STATWORX

EXPLAINABLE AI
OPENING THE MACHINE LEARNING BLACK BOX

STATWORX GmbH
Fabian Müller, Head of Data Science

Frankfurt, 25.04.2019

AGENDA

Key questions I am going to answer in this talk

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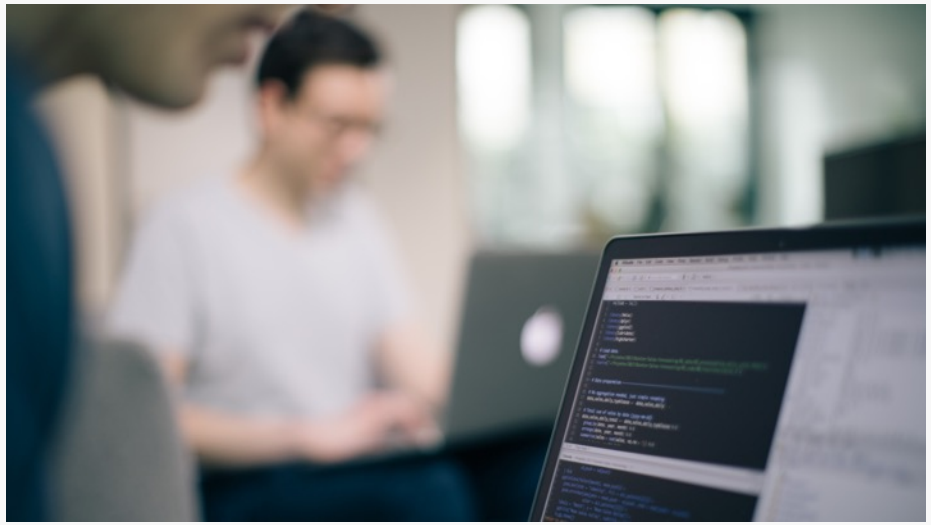

1. **WHO IS STATWORX? ☺**
2. **WHAT IS MODEL INTERPRETABILITY?**
3. **WHY DO WE NEED MODEL INTERPRETABILITY?**
4. **WHAT METHODS ARE AVAILABLE?**
5. **EXAMPLE IMPLEMENTATIONS USING CUTE PETS!**

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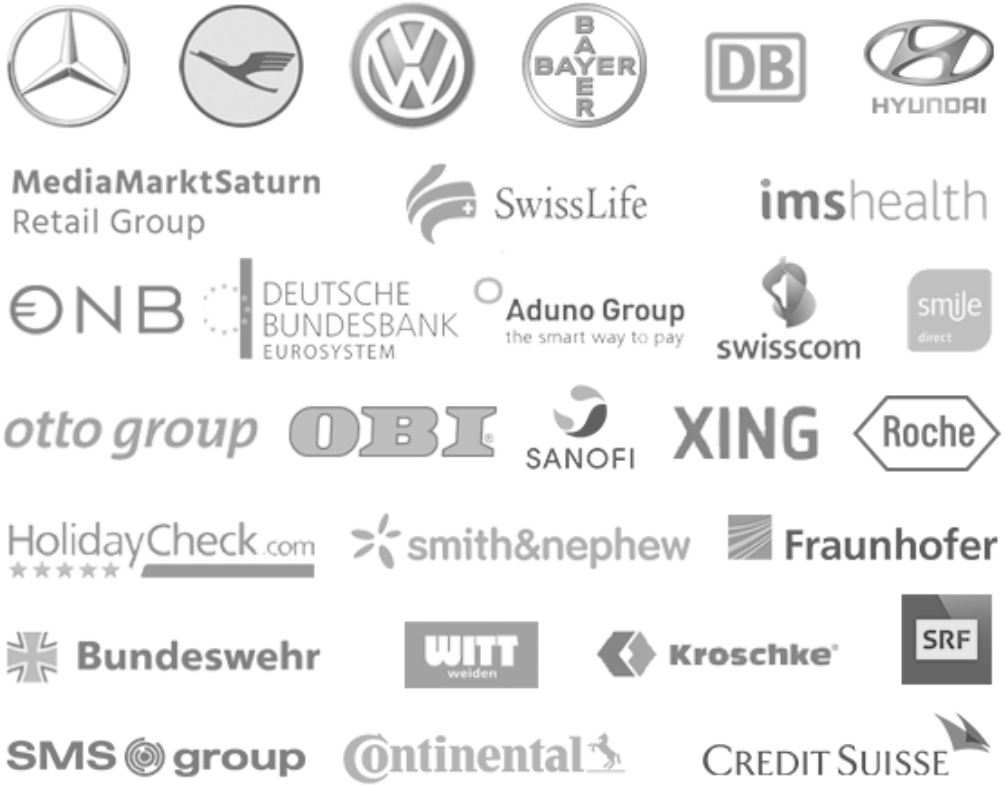
Facts and figures

SOME OF OUR CUSTOMERS



COMPANY PROFILE

STATWORX is a consulting company for data science, machine learning, and AI located in Frankfurt, Vienna and Zurich. We support our customers in the development and implementation of data science and machine learning projects as well as data driven products.

2011
FOUNDED

3
OFFICES

35+
EMPLOYEES

200+
DATA SCIENCE PROJECTS

50+
INDUSTRY CUSTOMERS

1000+
DATA ACADEMY PARTICIPANTS

TOOL STACK & PARTNER

END-2-END DATA CONSULTING

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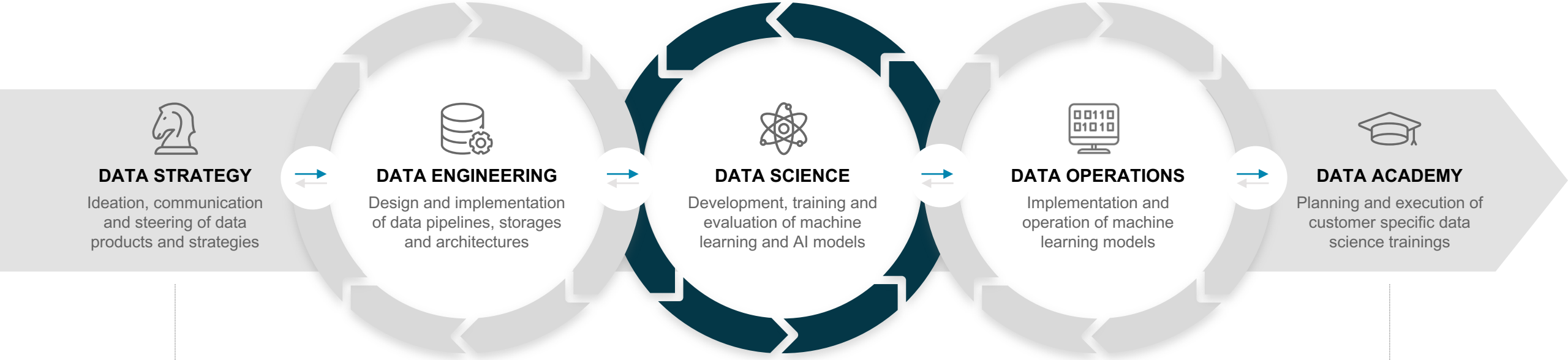
We support our customers along the whole process of data driven decision making



MOTIVATION

What makes Danny more likely to get adopted compared to Beauty and Kat?

