大数据机器学习模型在经济学的应用（Machine Learning for Economists）

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什么是机器学习模型

机器学习模型的优势

经济与金融行业就业需求

学习与实战资源

我们作为经济学本科生为什么要学习机器学习？

- 我们作为经济学本科生为什么要学习机器学习等量化方法？
- 学会这些经济学量化方法对我们未来的工作有什么帮助？
- 该怎样入门学习？

机器学习模型 (Machine learning model is dominating in various areas)

机器学习模型（Machine Learning）是人工智能领域的算法支持与核心。因为机器学习模型的强大预测能力与准确程度，近些年来被用于生活中各种领域。比如：

1. 图像识别（人脸识别）
2. 语音识别（语音输入发）
3. 推荐算法（淘宝、京东、Amazon）
4. 医药（大大加快新冠疫苗开发进程）等等当然
5. 我们的**金融学与经济学**中的很多分析与预测，也在近几年逐渐被机器学习算法所占领。

为什么近些年机器学习成为金融经济市场的宠儿

So，why now machine learning in economic & financial market？

- 高度竞争的经济金融市场需求
- 机器学习模型不但可以准确分析价值，还可以分析风险
- 市场风险加大，各大企业需要对投资与风险进行准确分析（如：房地产公司的投资）

AI vs Machine Learning vs Deep Learning

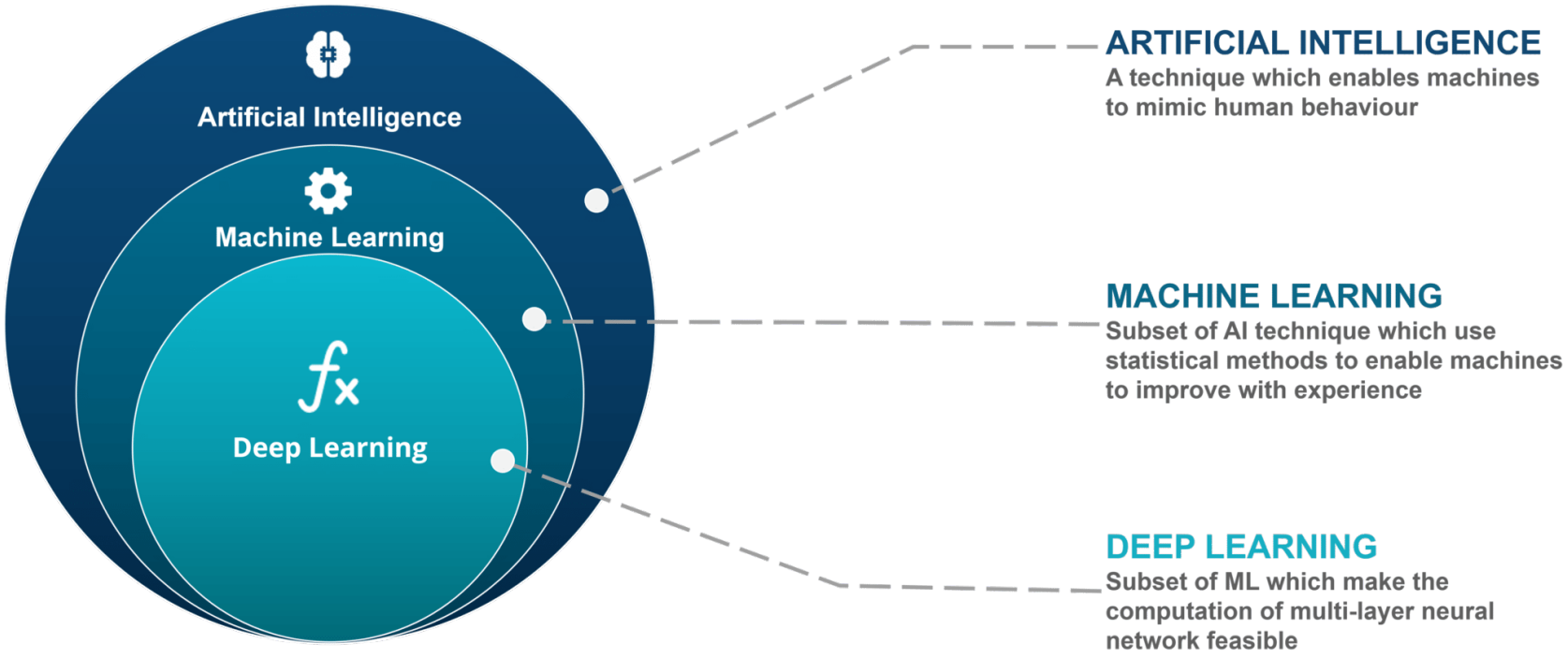


图: AI vs Machine Learning vs Deep Learning

source：https://www.edureka.co/

机器学习在经济学上的常用算法

在经济学数量建模上常用的Machine Learning算法主要有：

1. **线性算法：** OLS，2SLS，Logit等。重要，是我们经济学的基本功，也被称为BLUE，Best Linear Unbiased Estimation,是作为无偏因果分析的重要工具。作为经济学专业的同学们，学好计量经济学与统计学是非常重要的，也是其他机器学习模型学习的重要基础。其他的常用线性算法：LASSO， Ridge，Elastic， MARS（Multivariate adaptive regression spline）
2. **集成学习（Ensemble Learning）：** Xgboost,Catboost,Adaboost,Random Forest
3. **深度学习（Deep Learning）：** Artificial Neural Network(ANN)，CNN (Convolutional Neural Network)，RNN (Recurrent Neural Netwrok)
4. **其他算法：** Bayesian Estimation，KNN，K-means，PCA，Causal Forest （Susan Athey)， Double Machine Learning（Victor Chernozhukov）等等

