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CatBoost

Introducing CatBoost for Apache Spark

Andrei Khropov,
CatBoost team @ Yandex

Plan

- What is CatBoost?
- Why CatBoost?
- Why CatBoost for Apache Spark?
- CatBoost for Apache Spark and Competitors

What is CatBoost?

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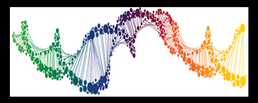
- CatBoost is a machine learning algorithm that uses gradient boosting on decision trees (GBDT).
- It is available as an open source library.

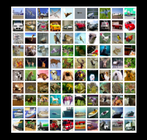
Data at hand

Unstructured data

Music



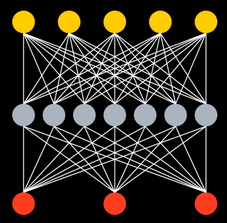
DNA



Images

Text

End2End with Deep NN

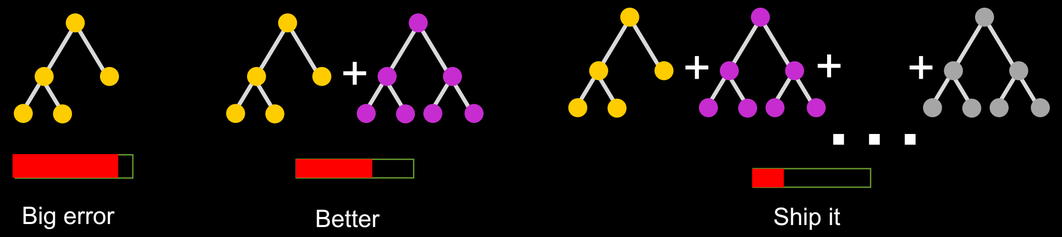


Tabular (or structured) data

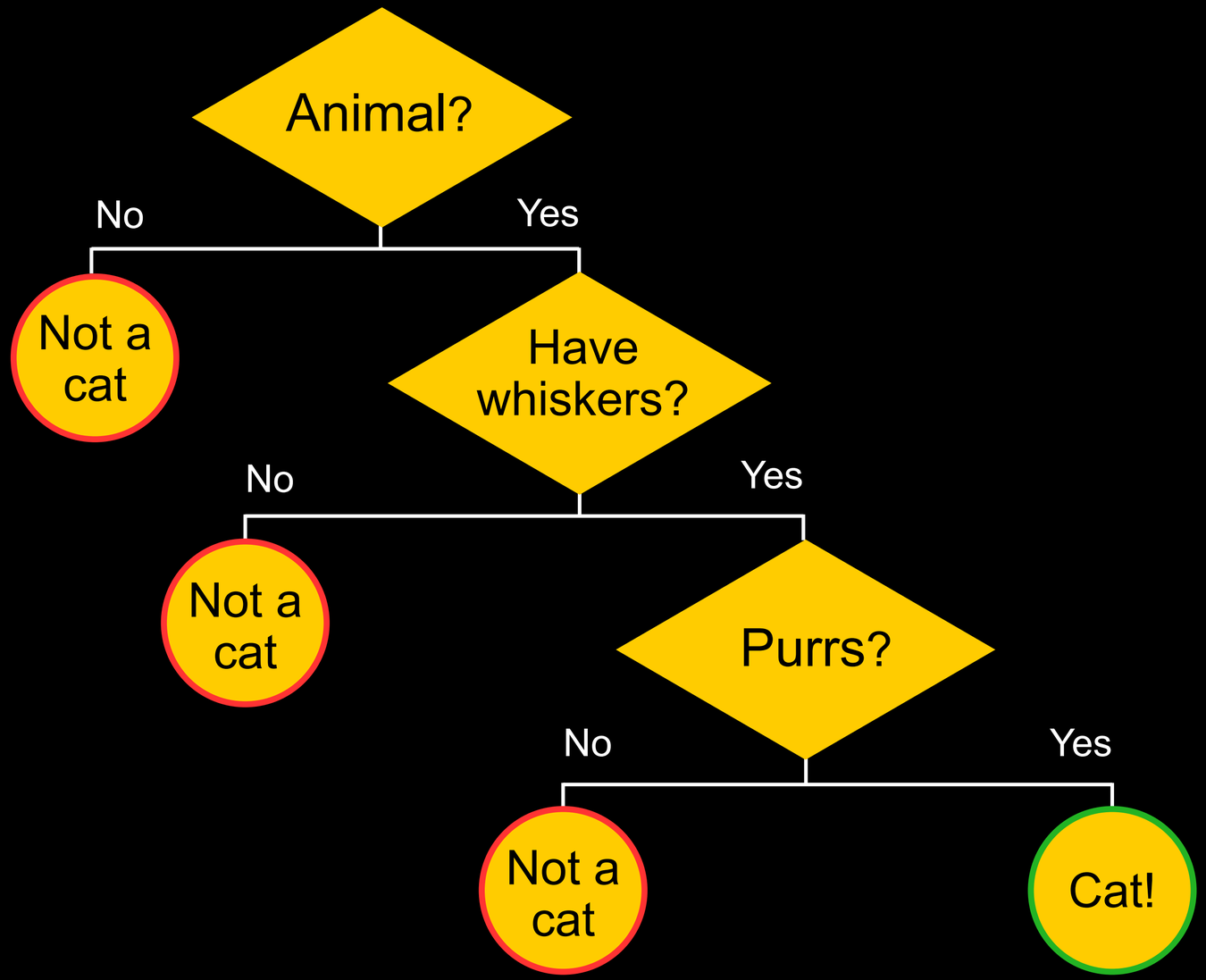
Well engineered features

Music track length	Year	Rating	Label
2	1990	3	1
3	1950	5	0
15	1970	4	1

GBDT

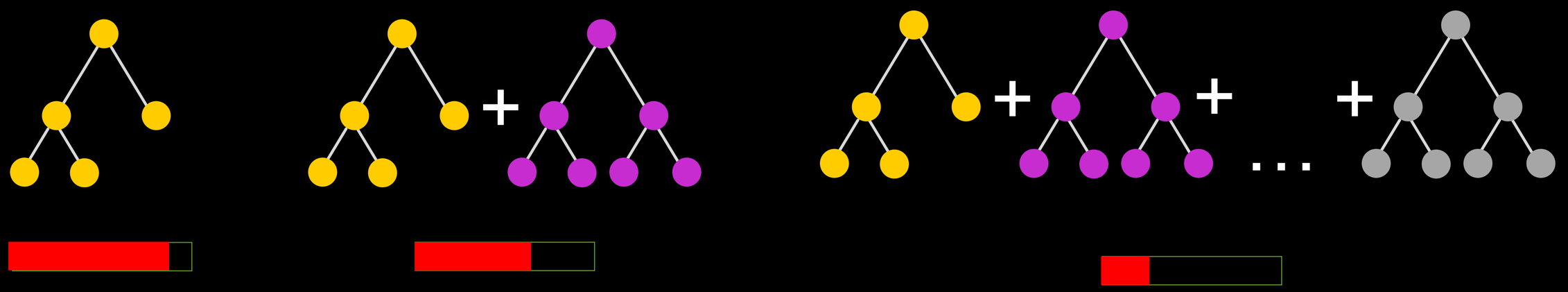


Tabular data? Decision trees!



Gradient boosted decision trees

- State-of-the-art quality on tabular data
- Easy to use, no sophisticated parameter tuning
- Works well with small data and scales for big data problems



Why CatBoost?