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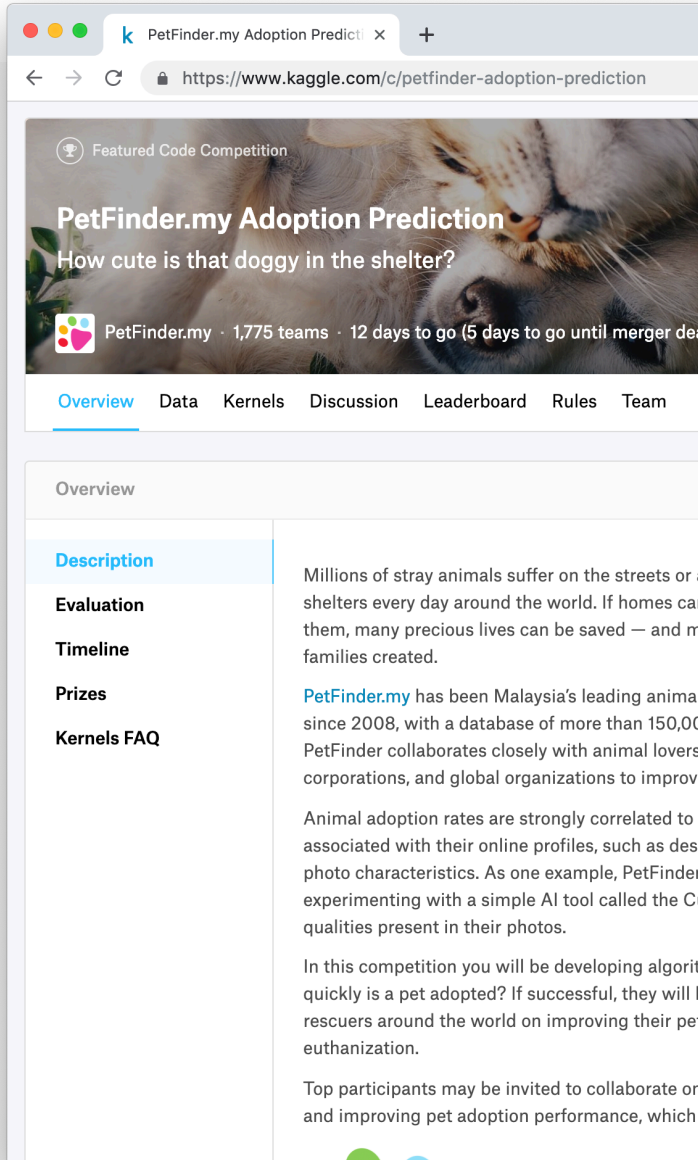
Danny

Kat

Beauty



DEFINITION

What model interpretability is about

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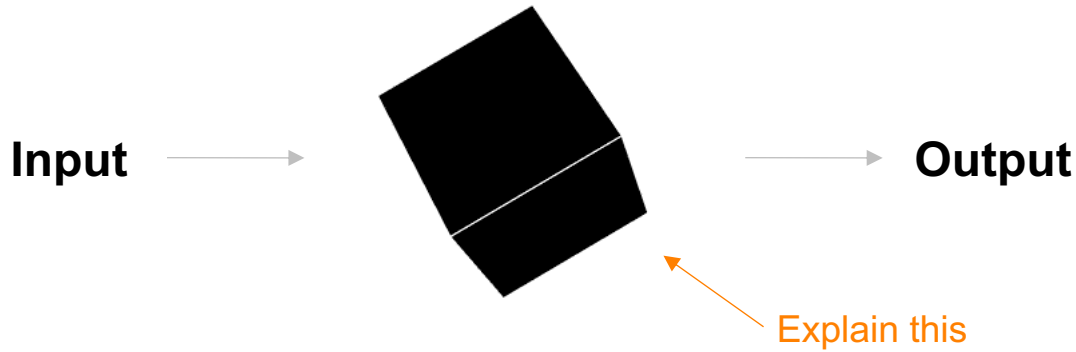
"Interpretability is the degree to which a human can understand the cause of a decision."

Miller, Tim. "Explanation in artificial intelligence: Insights from the social sciences." arXiv Preprint arXiv:1706.07269. (2017).



Interpretability is NOT about understanding all bits and bytes of the model for all data points (we cannot).

It's about knowing enough for your downstream tasks.

IMPORTANCE OF INTERPRETABILITY

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Some (certainly unrepresentative) thoughts from Google about model interpretability

"People can't explain how they work, for most of the things they do."

Geoffrey Hinton, Google Fellow

"Don't limit your solutions to what the simple human mind can wrap itself around."

Cassie Kozyrkov, Chief Decision Intelligence Engineer, Google

IMPORTANCE OF INTERPRETABILITY

STATWORX

Why we should care about model interpretability

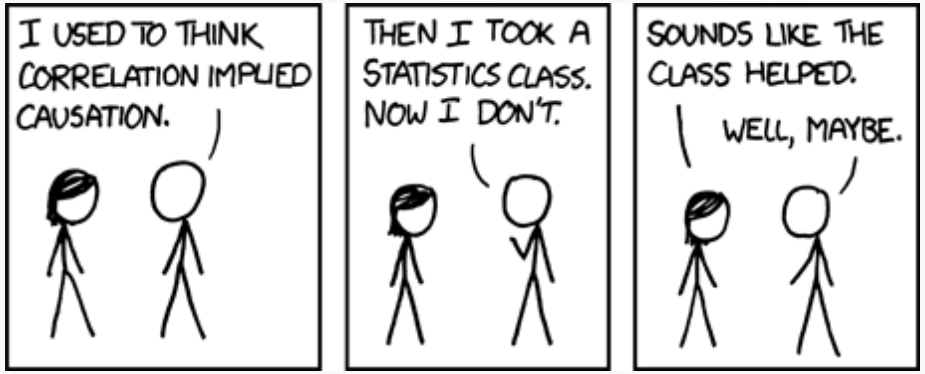
1. **Mismatched objectives and multi-objective trade-offs:**
   The problem is that a single metric, such as classification accuracy, is an incomplete description of most real-world tasks (simply minimizing the loss does not work).

2. **Human curiosity**
   Gain knowledge from data and learn from models (e.g. improve feature engineering by understanding the model).

3. **Detect bias**
   Discrimination against a minority when only minimizing arbitraryloss.

4. **Social acceptance and trust**
   It is easier for humans to trust a system that explains its decisions compared to a black box and sometimes insights are more valuable than predictions.

5. **Debugging**
   You can not test everything, if anything goes wrong, interpretability can help to find problems quickly, also humans tend to start asking questions when things go wrong.



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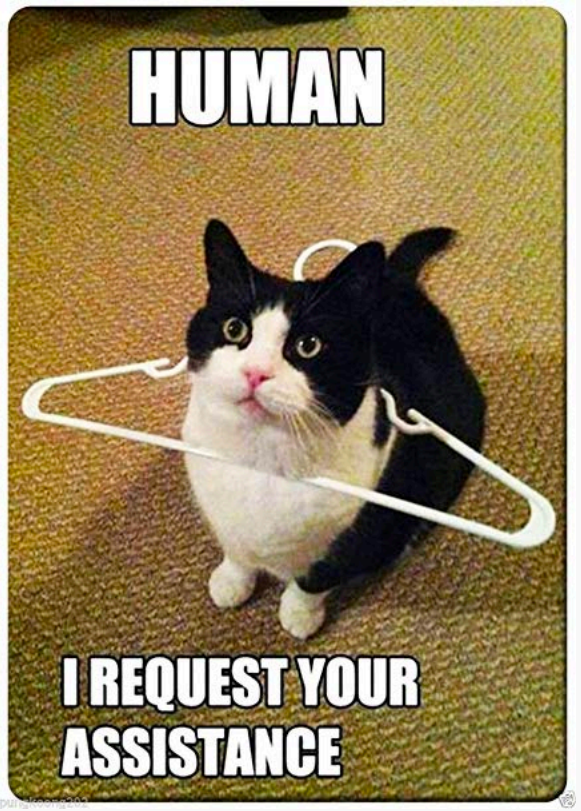