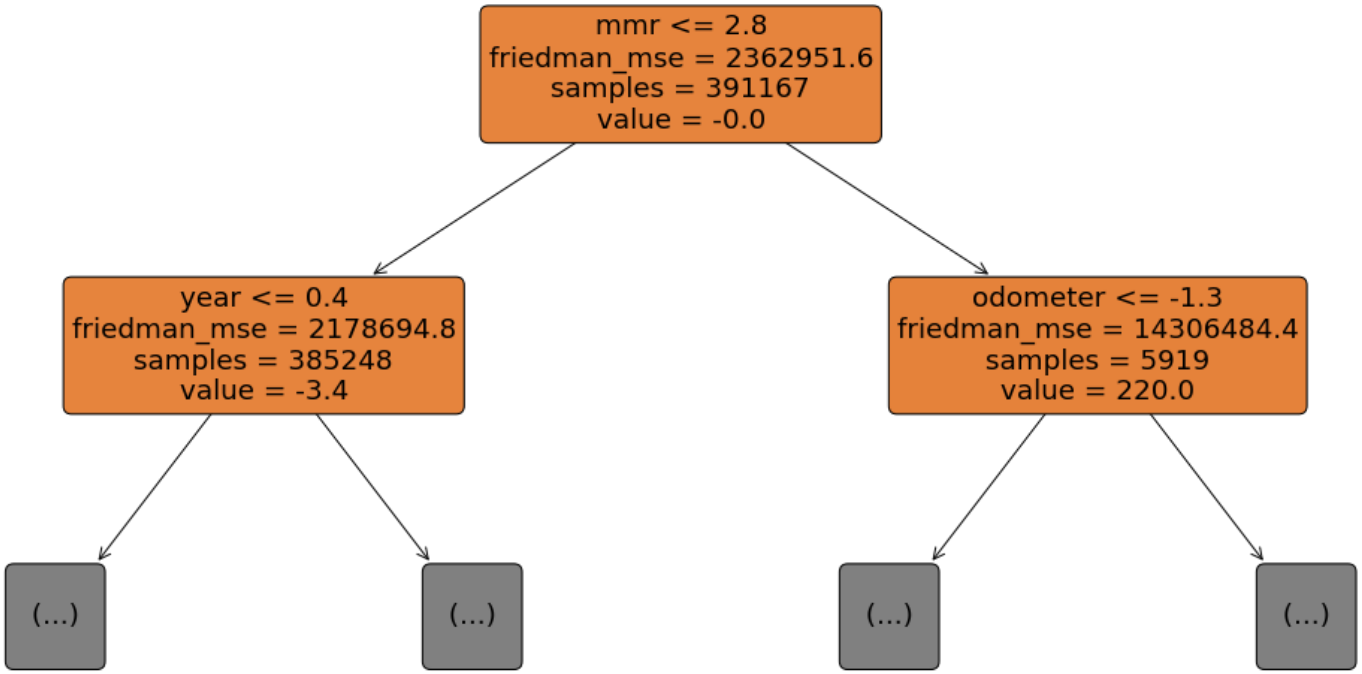
Machine learning is not a black box

- 在python环境下，构建机器学习模型非常简单与直白
- 比如，TensorFlow将深度学习模型的构建简单化，Keras有进一步将TensorFlow简单化
- Xgboost, Catboost, Adaboost将集成学习简单化
- 下面我们展示两个简化的机器学习模型 (为了学习需要模型结构和参数都为最简单设定)

