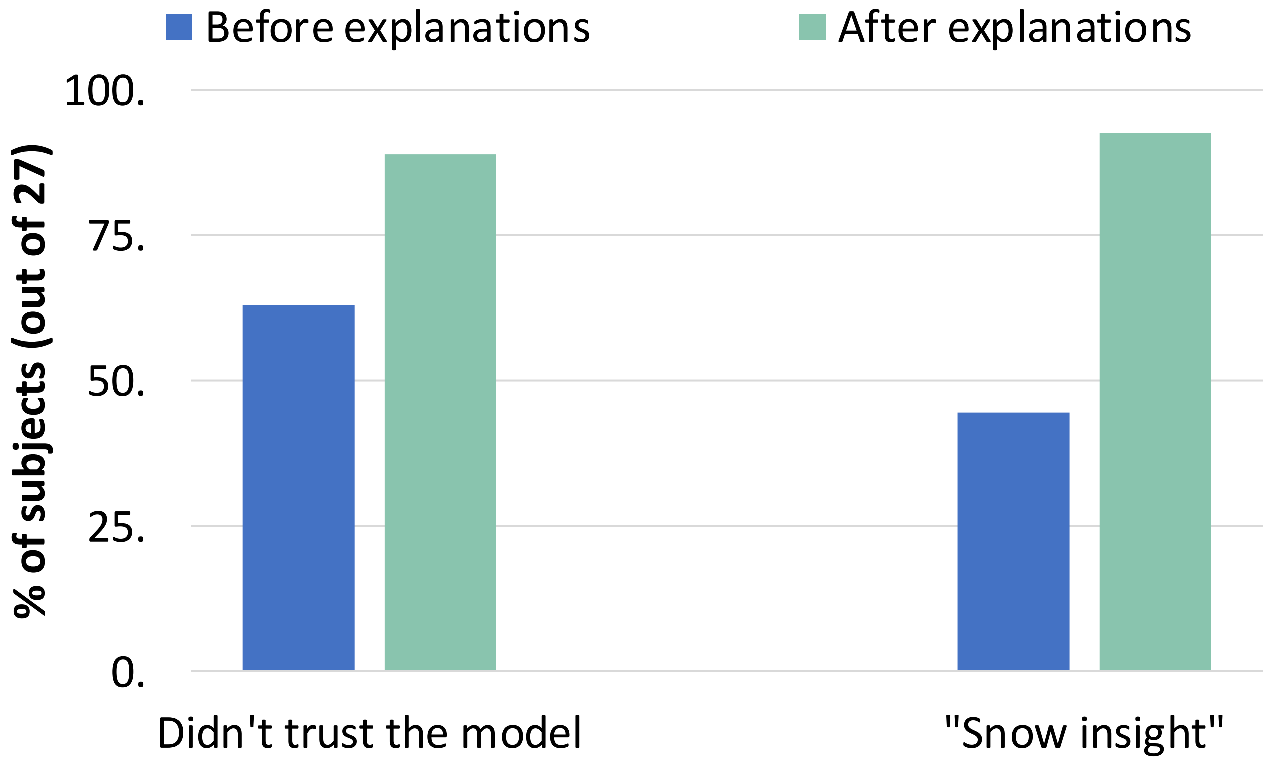


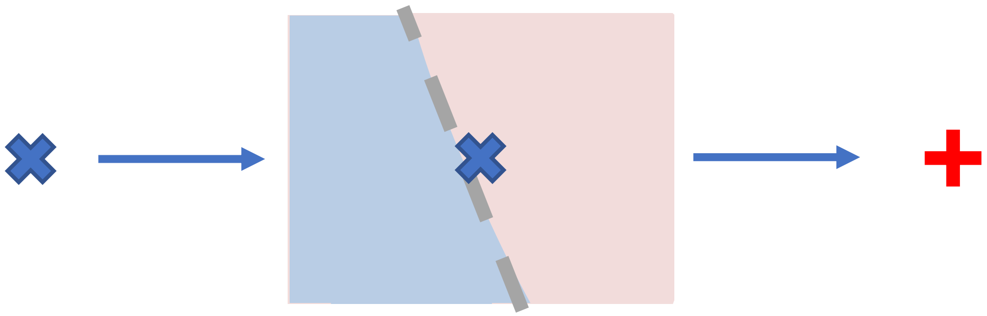
Predicted: wolf
True: wolf

Did explanations help with wolf problem?