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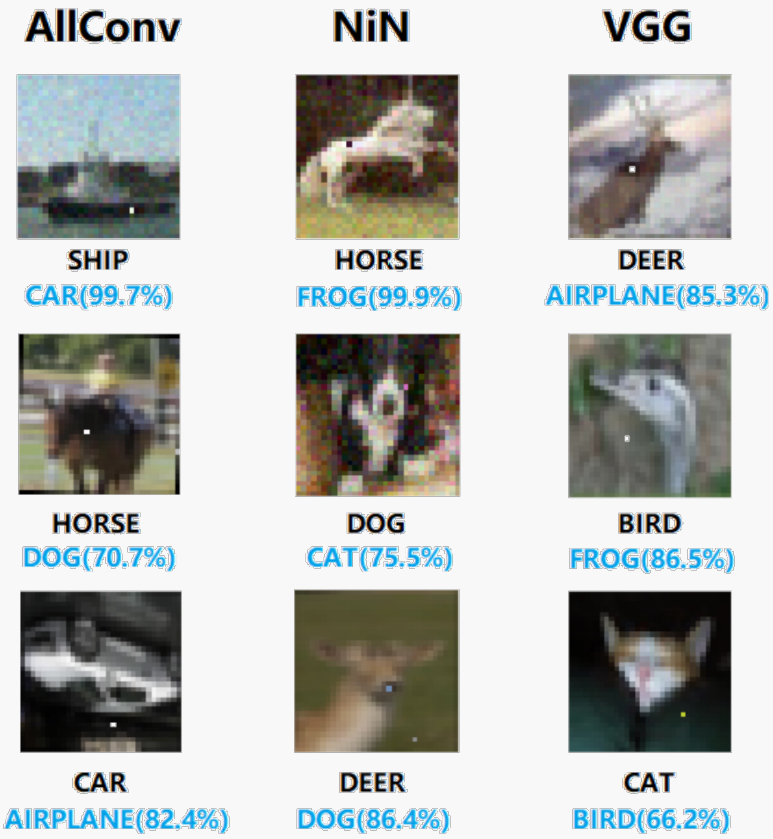

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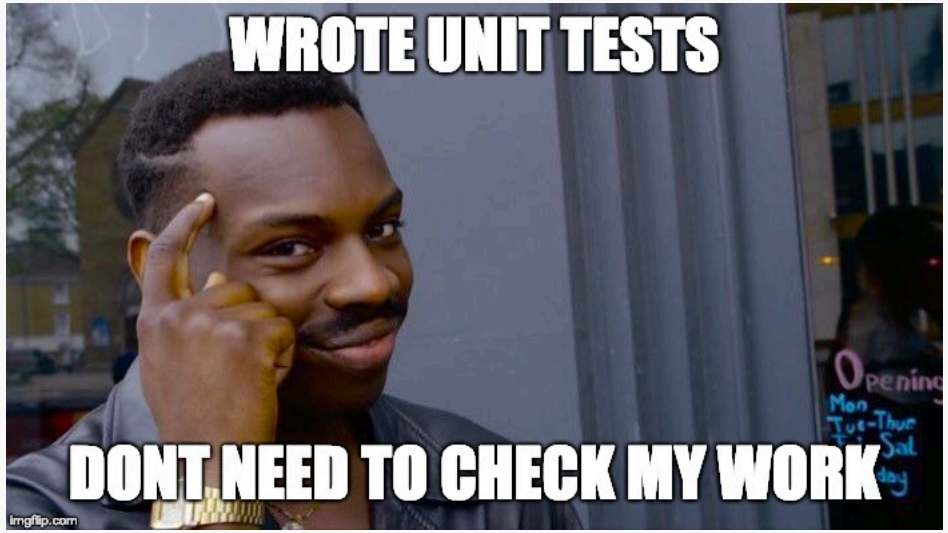
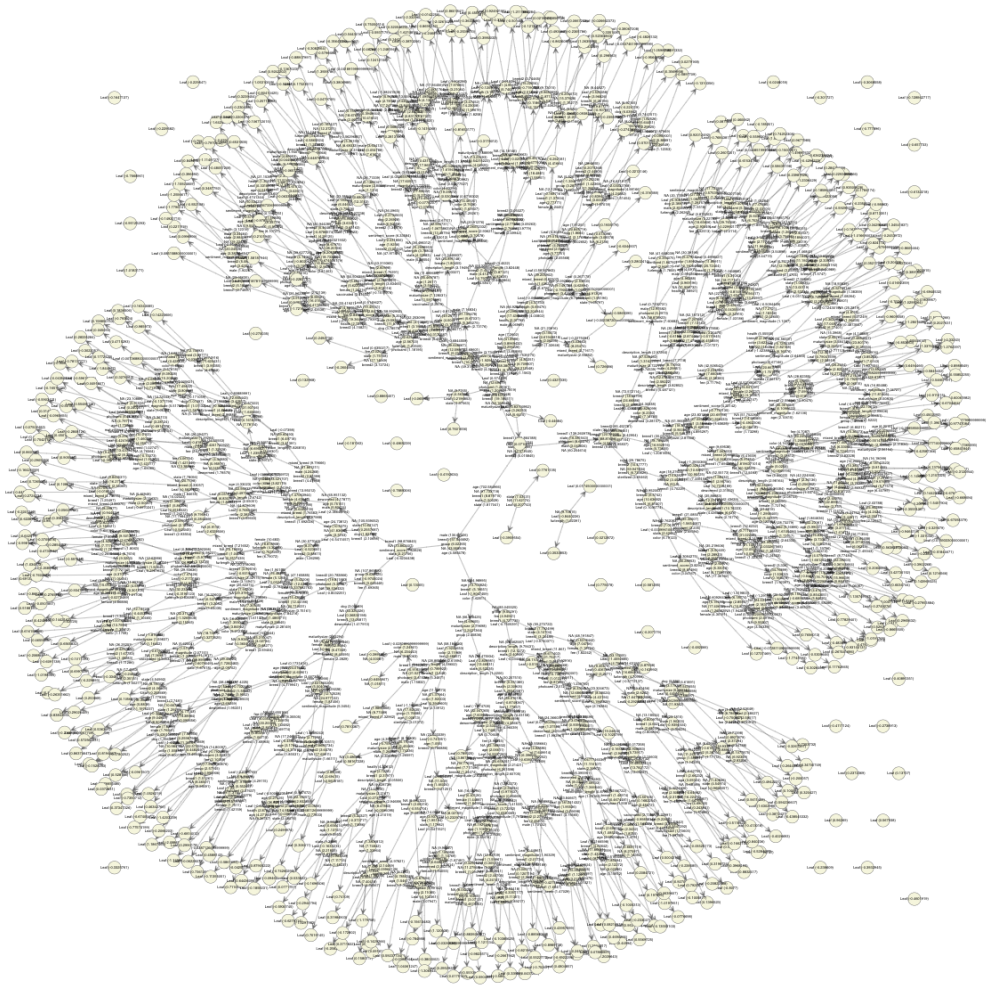


INTERPRETATION IS NO FREE LUNCH

STATWORX

Since interpretation is important, let's take a look at the model… ok shit!



dmlc XGBoost

INTERPRETATION IS NO FREE LUNCH

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One does not simply interpret ML models, or does one?

