dalex: Responsible Machine Learning

with Interactive Explainability and Fairness in Python

Hubert Baniecki
Warsaw University of Technology, Poland

Joint Statistical Meetings
August 8, 2022

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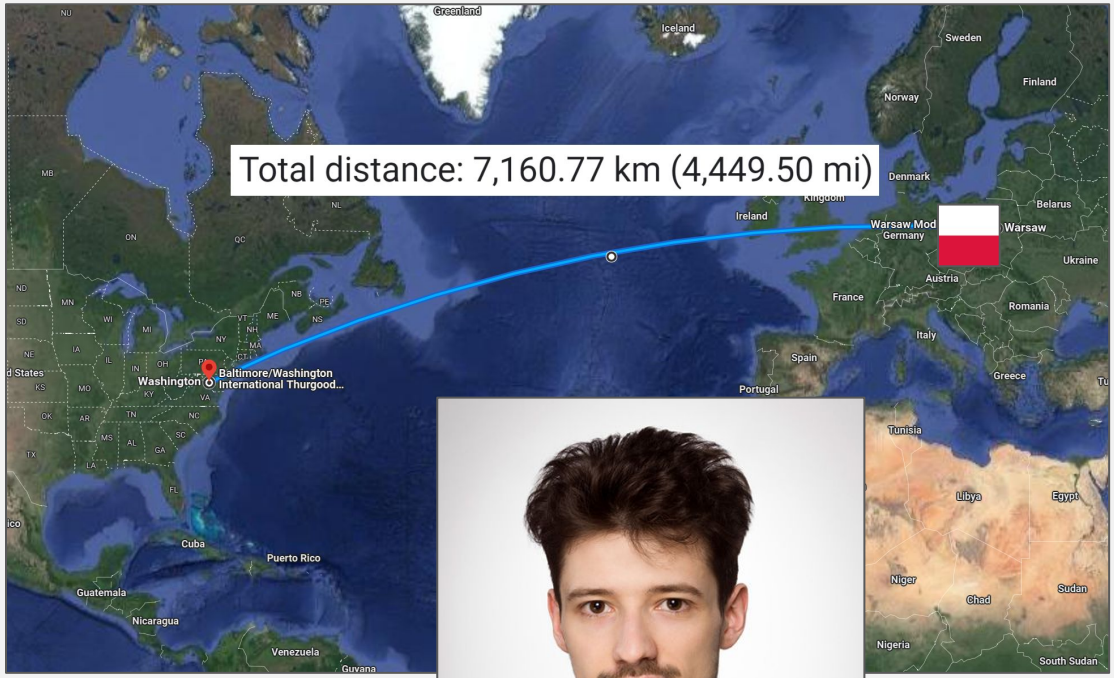
MI RESEARCH

Hi!

Finishing my master's in **Data Science** at Warsaw University of Technology, Poland

Research in explainable and interpretable **machine learning**

Main author of the **dalex** Python package
John M. Chambers Statistical Software Award (2022)



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John M. Chambers Statistical Software Award

Many thanks to organizers and the review panel: **Raymond Wong** (Texas A&M University), **Yixuan Qiu** (Shanghai University of Finance and Economics), **Samantha Tyner** (Tritura), **Philip Waggoner** (YouGov America, Northwestern University, University of Virginia).

Congratulations to **Vittorio Orlandi** (Duke University) for the award's honorable mention, for the R package **FLAME**: interpretable matching methods for performing causal inference on observational data with discrete covariates.

dalex team

Przemysław Biecek

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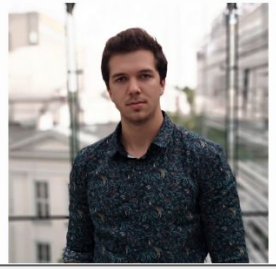
Wojciech Kretowicz, Mateusz Krzyziński, Piotr Piątyszek, Jakub Wiśniewski, Artur Żółkowski




Faculty of Mathematics and Information Science, Warsaw University of Technology

Faculty of Mathematics and Information Science

WARSAW UNIVERSITY OF TECHNOLOGY

National Science Centre (Poland) grants No. *2017/27/B/ST6/0130* and *2019/34/E/ST6/00052*

NATIONAL SCIENCE CENTRE
POLAND

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Outline

1. Responsible machine learning – Why should I care?
2. dalex: the main idea and software – What and how?
3. Educational materials – Where to start?
4. What's next?