More Examples

LIME: Learn locally sparse linear model around each prediction



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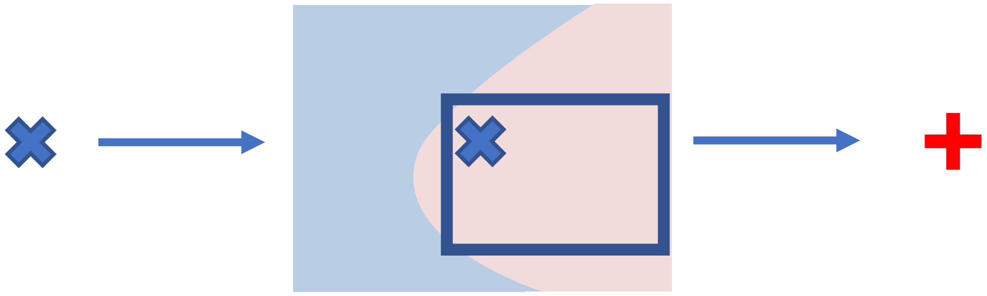
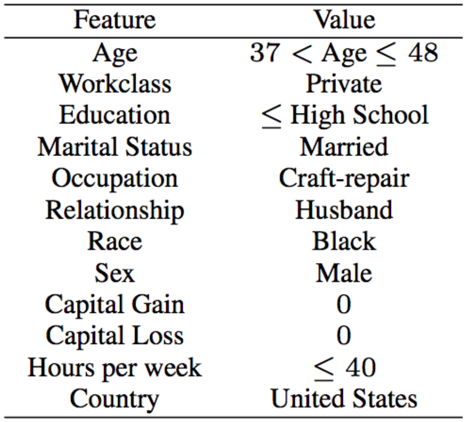
Anchors: Sufficient Conditions

Conditions under which classifier makes same prediction

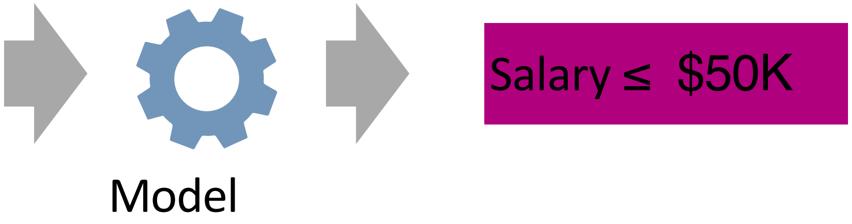


Anchors: High-Precision Model-Agnostic Explanations. Ribeiro, Singh & G. AAAI 18

Salary Prediction



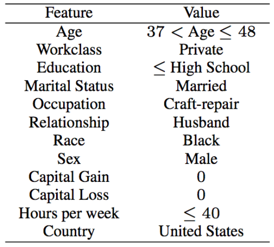
Feature	Value
Age	$37 < \text{Age} \leq 48$
Workclass	Private
Education	$\leq$ High School
Marital Status	Married
Occupation	Craft-repair
Relationship	Husband
Race	Black
Sex	Male
Capital Gain	0
Capital Loss	0
Hours per week	≤ 40
Country	United States



Model

Salary ≤ $50K

Salary Prediction: LIME vs Anchors



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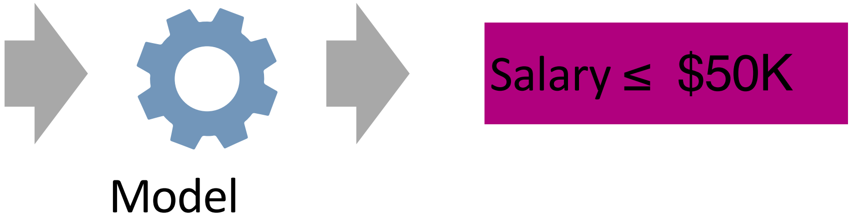
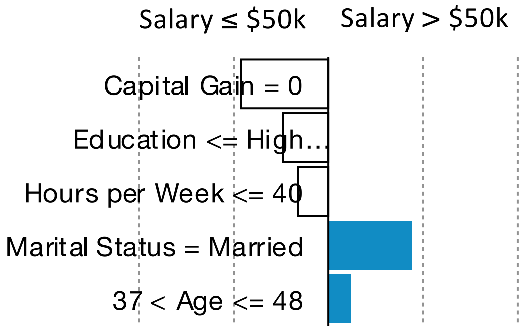