INTERPRETATION IS NO FREE LUNCH

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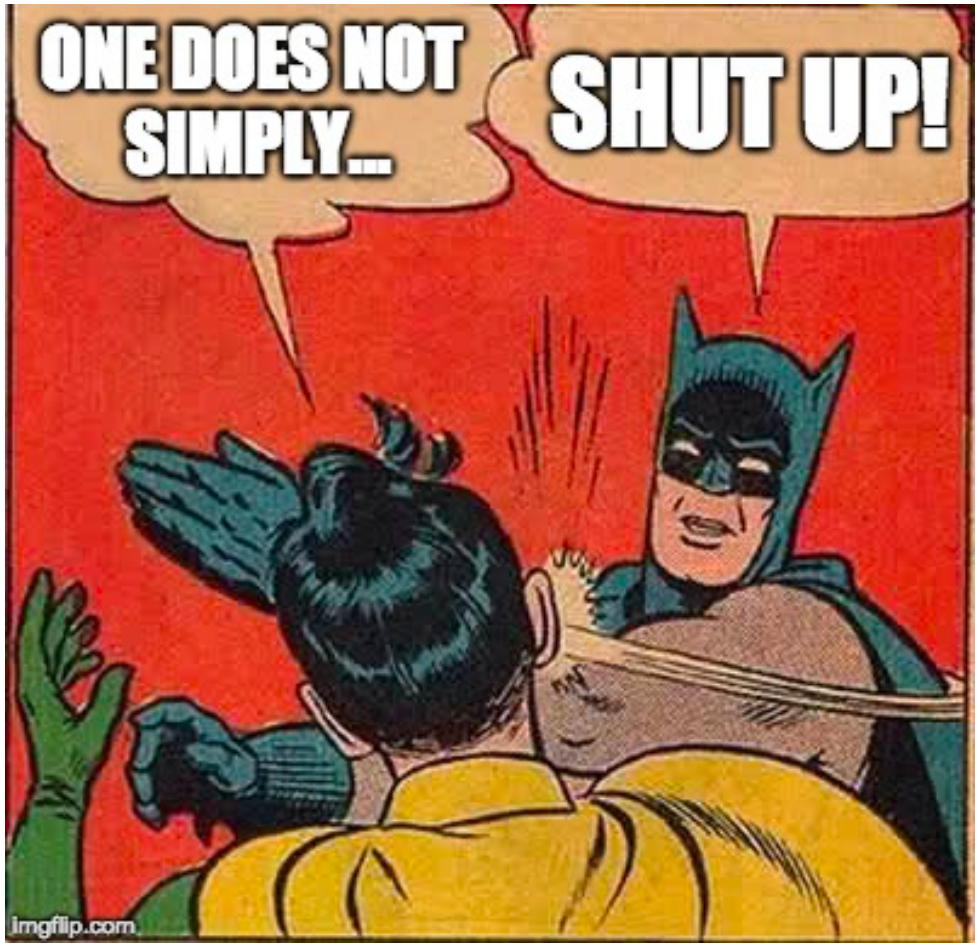

TAXONOMY OF INTERPRETABILITY

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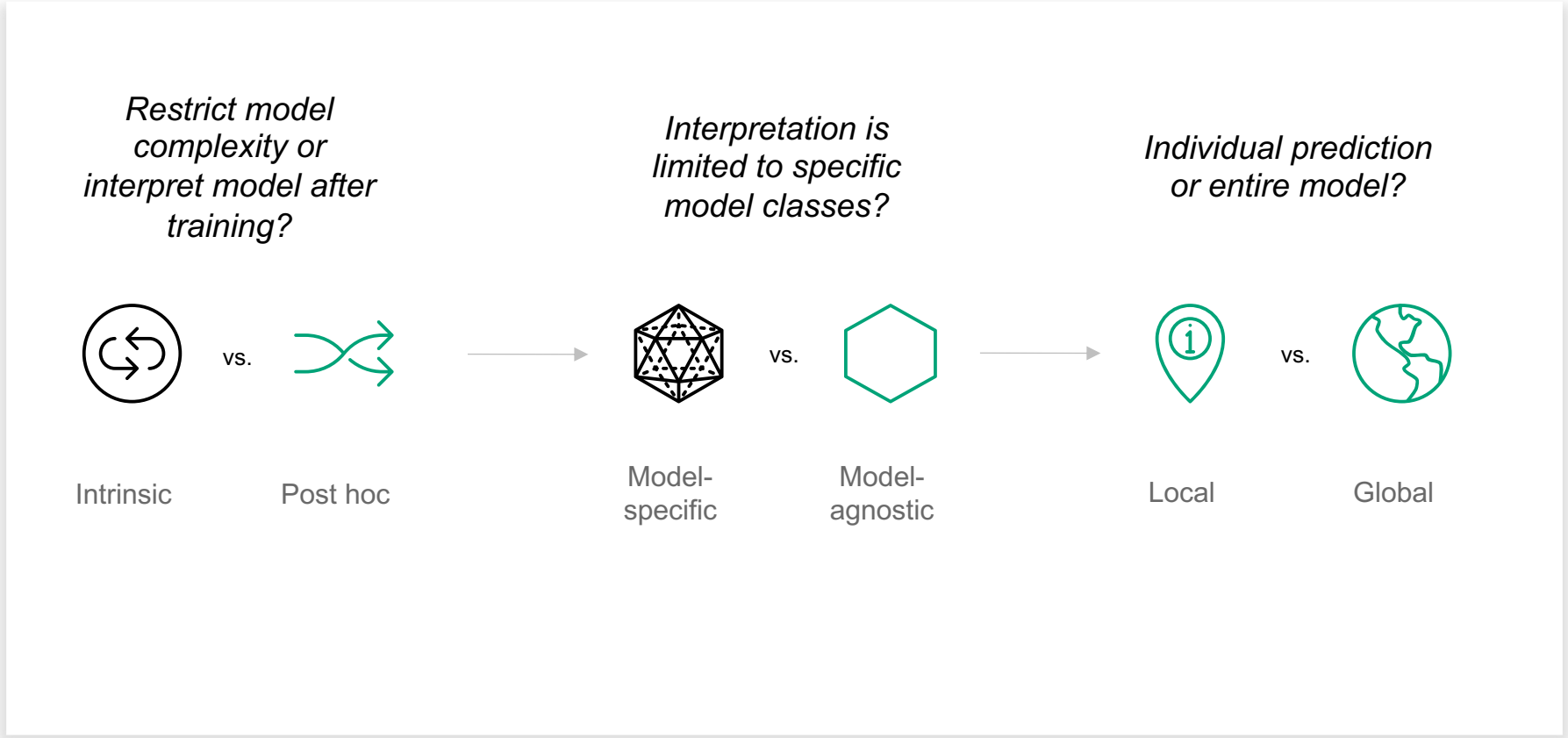
There is more than one method for model interpretability



TAXONOMY OF INTERPRETABILITY

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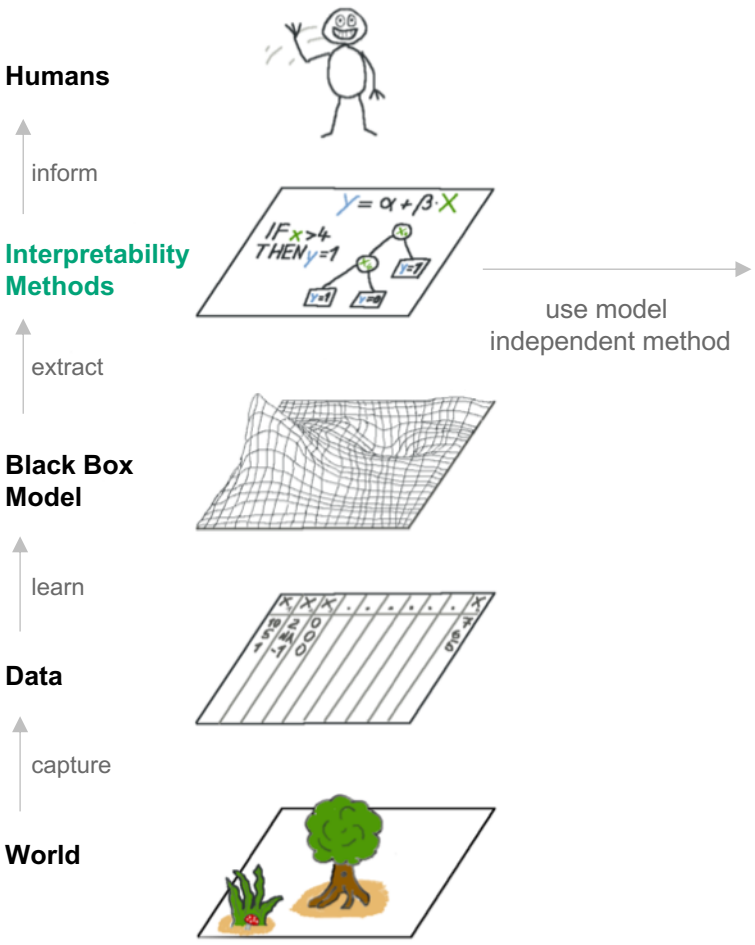
Post hoc, model-agnostic methods for interpretation



Source: christophm.github.io/interpretable-ml-book

Model-agnostic methods build solely upon the model's predictions and thus separate learning from explanation.