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1. Decision making: from credit scoring to precision diagnostics in bio-medicine

The Washington Post
Democracy Dies in Darkness

This article was published more than **3 years ago**

BUSINESS

2019

Apple Card algorithm sparks gender bias allegations against Goldman Sachs

Entrepreneur David Heinemeier Hansson says his credit limit was 20 times that of his wife, even th higher credit score

By Taylor Telford
November 11, 2019 at 10:44 a.m. EST

Many articles have been published in 2020 describing new machine learning-based models for [detection and prognostication of COVID-19], but it is unclear which are of potential clinical utility. [...] Our review finds that none of the models identified are of potential clinical use due to methodological flaws and/or underlying biases.

nature machine intelligence

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2021

nature > nature machine intelligence > analyses > article

Analysis | Open Access | Published: 15 March 2021

Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans

Michael Roberts, Derek Driggs, Matthew Thorpe, Julian Gilbey, Michael Yeung, Stephan Ursprung, Angelica I. Aviles-Rivero, Christian Etmann, Cathal McCague, Lucian Beer, Jonathan R. Weir-McCall, Zhongzhao Teng, Effrossyni Gkrania-Klotsas, AIX-COVNET, James H. F. Rudd, Evis Sala & Carola-Bibiane Schönlieb

Nature Machine Intelligence **3**, 199–217 (2021) | Cite this article

74k Accesses | **237** Citations | **1159** Altmetric | Metrics

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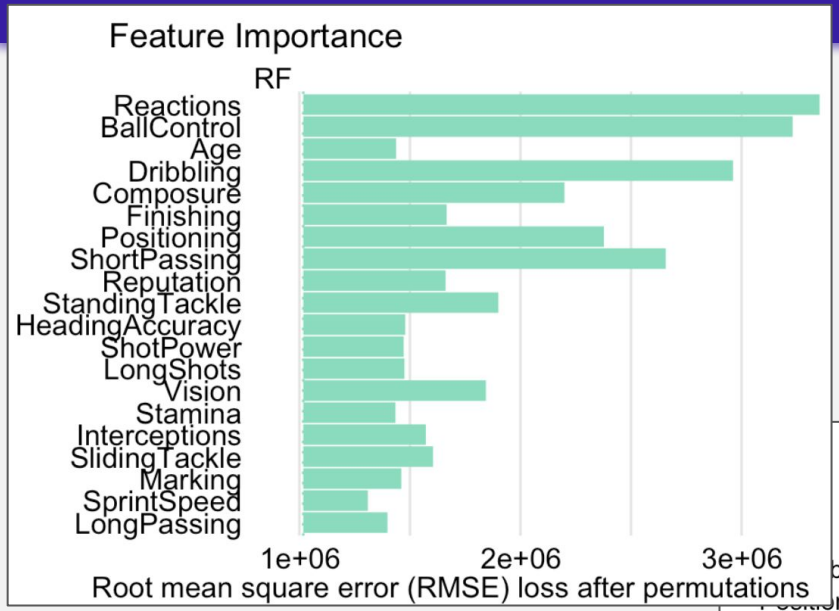
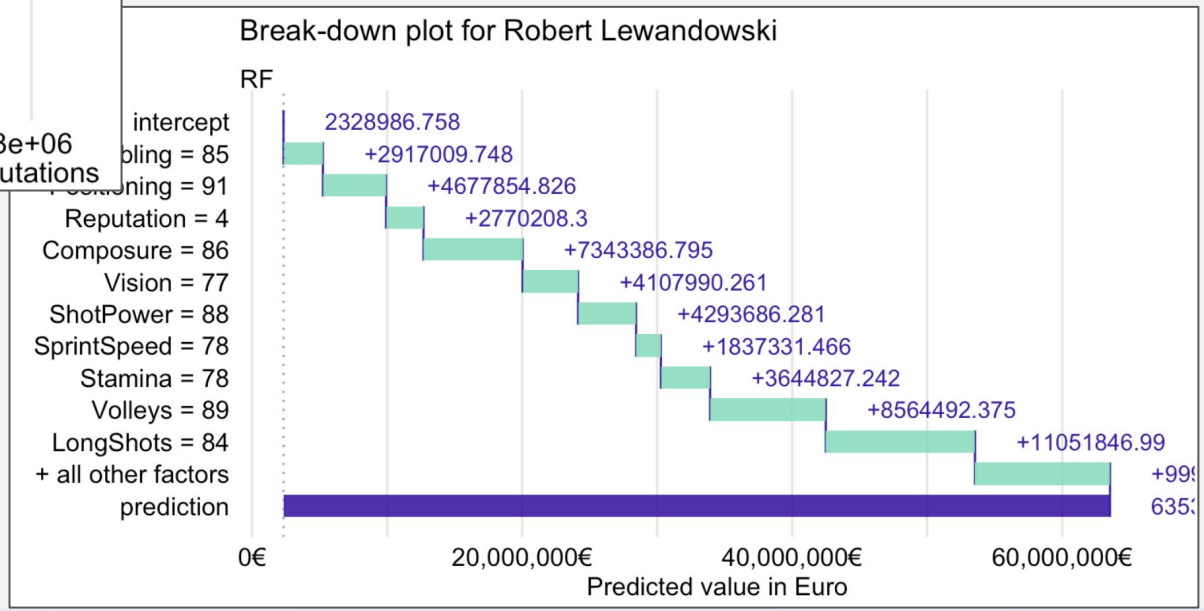


2. Knowledge discovery through explanatory model analysis



ModelOriented / DALEX Public

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Code | Issues 20 | Pull requests 2 | Discussions | Actions | Projects | ...