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- Sophisticated feature types support
- Training with pairs
- Good quality with default parameters
- Fast applier
- Extensive support of model formats
- Model analysis tools
- Stable, Production quality

Features

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- Numerical
- Categorical
- Text
- Embeddings

Features

Numerical

Categorical

Text

Embeddings

Length: 0.25
Weight: 57

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Features

Yandex
CatBoost

- Numerical
- Categorical
- Text
- Embeddings

Gender: Male
Profession: Scientist
Country: Switzerland

Features

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Numerical

Categorical

Text

Embeddings

Title: "CatBoost Spark"
Description:
"CatBoost is a fast, scalable, high performance gradient boosting on decision trees library."

Features

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Numerical

Categorical

Text

Embeddings

Book name:	"War and peace"	"Lord of the Rings"
Embedding:	[0.1, 2.3, 0.0]	[0.3, 0.0, -4.2]

Model formats

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- CatBoost Native
- CoreML
- ONNX
- PMML
- Raw code:
  - C++
  - Python

Model analysis

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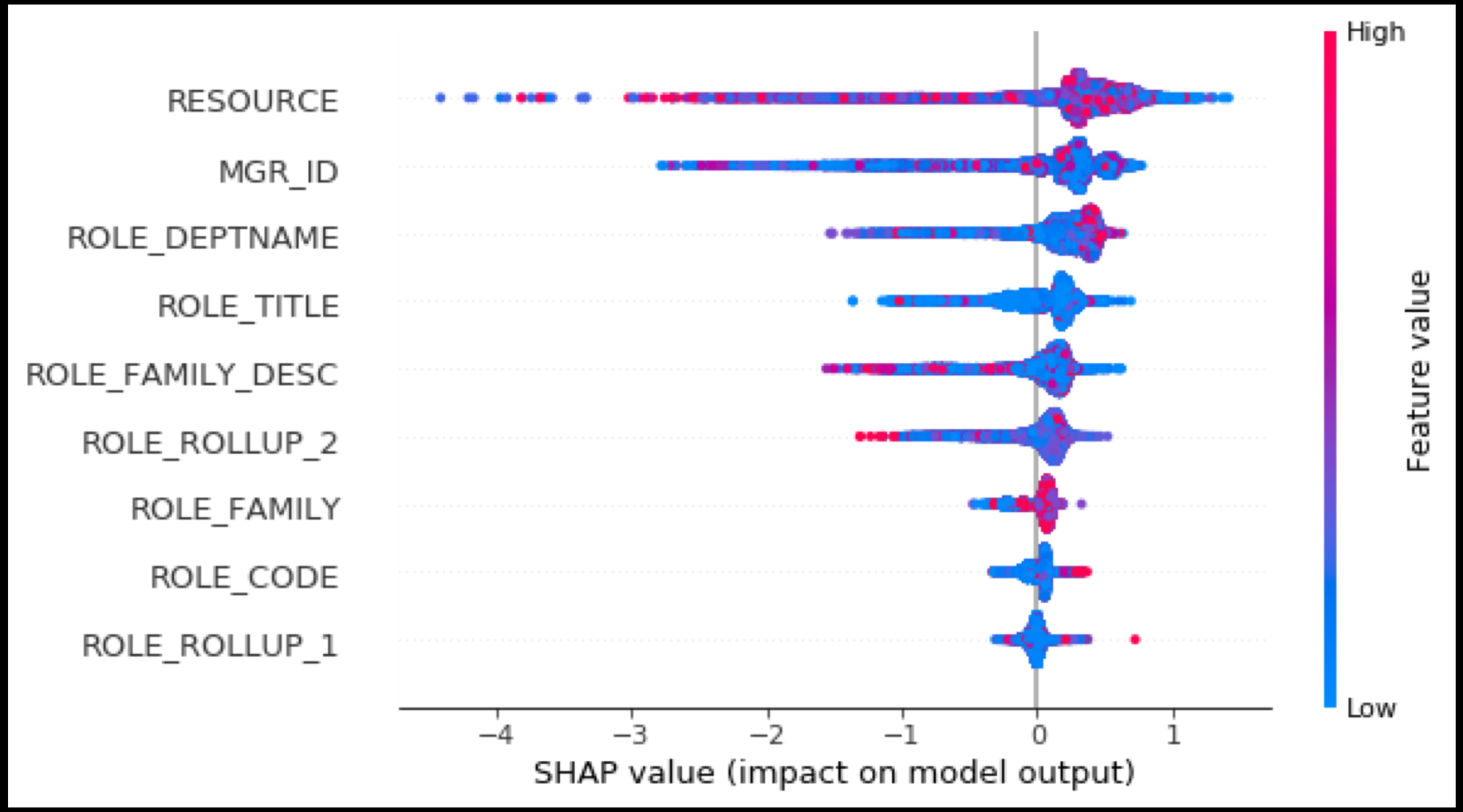
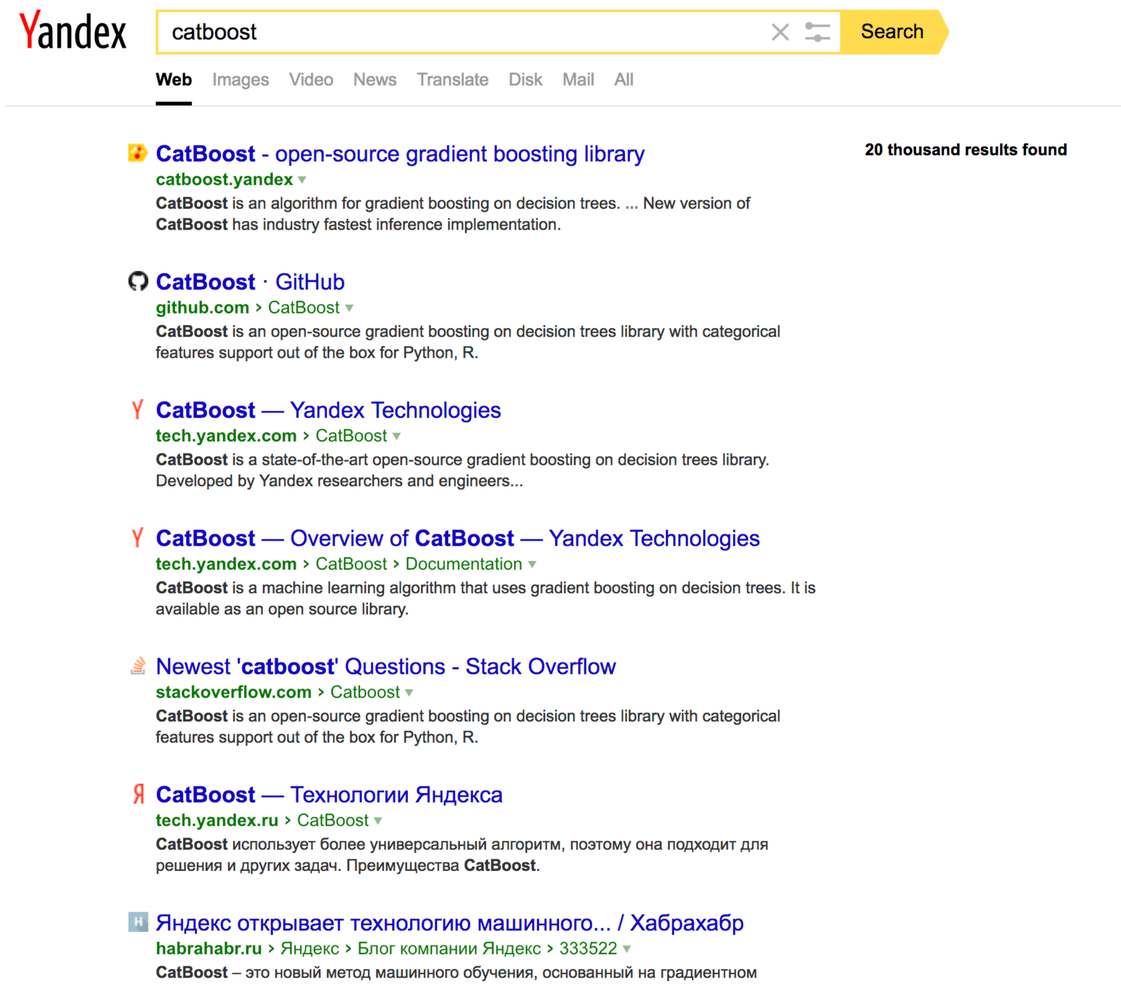
- Example with SHAP values (uses ‘shap’ python package)
- From https://github.com/catboost/tutorials/blob/master/model_analysis/shap_values_tutorial.ipynb