Advantages of model-agnostic methods:

- ✓ High flexibility
- ✓ Model-independent explanation
- ✓ Explanations are comparable between different model classes

TAXONOMY OF INTERPRETABILITY

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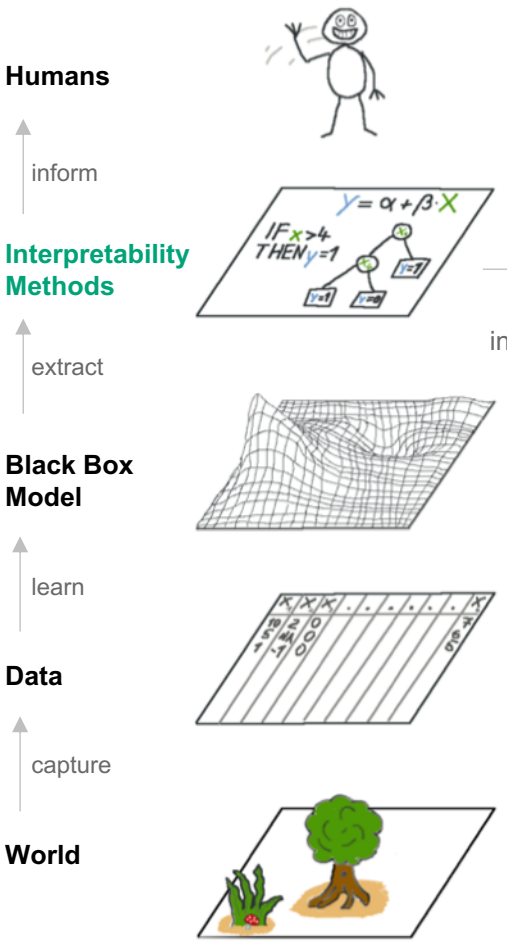
What method to use when?



use model independent method

Understand *model* or single *prediction*?

model

Model *performance* or *structure*?

performance

Performance plot
Residual values

Partial dependency
ICE
ALE
Feature importance
Feature interaction
Merging path plot
Global surrogates

single prediction

How to change it or *why* is it happening?

local effects

Variable *attribution* or *importance*?

key features

LIME

what-if scenarios

Ceteris paribus plot

decompose prediction

Break down plots
Shapley / SHAP

Source: christophm.github.io/interpretable-ml-book

ADOPTION PREDICTION

STATWORX

Explaining the overall model structure with visualized feature importance

Feature importance explained by:
Permutation feature importance

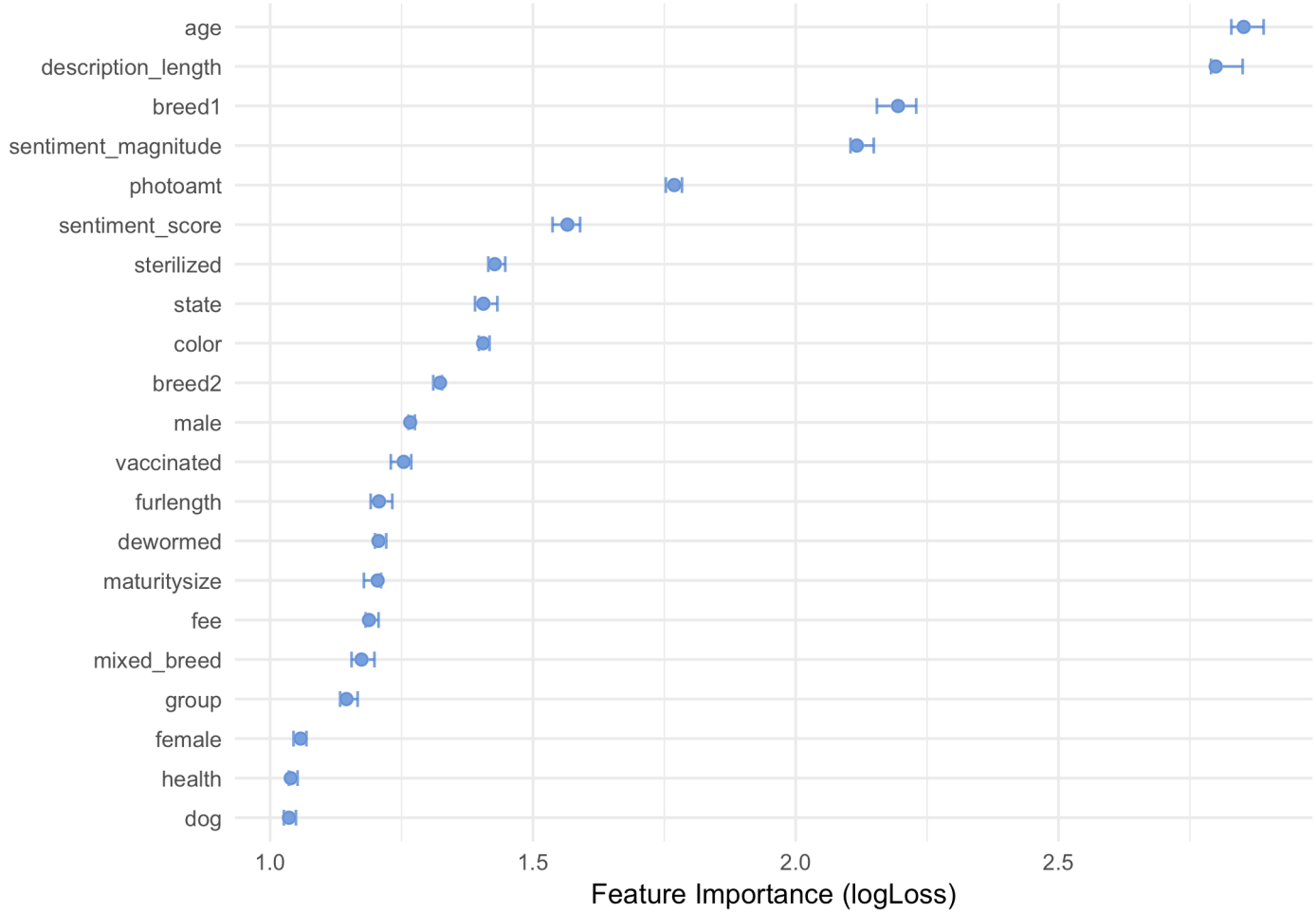
- Measure feature importance by increase in model error after feature permutation

✓ Intuitive calculation and easy interpretation

✓ Comparable between algorithms

✗ Feature importance on training or testing data?

✗ Importance based on prediction error (no variance component)