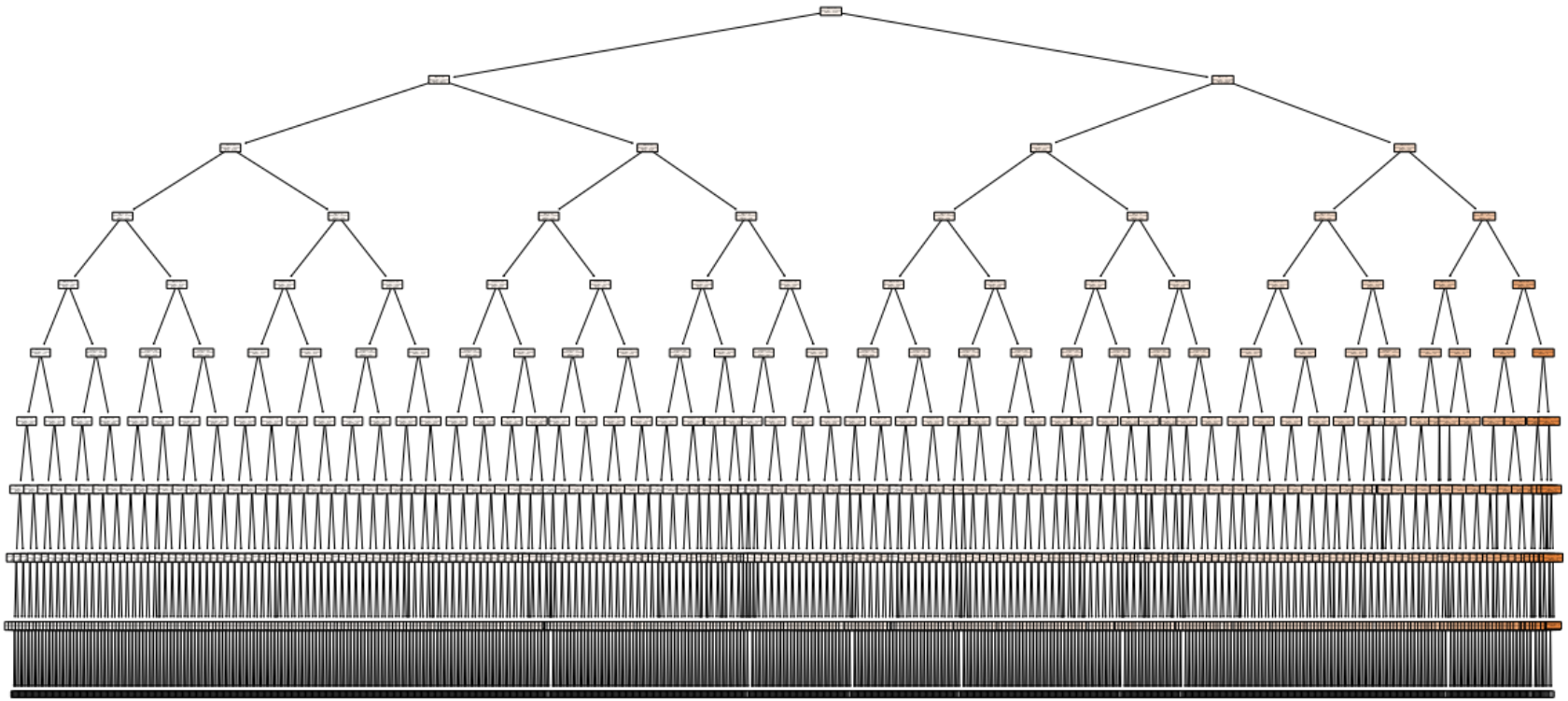
集成学习(Gradient Boosting 模型构建+预测)

```
hyperparameters_gb={'n_estimators':200,'learning_rate':0.1,
reg_gb=GradientBoostingRegressor(**hyperparameters_gb)
reg_gb.fit(xtrain_ann,ytrain_ann)
ypred_gb = reg_gb.predict(xtest_ann)
```