CatBoost in production

- **Yandex.Search**
  - Big datasets up to several Terabytes
  - Multi-host multi-GPU training

… many other users inside Yandex



CatBoost outside Yandex

- Recommendations at Netflix
- Hotel ranking in Aviasales
- Protection against bots in CloudFlare
- Particle classification in CERN
- Medical research at University of NSW Sydney
- Destination prediction in Careem taxi service
- ML competitions on Kaggle
- Join our Awesome Users List! ☺

Why CatBoost for Apache Spark?

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› When data size is too big for a single machine

Why CatBoost for Apache Spark?

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- When data size is too big for a single machine
- Processing speed

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- When you need the flexibility of working with data on Spark

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- When data size is too big for a single machine
- Processing speed
- When you need the flexibility of working with data on Spark
- Low-level data processing in Spark Scala/Java API vs faster than Python API

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- When data size is too big for a single machine
- Processing speed
- When you need the flexibility of working with data on Spark
- Low-level data processing in Spark Scala/Java API vs faster than Python API
- CatBoost model training and analysis with JVM platform API
  (PySpark is also supported)

Why CatBoost for Apache Spark?

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- When data size is too big for a single machine
- Processing speed
- When you need the flexibility of working with data on Spark
- Low-level data processing in Spark Scala/Java API vs faster than Python API
- CatBoost model training and analysis with JVM platform API (PySpark is also supported)
- API is fully compatible with Spark ML library