ADOPTION PREDICTION

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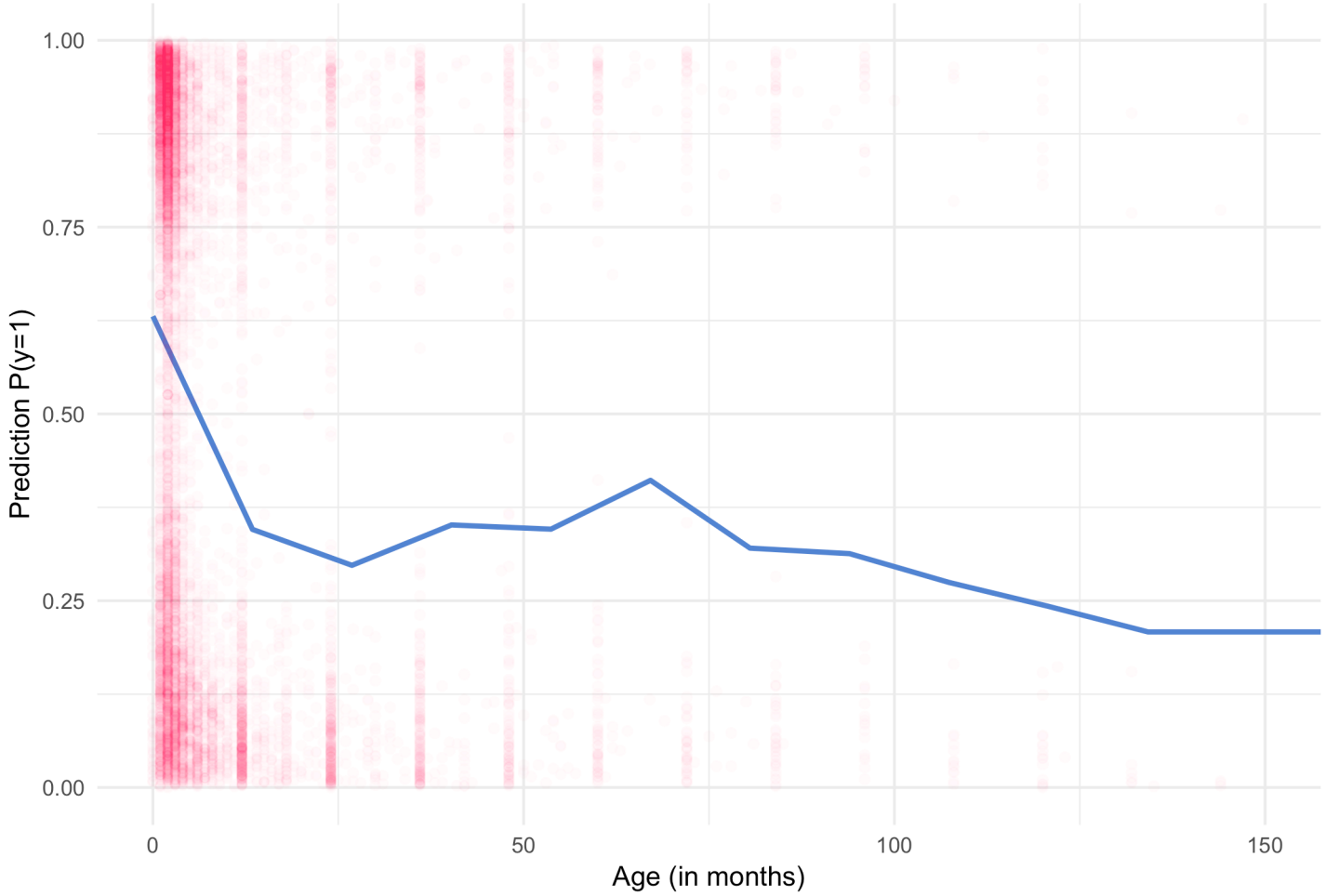
Explaining the effect of a single feature

Feature effect explained by:
Partial dependency plot (PDP)

- PDP shows the marginal effect of one features on the predicted outcome
- For a given feature value (e.g. age=2) take the average prediction over the entire dataset

✓ Intuitive calculation and easy interpretation

✗ Assumes independence between features



ADOPTION PREDICTION

STATWORX

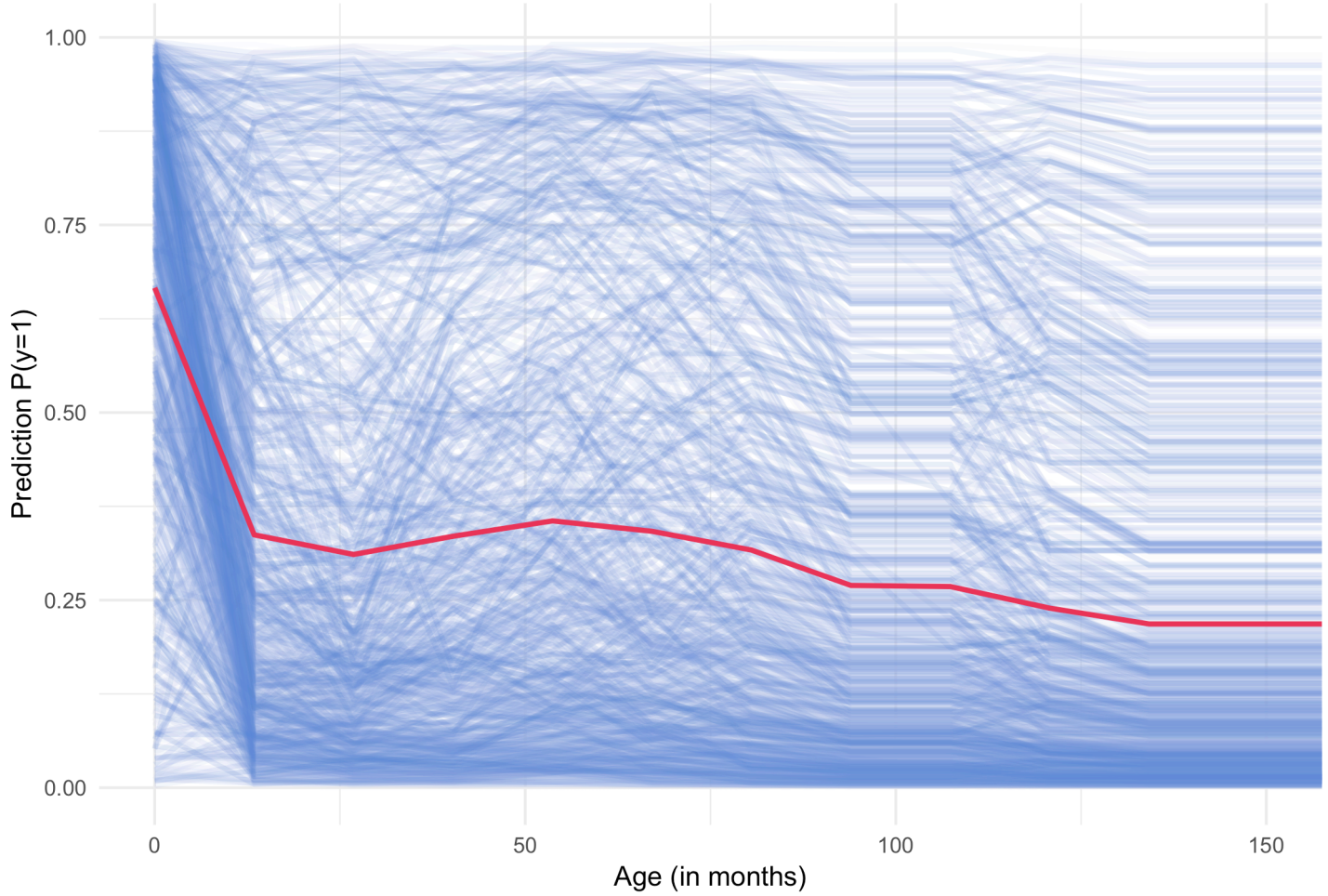
Explaining the effect of a single feature

Feature effect explained by:
Individual Conditional Expectation (ICE)

- Shows dependence of the prediction on a feature for each instance separately

✓ Uncover obscure heterogeneous relationship

✗ Overplotting for medium/large data



ADOPTION PREDICTION

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Explaining the model structure with a global surrogate model