master | Go to file | Add file | Code

README.md

moDel Agnostic Language for Exploration and eXplanation

R-CMD-check passing
coverage 85% CRAN 2.4.2
downloads 169K
DrWhy BackBone

Python-check passing
python 3.6 | 3.7 | 3.8 | 3.9
pypi package 1.4.1 downloads 187k

About

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Readme
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1.1k stars
43 watching
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Used by 49

+ 41

Contributors 20

DALEX project in numbers:

- 4+ years
- 50+ package releases
- 350K+ downloads
- 1000+ stars on GitHub
- 50+ dependant software projects

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Journal of Machine Learning Research 22 (2021) 1-7 Submitted 12/20; Revised 7/21; Published 9/21

JMLR, 2021

dalex: Responsible Machine Learning with Interactive Explainability and Fairness in Python

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Editor: Joaquin Vanschoren

Journal of Machine Learning Research 19 (2018) 1-5 Submitted 6/18; Revised 10/18; Published 11/18

JMLR, 2018

DALEX: Explainers for Complex Predictive Models in R

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Samsung Research Poland

Editor: Alexandre Gramfort

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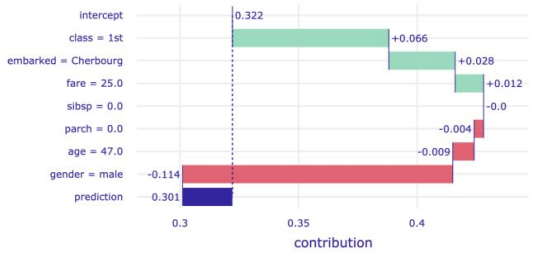
A. Explainer: Uniform abstraction over predictive models

⟷ Model	scikit-learn	h2o
	xgboost	tensorflow
⟷ Data	numpy	pandas
⟷ Predict interface		
⟷ Model metadata (label, type, info ...)		

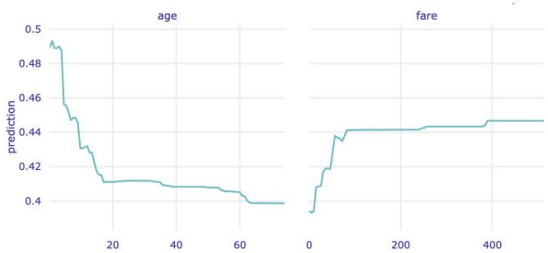
B. Consistent grammar for model analysis

```
import dalex as dx
explainer = dx.Explainer(model, X, y)

explanation = explainer.model_parts()
explanation.result
explanation.plot()

explainer.predict_parts(new_observation).result
explainer.predict_parts(new_observation).plot()
```

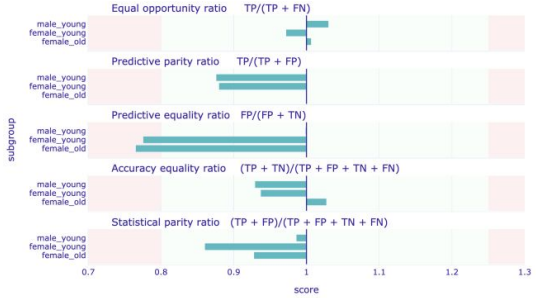
C. Predict-level explanations



D. Model-level explanations



E. Fairness checks



F. Arena: Interactive comparative model analysis

Baniecki et al. **dalex: Responsible Machine Learning with Interactive Explainability and Fairness in Python**. JMLR, 2021.