集成学习(Gradient Boosting 框架)



集成学习(Gradient Boosting 框架)



深度学习（ANN 模型构建）

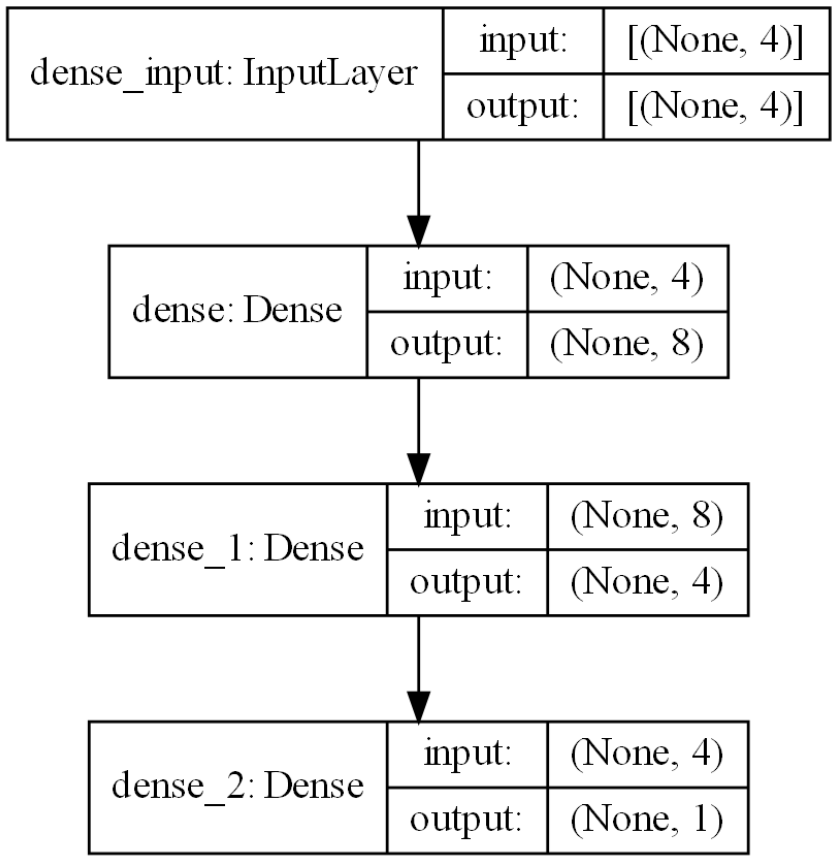
```
K.clear_session()
epochs=10
batch_size=128
model_ann = Sequential()
optimizer = keras.optimizers.Adam(lr=0.001)
model_ann.add(Dense(8,activation = 'relu',
                    input_dim = len(xtrain_ann.columns)))
model_ann.add(Dense(4,activation = 'relu'))
model_ann.add(Dense(1,activation ='linear'))
model_ann.compile(optimizer = optimizer,loss = 'mse',metrics = ['mae'])
model_ann.summary()
```