Model structure explained by:
Global Surrogate Tree

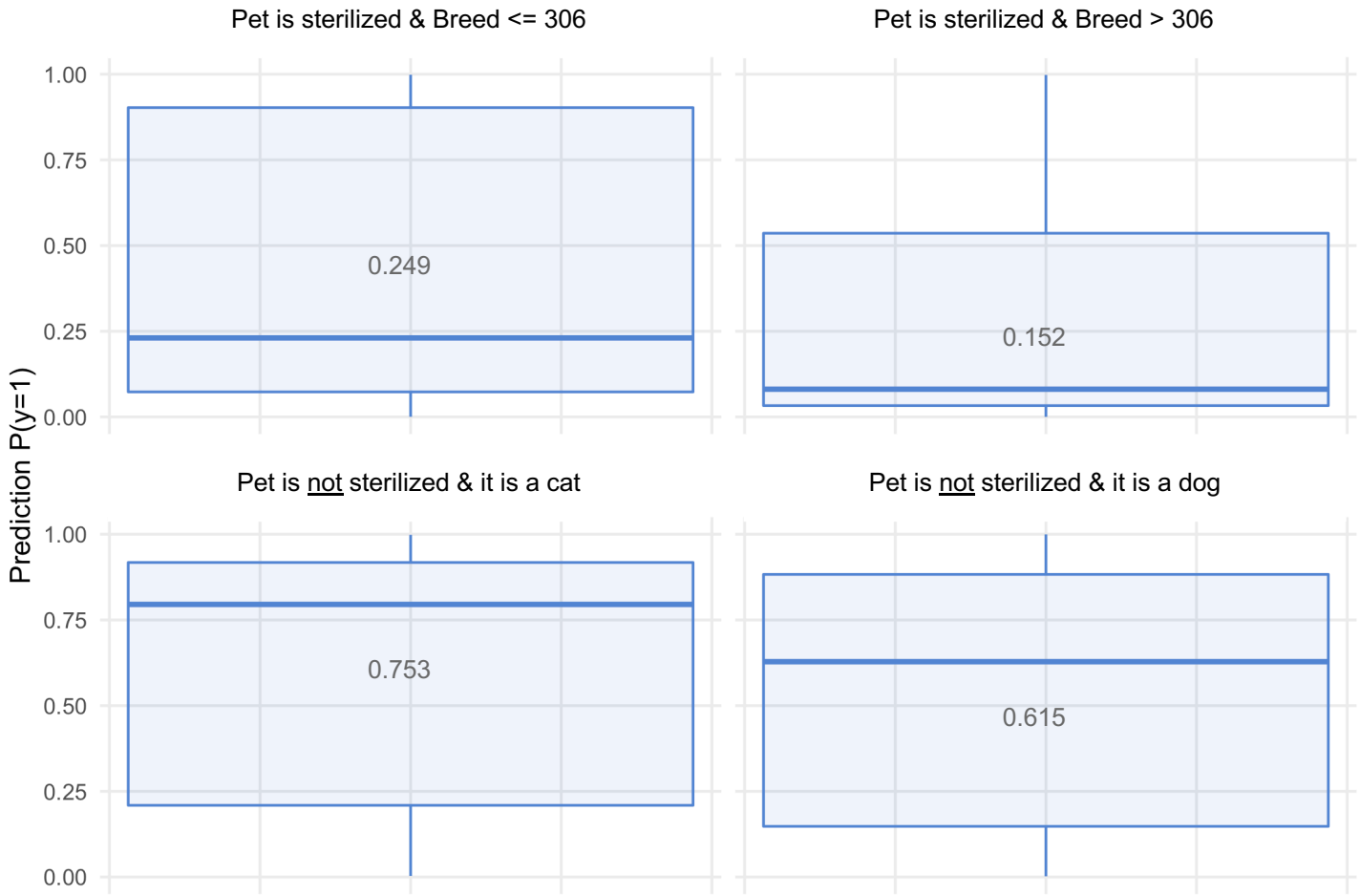
- Train interpretable model (e.g. tree) to approximate predictions of black box model

✓ Intuitive and straightforward

✓ Approximation quality can be measured

✓ Extendable to local surrogate models (e.g. LIME)

✗ Approximation can be (locally/globally) misleading



ADOPTION PREDICTION

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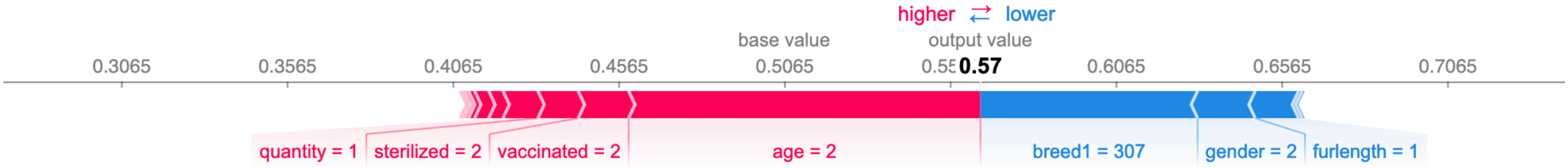
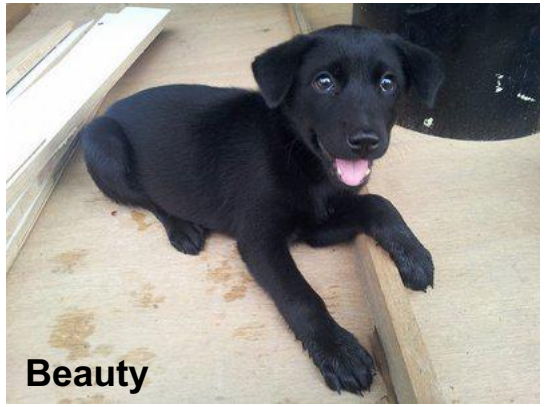
Beauty‘s probability for adoption explained by Shapley Values





Explain Beauty’s probability of adoption:

\+ Beauty's age of two years makes her more likely to get adopted (by ~10%)
\+ Being neither sterilized nor vaccinated makes her more likely to get adopted (by ~3%)

– Beauty is of mixed breed, which makes here less likely to get adopted (by ~7%)
– Beauty is a female dog, which makes here less likely to get adopted (by ~3%)
– Beauty has short hear, which makes here less likely to get adopted (by ~2%)

ADOPTION PREDICTION

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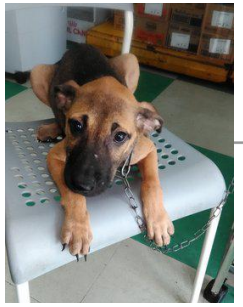
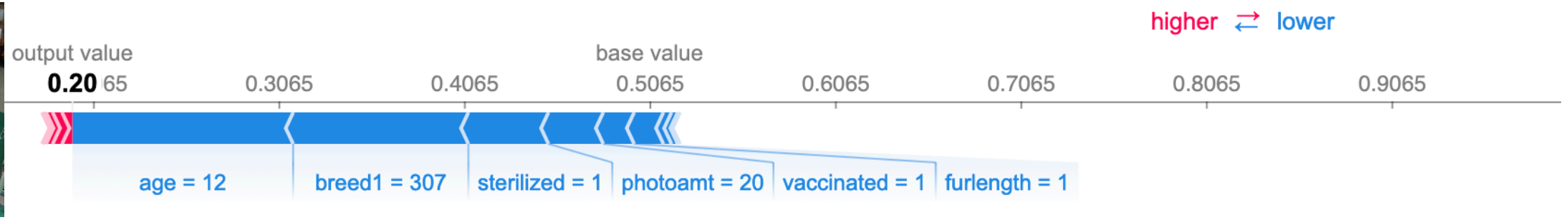
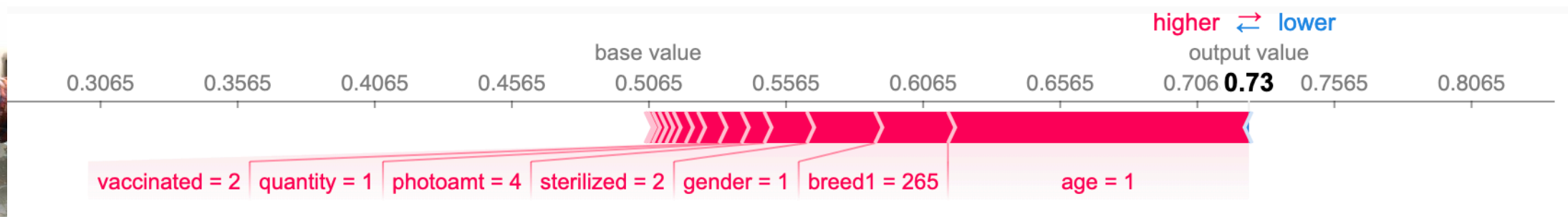
What about the Shapley Values for Danny and Kat?







ADOPTION PREDICTION

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One does not simply interpret deep learning models, or does one?