LIME

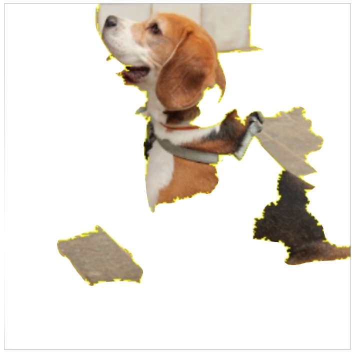


Anchor

IF Education ≤ High School
Then
P(prediction = ≤ 50K) > 0.95

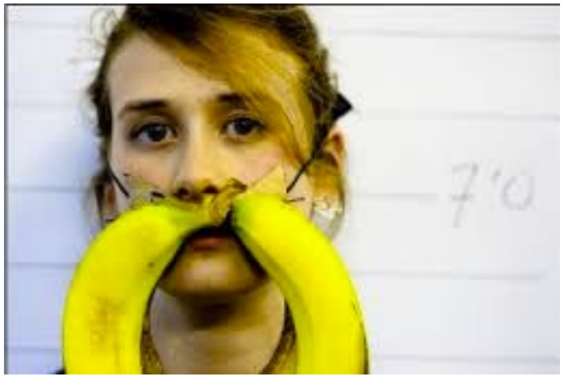
Anchors for Images: Classification

Prediction: Beagle



Anchor for Beagle

Anchors for Visual Question Answering

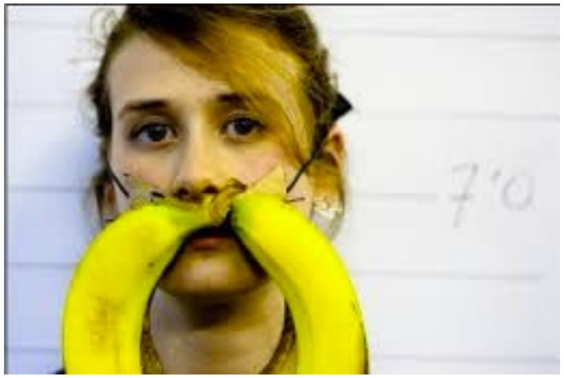


What is the mustache made of?	*Banana*

Anchor

How many bananas are in the picture?	*2*

Anchors for Visual Question Answering

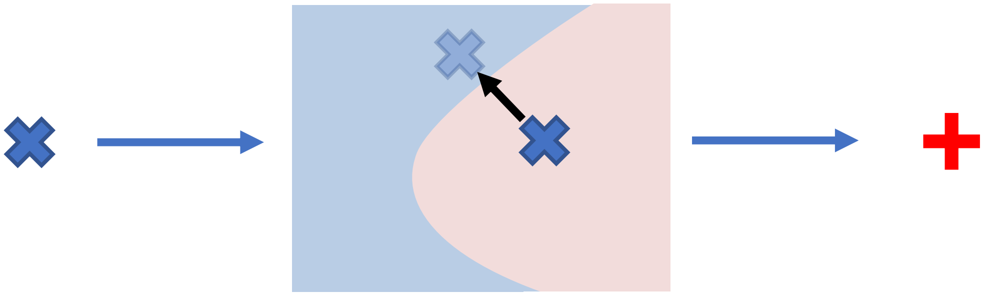


What is the mustache made of?	*Banana*
What is the ground made of?	*Banana*
What is the hair made of?	*Banana*
What is the picture of?	*Banana*
What was the head of the US?	*Banana*