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General idea

A. Explainer: Uniform abstraction over predictive models

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⟷ Data	numpy	pandas
⟷ Predict interface		
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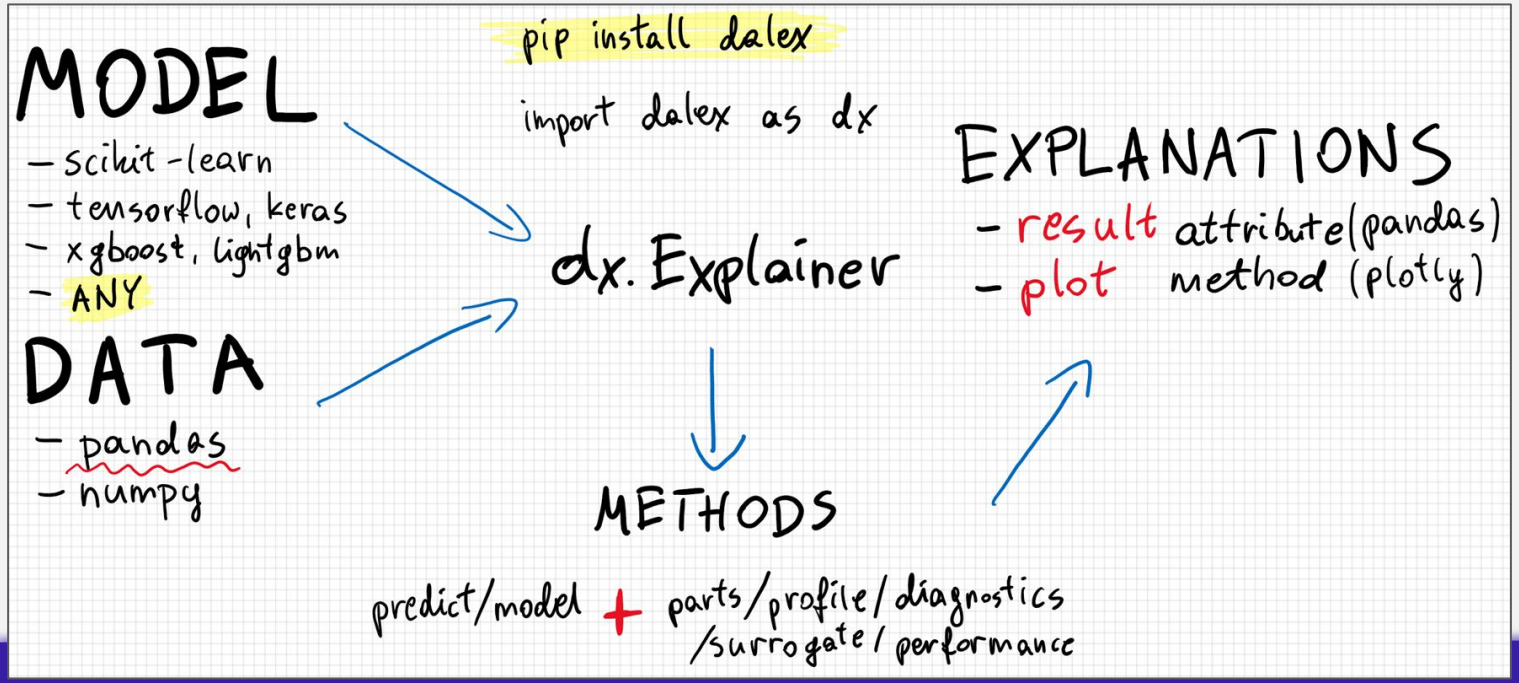

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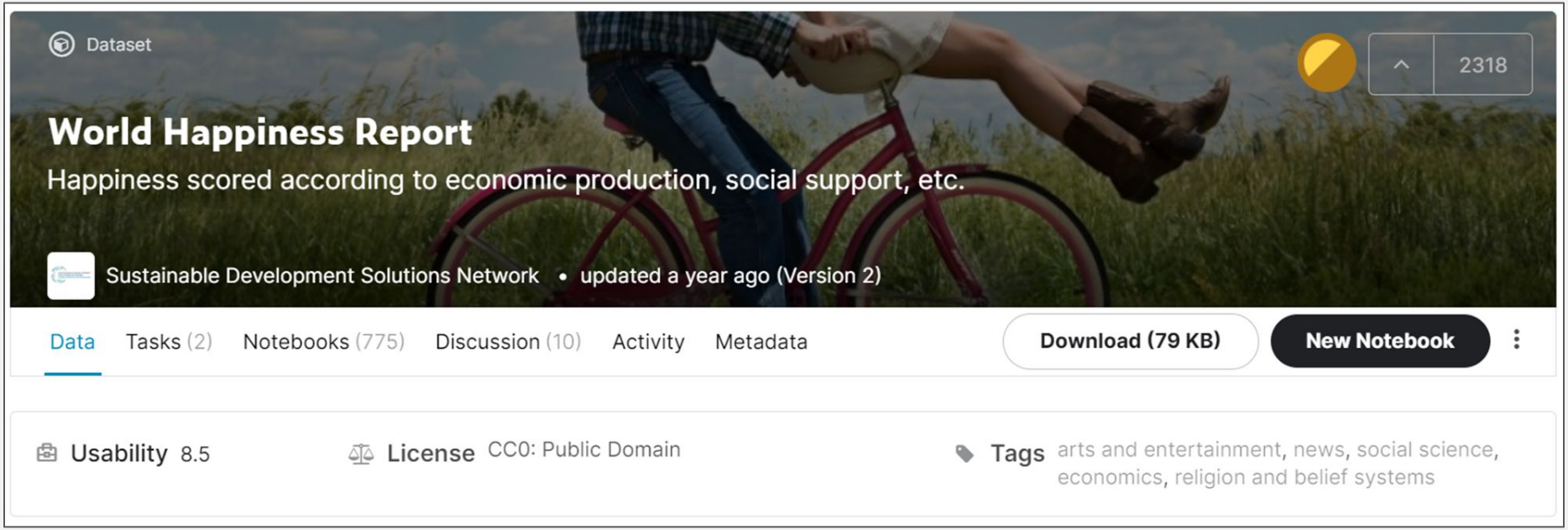
Exemplary machine learning predictive task



GDP, life expectancy, freedom, social => country happiness score [0, 10]

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https://hbaniecki.com/jsm2022