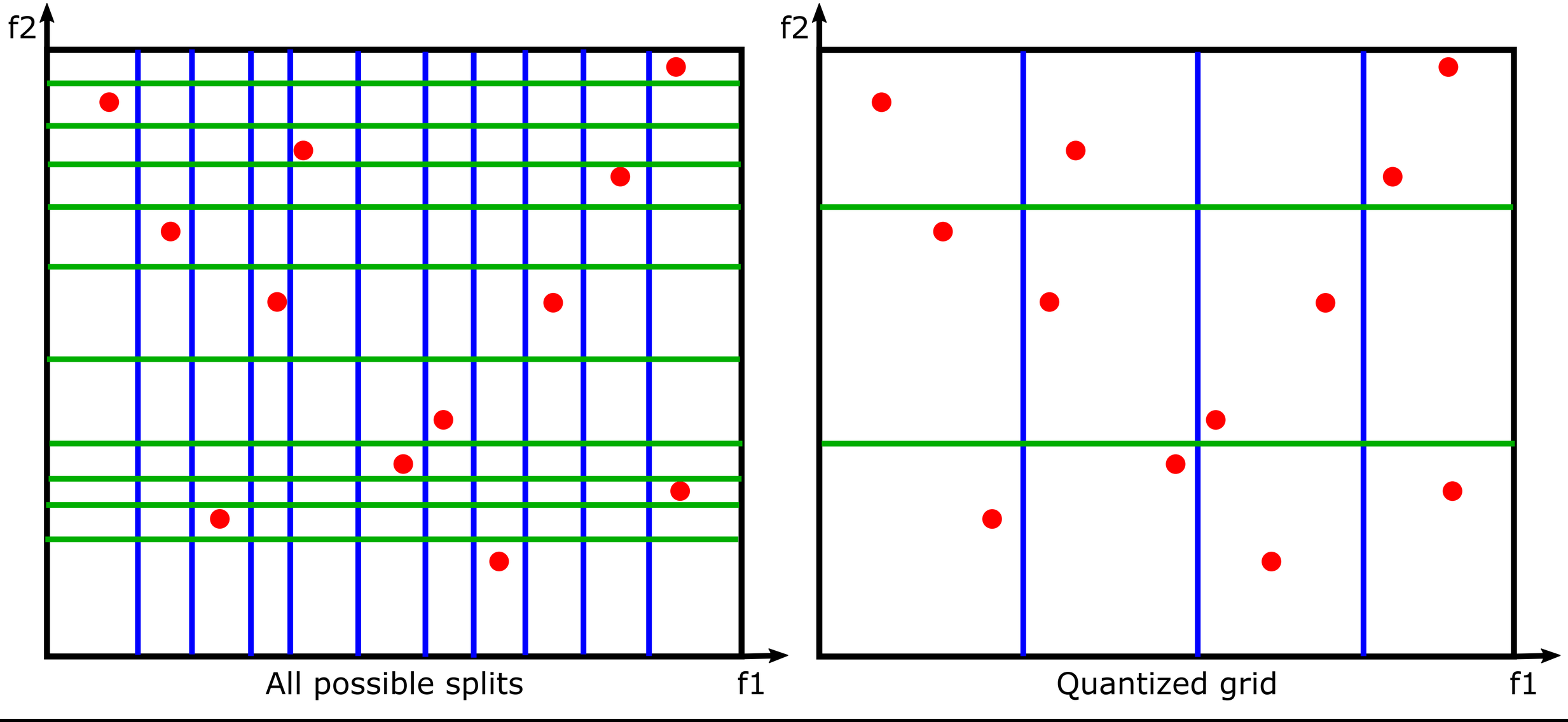
API is fully compatible with Spark ML library

```
from pyspark.sql import SparkSession

sparkSession = (SparkSession.builder
    .master("local[*]")
    .config(
        "spark.jars.packages",
        "ai.catboost:catboost-spark_2.4_2.12:0.25-rc4"
    ).getOrCreate()
)

import catboost_spark

trainDf = sparkSession.read().load("/my_datasets/train")

classifier = catboost_spark.CatBoostClassifier(iterations=20)
classifier.write().save("/my_classifier")

model = classifier.fit(trainDf)
model.write().save("/my_model")

applyDf = sparkSession.read().load("/my_datasets/for_application")

dfWithPredictions = model.predict(applyDf)
```

CatBoost for Spark vs Competitors

	CatBoost	LightGBM	dmlc XGBoost
GPU support	No (planned)	No	Yes
Categorical features	Yes, including CTR statistics	Yes	Only preprocessed as one hot
Pairs	Yes	No	No
Pre-quantization	Yes	No	No
PySpark support	Yes	Yes	No
SparkR support	No	Beta	No

Feature quantization



CatBoost Spark Performance vs Competitors

	Criteo derived 170 m samples 65 features		Epsilon 400 k samples 2000 features		Higgs 10.5 m samples 28 features	
	total	per iter	total	per iter	total	per iter
CatBoost	53 m 52 s	2.8 s	1 h 5 m	3.7 s	7 m 40 s	0.31 s
LightGBM	59 m	3.5 s	2 h 36 m	9.4 s	2 h 25 m	8.7 s
dmlc XGBoost	est. 8 h	28.9 s	17 m 25 s	1 s	10 m	0.6 s

- Cluster configuration – 16 nodes x 16 cores
- Time on 1000 iterations, total time includes preprocessing

The End

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- CatBoost website: https://catboost.ai/
- CatBoost documentation: https://catboost.ai/docs
- CatBoost on GitHub: https://github.com/catboost
- CatBoost for Apache Spark home: https://github.com/catboost/catboost/tree/master/catboost/spark/catboost4j-spark