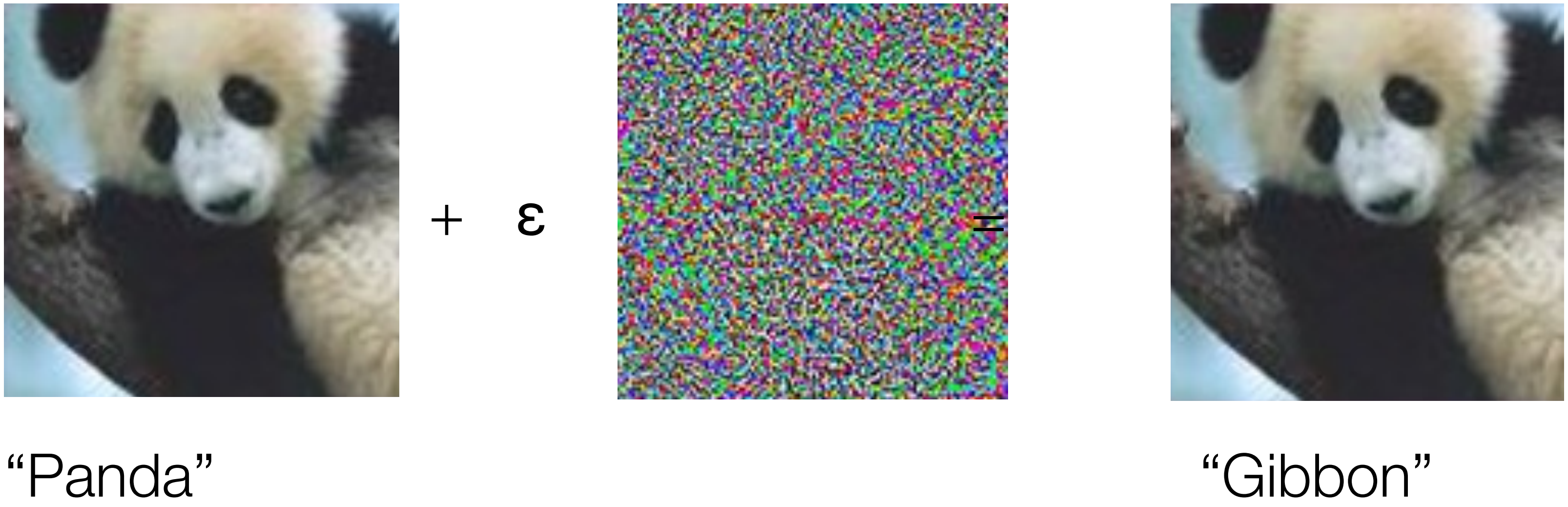
How **many** bananas are in the picture?	*2*
How **many** are in the picture?	*2*
How **many** people in the picture?	*2*
Are there **many** animals in the picture?	*2*
How **many** is too many?	*2*

Adversarial Bug Discovery

Find closest input with different prediction

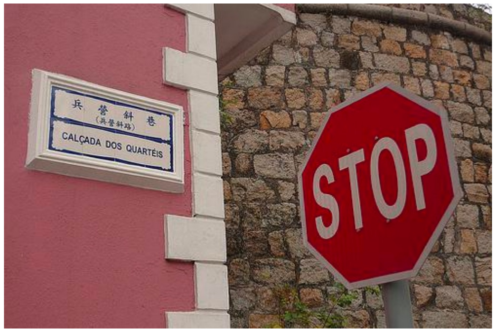


Oversensitivity in image classification



Adversary not distinguishable by human
→ Unlikely to be a real-world issue (except for attacks)

Explaining and Harnessing Adversarial Examples. Goodfellow, Shlens & Szegedy 2015



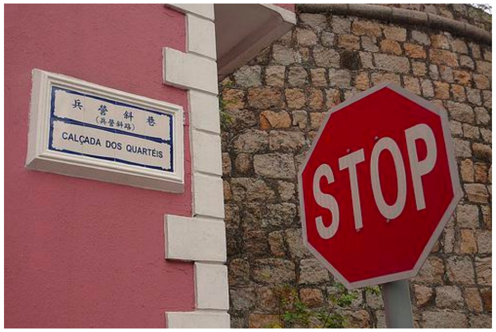
What type of
road sign is shown?

STOP

The biggest city on the river Rhine is Cologne, Germany with a population of more than 1,050,000 people. It is the second-longest river in Central and Western Europe, at about 1,230 km.

How long is
the Rhine?

1,230 km



What type of road sign is shown?

STOP

Which type of road sign is shown?

Do not enter

The biggest city on the river Rhine is Cologne, Germany with a population of more than 1,050,000 people. It is the second-longest river in Central and Western Europe, at about 1,230 km.

How long is the Rhine?

1,230 km

How long is the Rhine??