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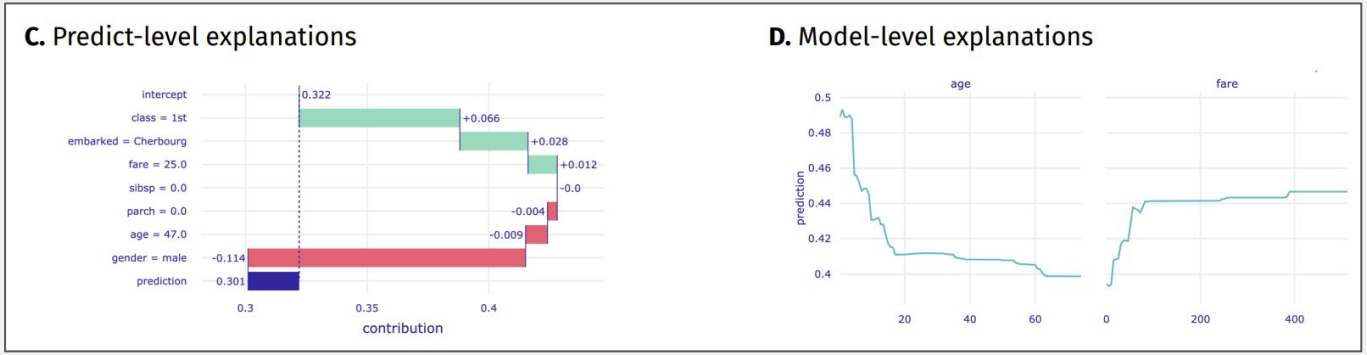
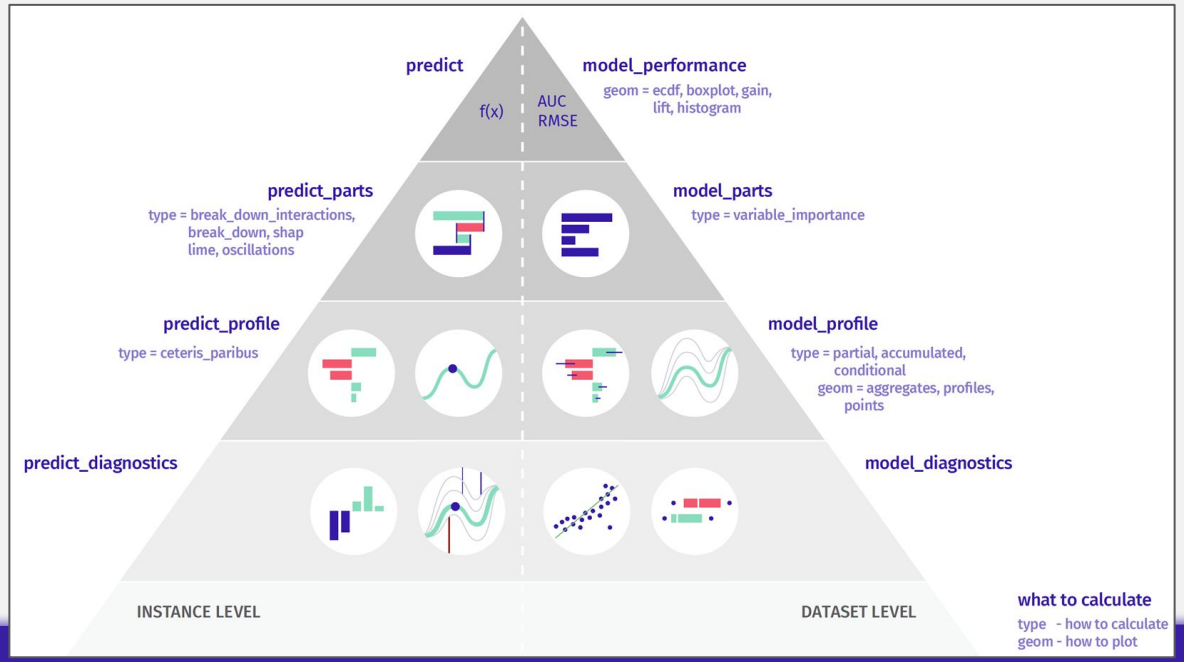
Explainer

```python
# 0. package
import dalex as dx

# 1. data
X, y = ...

# 2. model
model = ...
model.fit(X, y)

# 3. explainer
explainer = dx.Explainer(model, X, y)
```

```
Preparation of a new explainer is initiated

  -> data              : 156 rows 6 cols
  -> target variable   : Argument 'y' was a pandas.Series. Converted to a numpy.ndarray.
  -> target variable   : 156 values
  -> model_class       : tensorflow.python.keras.engine.sequential.Sequential (default)
  -> label             : custom label
  -> predict function  : <function yhat_tf_regression at 0x000001D7649554C0> will be used
  -> predict function  : accepts pandas.DataFrame and numpy.ndarray
  -> predicted values  : min = 2.86, mean = 5.42, max = 7.73
  -> model type        : regression will be used (default)
  -> residual function : difference between y and yhat (default)
  -> residuals         : min = -0.616, mean = -0.0103, max = 0.555
  -> model_info        : package tensorflow

A new explainer has been created!
```