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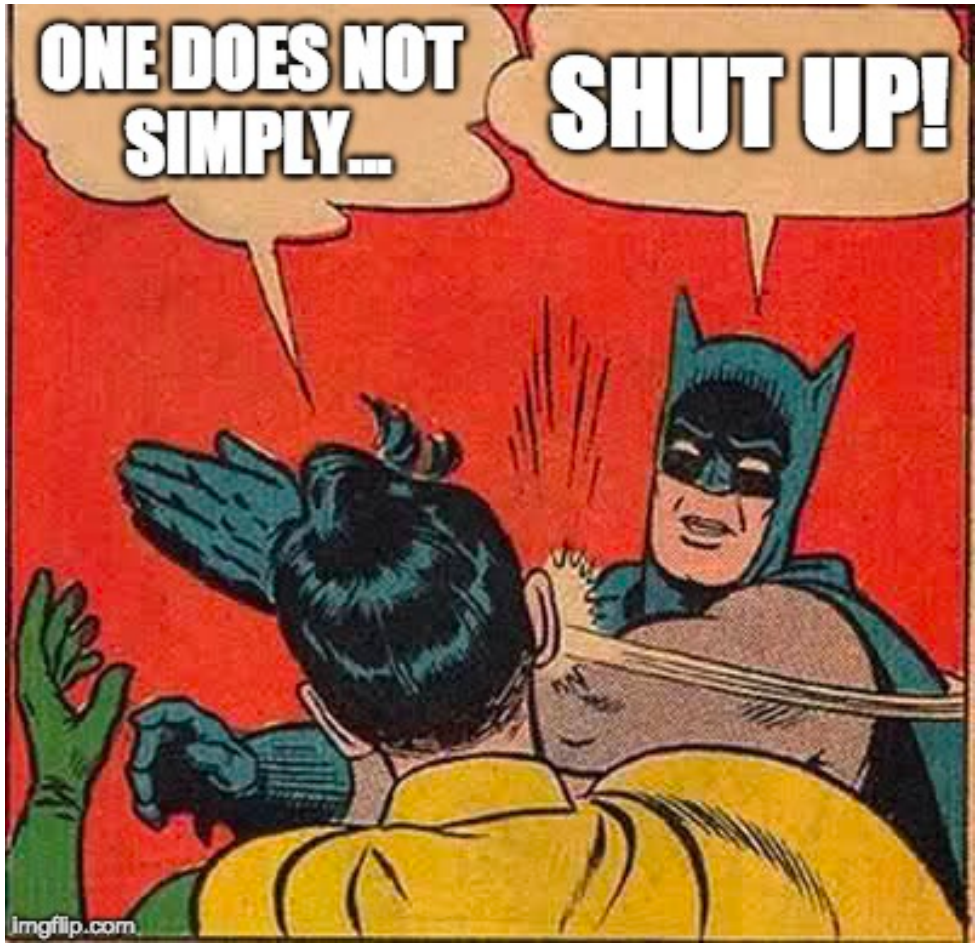

ADOPTION PREDICTION

Explaining fine-tuned VGG16 predictions with Shapley Values

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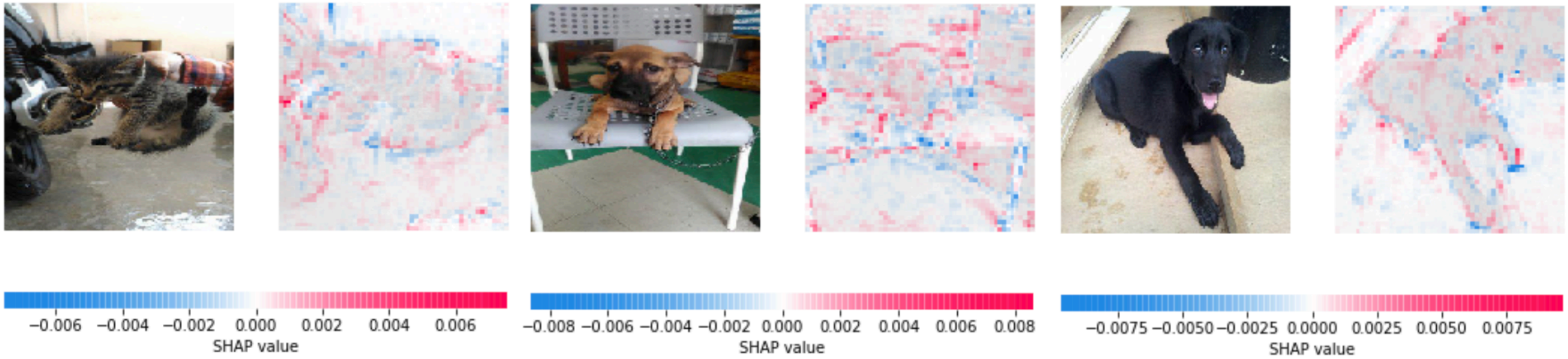

CONCLUSION

What to take home

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Interpretability is important

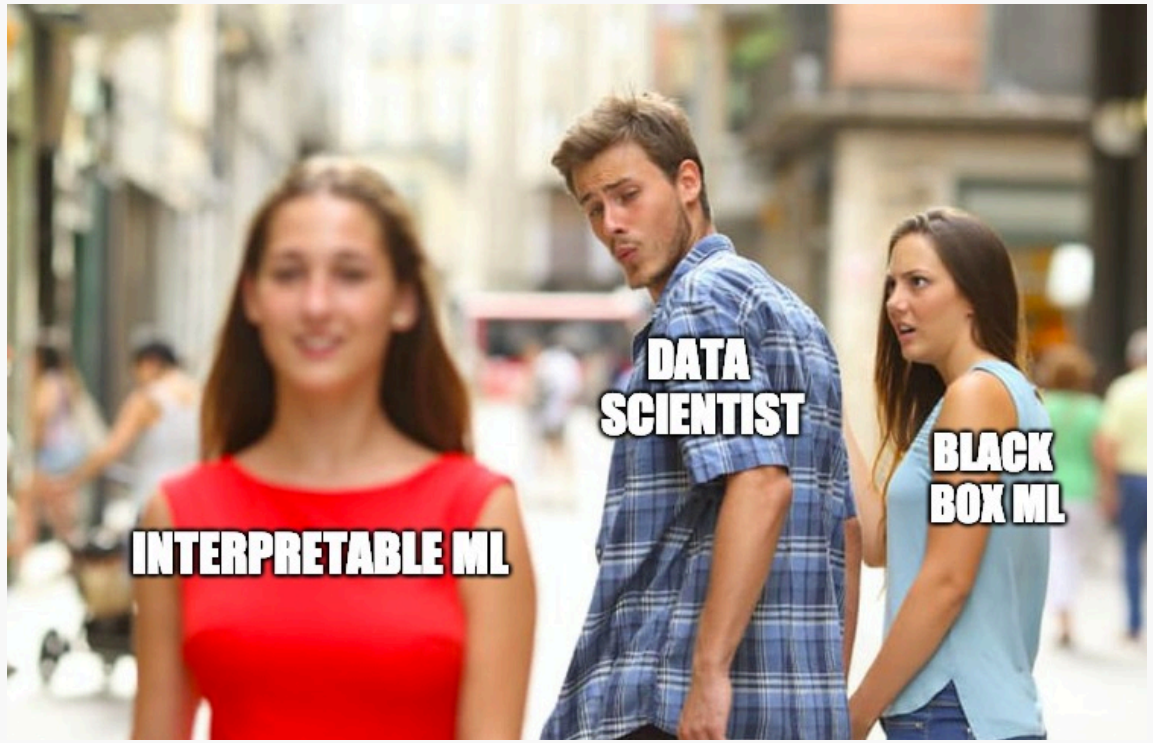
- … to accurately describe real-world tasks
- … to satisfy human curiosity
- … to detect bias in your models
- … to generate social acceptance and trust
- … to allow for easy model debugging

Interpretability is “easy” to implement

- Use model-agnostic methods
- Global methods: PDP, ICE & surrogate models
- Local methods: Shapley Values (and Lime)
- and many more

Resources

- github.com/fabianmax/pet-finder
- www.statworx.com/blog



WE ARE HIRING!
JOIN OUR TEAM

(Senior) Data Scientist (m/w/d)
(Senior) Data Engineer (m/w/d)

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VIELEN DANK
FÜR IHRE AUFMERKSAMKEIT.

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