深度学习（ANN 模型训练与预测）

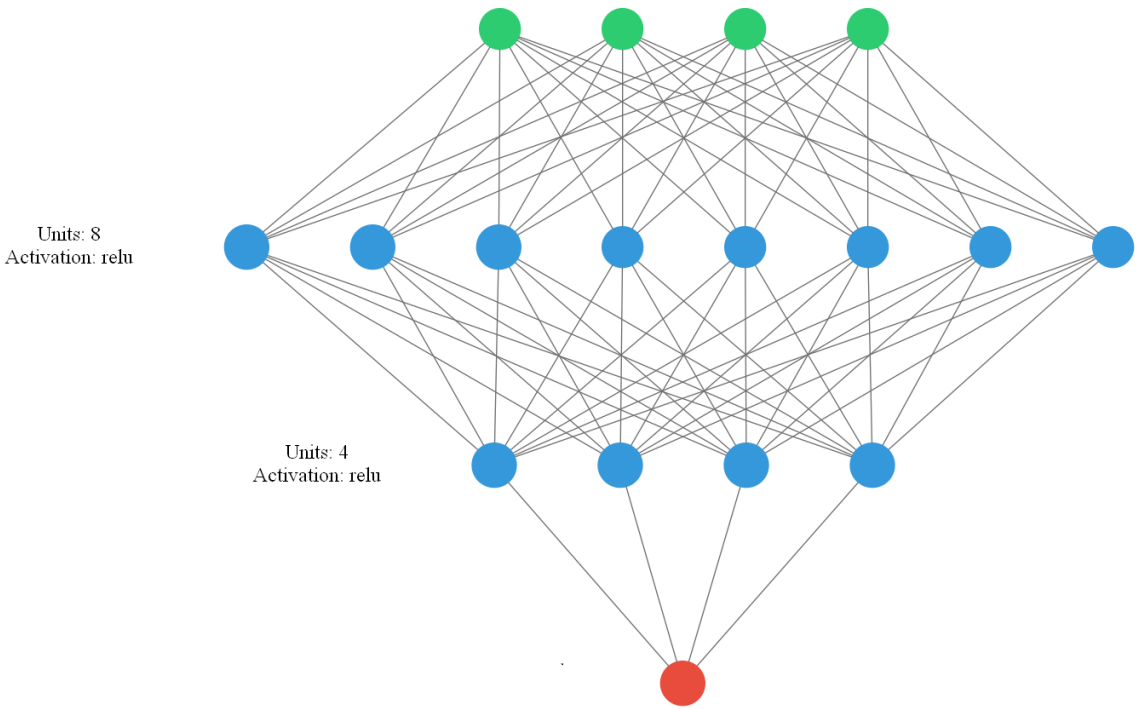
```
%%time
with tf.device('/gpu:0'):
    model_ann.fit(xtrain_ann,ytrain_ann,
                  batch_size=batch_size,epochs=epochs,
                  verbose=0)
ypred_ann = model_ann.predict(xtest_ann,batch_size = 32)
```

```
Wall time: 1min 29s
```

深度学习（ANN 模型框架）



深度学习（ANN 模型框架）



Short history of machine learning

1. 线性模型的创立： Legendre (1805) and Gauss (1809) used the linear regression for the prediction of planetary movement.