Local & global explanations



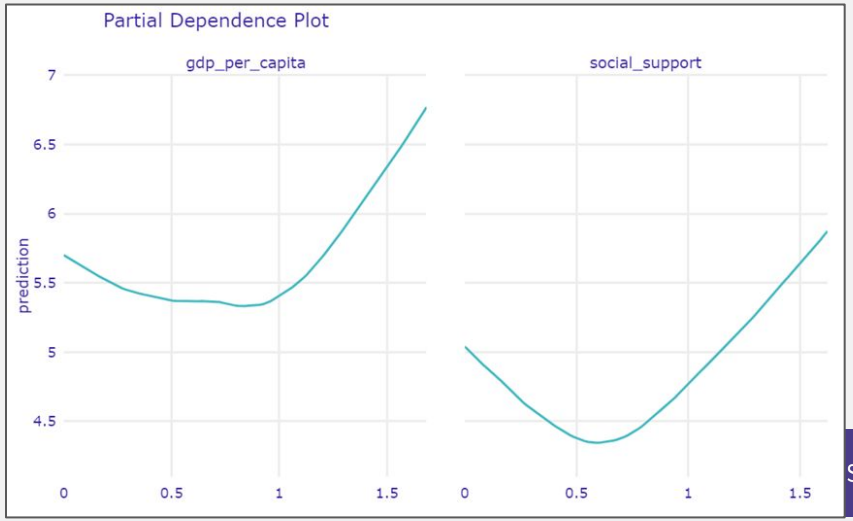


Model-level explanation

```python
# 4. examine
explainer.model_performance()

# 5. explain
explainer.model_parts().result

# 6. explore
explainer.model_profile().plot()
```

	variable	dropout_loss	label
0	_full_model_	0.132549	custom label
1	generosity	0.567029	custom label
2	perceptions_of_corruption	0.572801	custom label
3	freedom_to_make_life_choices	0.665235	custom label
4	gdp_per_capita	0.888245	custom label
5	healthy_life_expectancy	0.917414	custom label
6	social_support	1.046778	custom label
7	_baseline_	1.557307	custom label

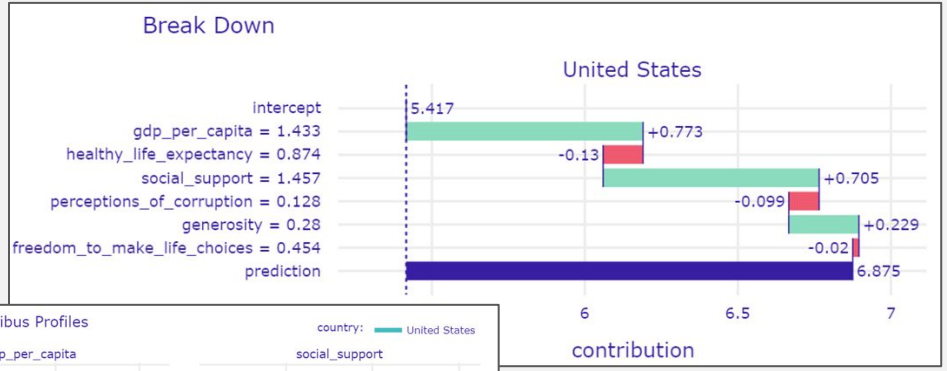
mse	rmse	r2	mae	mad
0.017569	0.132549	0.985729	0.072329	0.03636