More than 1,050,000

Goal: Find semantically-equivalent adversarial examples

Semantically Equivalent Adversarial Rules for Debugging NLP Models. Ribeiro, Singh & G. ACL 18

Semantically-equivalent

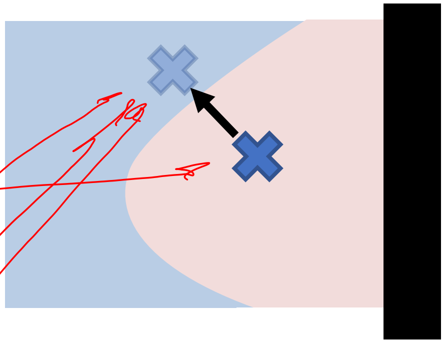
Use paraphrasing model [Lapata et al. 2017]

+

Adversarial

Changes correct model prediction

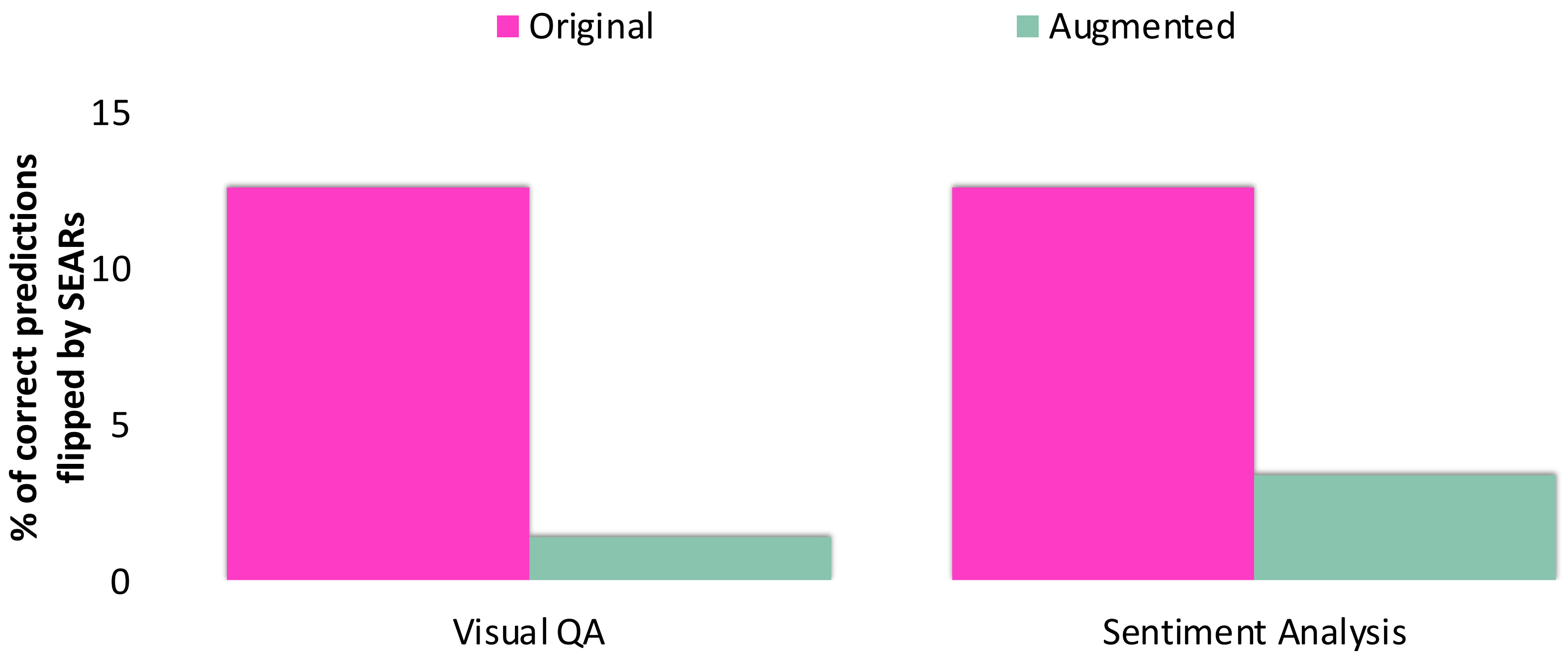
What color is the tray?	*Pink*
What **colour** is the tray?	*Green*
Which color is the tray?	*Green*
What color is **it**?	*Green*
What color is ~~the~~ tray?	*Pink*
How color is ~~the~~ tray?	*Green*



Semantically Equivalent Adversarial Rules for Debugging NLP Models. Ribeiro, Singh & G. ACL 18

Closing the Loop with Simple Data Augmentation

Augment by applying validated SEARs to training data



Typical challenges with explainability methods

- Explanations to simplistic
- Not focused on information needs for task
- Unstable
- Not causal
- …