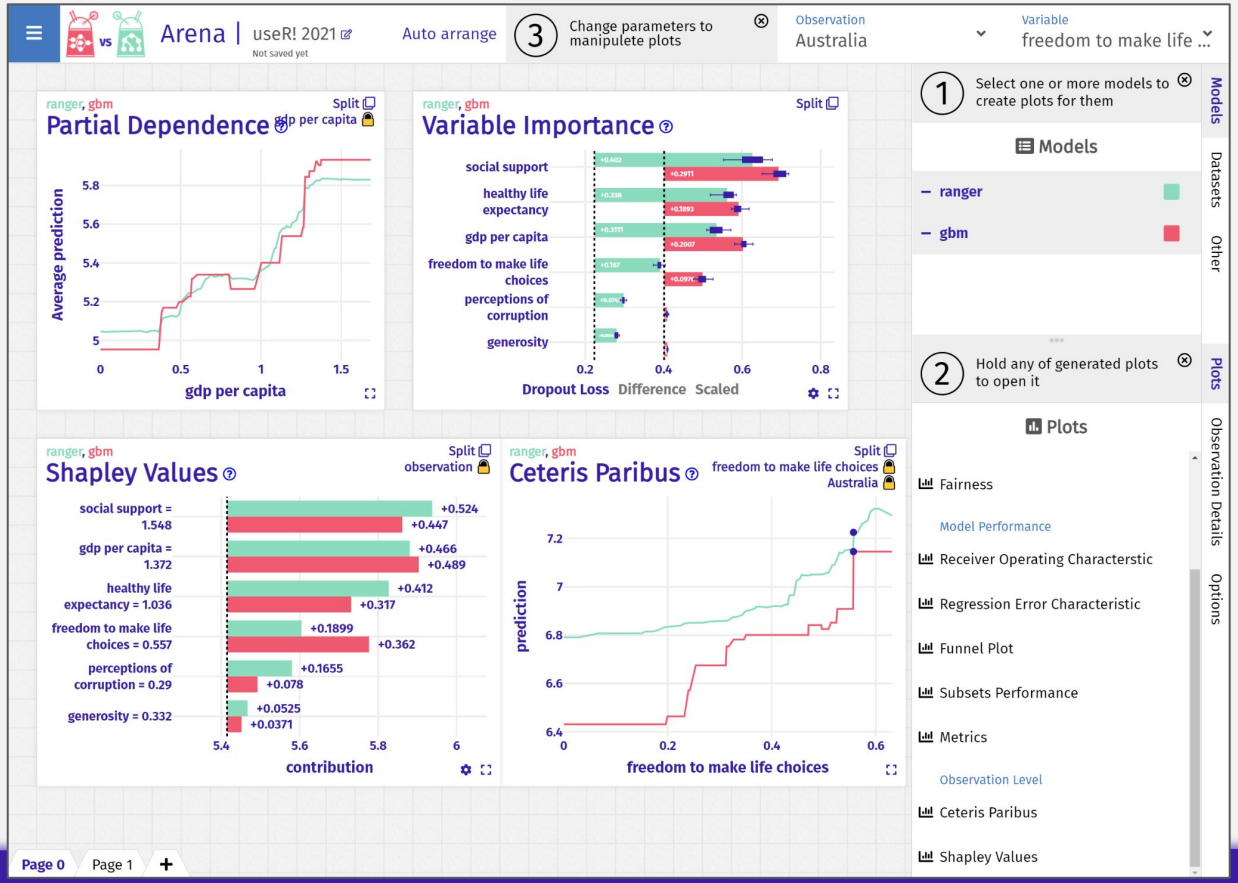
Predict-level

```python
# 7. observation
obs = ...
explainer.predict(obs)

# 8. why?
explanation = explainer.predict_parts(obs)
explanation.result
explanation.plot()

# 9. what if?
explainer.predict_profile(obs).plot()
```

	variable_name	variable_value	variable	cumulative	contribution	sign	position	label
0	intercept	1	intercept	5.417360	5.417360	1.0	7	custom label
1	gdp_per_capita	1.433	gdp_per_capita = 1.433	6.189979	0.772619	1.0	6	custom label
2	healthy_life_expectancy	0.874	healthy_life_expectancy = 0.874	6.059744	-0.130235	-1.0	5	custom label
3	social_support	1.457	social_support = 1.457	6.764811	0.705067	1.0	4	custom label
4	perceptions_of_corruption	0.128	perceptions_of_corruption = 0.128	6.666029	-0.098782	-1.0	3	custom label
5	generosity	0.28	generosity = 0.28	6.894894	0.228865	1.0	2	custom label
6	freedom_to_make_life_choices	0.454	freedom_to_make_life_choices = 0.454	6.874513	-0.020381	-1.0	1	custom label
7			prediction	6.874512	6.874512	1.0	0	custom label



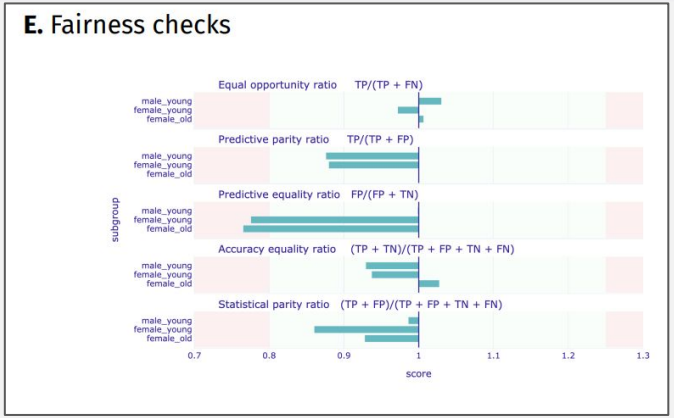
Interactive explainability



F. Arena: Interactive comparative model analysis

Fairness (German Credit Data)

```python
# 1. protected variable with subgroups
protected = [sex + age for ...]

# 2. priviliged subgroup
priviliged = "male_young"

# 3. fairness
explanation = explainer.model_fairness(
  protected, priviliged
)

# 4. check
explanation.fairness_check()

# 5. explain
explanation.result
explanation.plot()
```




```
No bias was detected!

Conclusion: your model is fair in terms of checked fairness criteria.

Ratios of metrics, based on 'male_old'. Parameter 'epsilon' was set to 0.8 and
therefore metrics should be within (0.8, 1.25)
                TPR       ACC       PPV       FPR       STP
female_old    1.018828  1.000000  0.971963  0.921525  0.964677
female_young  0.981172  0.938824  0.891355  0.872197  0.855055
male_young    1.019874  0.977647  0.929907  0.896861  0.918392
```

```
Bias detected in 3 metrics: PPV, FPR, STP

Conclusion: your model is not fair because 2 or more criteria exceeded acceptab
le limits set by epsilon.
```

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DATA SCIENCE SERIES

EXPLANATORY MODEL ANALYSIS

Explore, Explain, and Examine Predictive Models

PRZEMYSŁAW BIECEK
TOMASZ BURZYKOWSKI

CRC Press
Taylor & Francis Group
A CHAPMAN & HALL BOOK

Where to start?

useR! 2021
The R Conference

5-9 JULY, 2021

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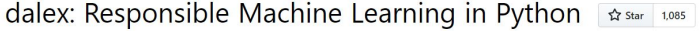
dalex: Responsible Machine Learning in Python



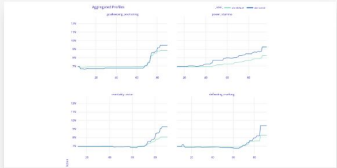
Install from PyPI

```
pip install dalex
```

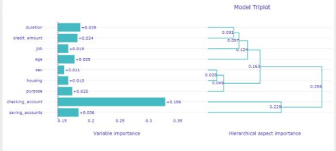
Explainability

Explanatory Model Analysis
Book with examples in Python

Introduction to dalex
Titanic: tutorial and examples



Key features explained
FIFA 20: explain default vs tuned model with dalex

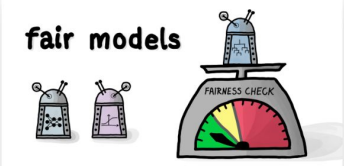


Aspect module in dalex
Case study - German Credit data

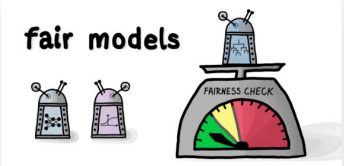
How to use dalex with XGBoost
Titanic classification example

How to use dalex with TensorFlow
Happiness regression example

Fairness

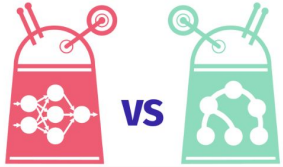


Fairness module in dalex
Case study - German Credit data



Tutorial on bias detection
Case study - COMPAS Recidivism data

Interactive analysis



Arena module in dalex
Introduction to the Arena dashboard features

Getting Started & Demos
Arena documentation

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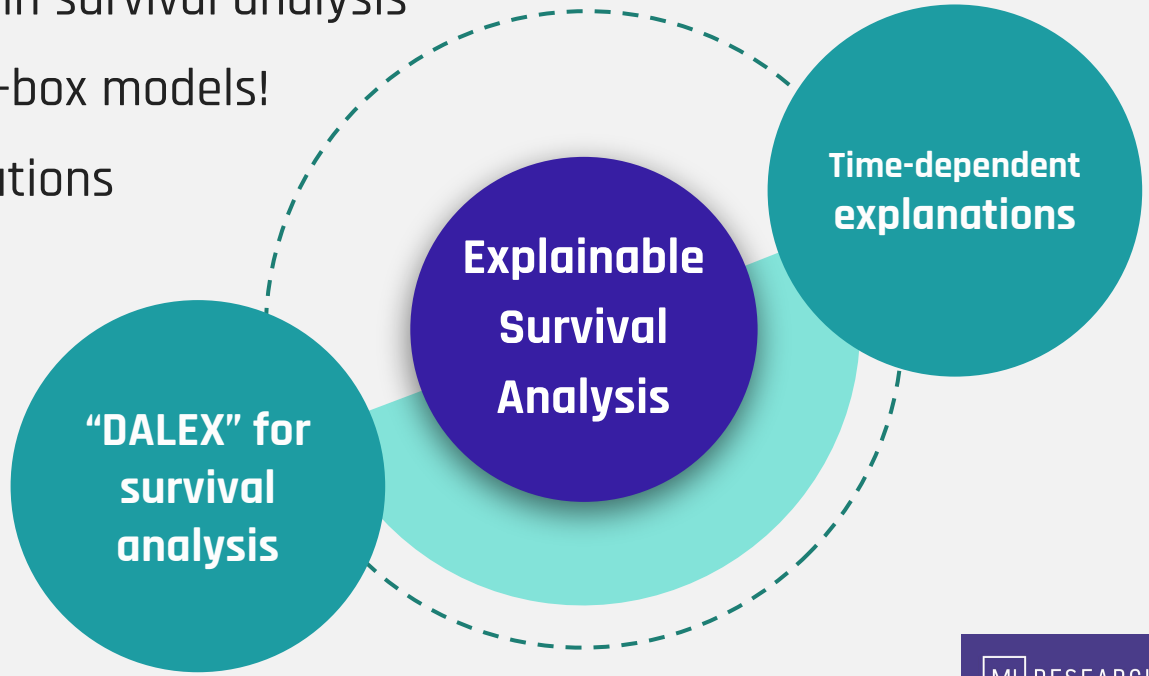
Spoiler: what's next?

Explainable machine learning in survival analysis

We want to understand black-box models!

1. Time-dependent explanations
2. Software... (R & Python)



John M. Chambers Statistical Software Award

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Questions? Feel free to reach out!

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