2. 深度学习的雏形： Warren McCulloch and Walter Pitts (1943) opened the subject by creating a computational model for neural networks.

source： History of the AI from Wikipedia

机器学习算法战胜人类的案例

1. AlphaGo： AlphaGo research project was formed around 2014 and beat world champion Lee Sedol 9th Dan in 2016.

2. Github Copolit：人工智能算法按照要求自动写代码,完成初级程序员的工作。`https://copilot.github.com/`(点击链接注册可用)

3. AlphaCode：人工智能算法按照要求自动生成算法，取代高级程序员的工作。 AlphaCode achieved an estimated rank within the top 54% of participants in CodeForces. `https://alphacode.deepmind.com`

4. 未来：人工智能算法→人工智能算法→人工智能算法→...

什么是学习：人类社会的学习过程（Human Society in Learning ）

我们可以对比机器学习与人类的学习:

1. 学习并不是一个新的概念
2. 人类与人类社会的演进也是一个学习的过程
3. 人类学习=尝试+改进+不断重复

人类的学习是一个缓慢积累的过程（Human Learning is a long and slow process）

人类从历史学到的唯一的教训，就是人类没有从历史中吸取任何教训。（We learn from history that we do not learn from history.）
——黑格尔

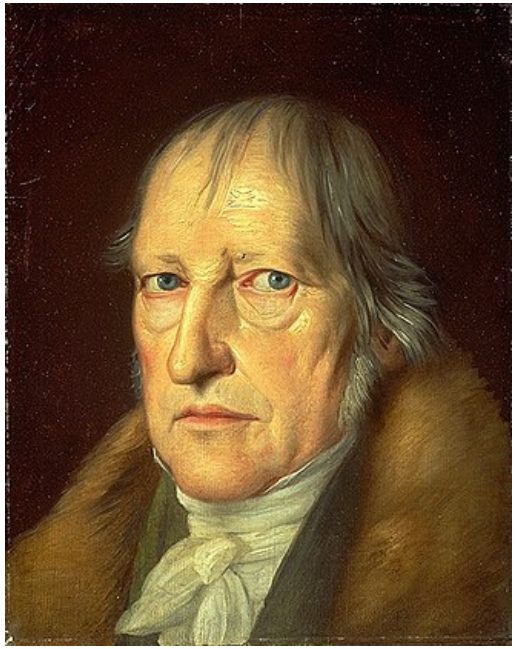


图: Georg Wilhelm Friedrich Hegel

人类的学习是一个缓慢积累的过程（Human Learning is a long and slow process）

人类历史上漫长与痛苦的学习过程：

1. 商有九世之乱：用了整整九个王，学习到了父死子继比兄终弟及更利于封建王朝的稳定统治 (中丁、外壬、河亶甲、祖乙、祖辛、沃甲、祖丁、南庚、阳甲)

2. 斯图尔特王朝:用了整整一百年的时间学习并从封建集权制过渡到资本主义议会制度（House of Stuart, 1603年至1714年，詹姆斯一世，查理一世，护国主克伦威尔...）

3. 高考刷题：五年高考三年模拟，高中三年不断尝试与改进的过程

人类学习的问题

- 用机器学习算法的角度总结黑格尔的话，就是人类社会的学习效率太低太慢。也就是Learning rate （η） is too low。
- 注： Learning Rate是机器学习模型中的一个重要的超参数（Hyperparameters），控制着机器学习算法的学习速度

机器学习相对人类学习的优势

1. 机器学习用算法高度模拟人类学习的过程

2. 和人类一样，机器学习算法的秘诀也是：尝试+改进+不断重复

3. 人类和机器在学习上的差别就是在不断重复与不断优化的效率上。人类重复一次学习的过程需要几个月甚至几年。但是机器只需要不到一秒的时间。

4. 人类资深金融分析师通过十几年的工作经验与几千个工作的案例不断重复总结经验，从而对金融资产进行准确定价。可机器学习算法只需要几个小时就可以轻松分析几十万个甚至上百上千万个资产。机器学习算法通过对大数据的分析，优化自身的评估预测能力。所以机器学习算法远远超出了人类分析师日积月累的经验，其精准度与效率也远远超出同一领域的人工分析师。

How machine learning from the data

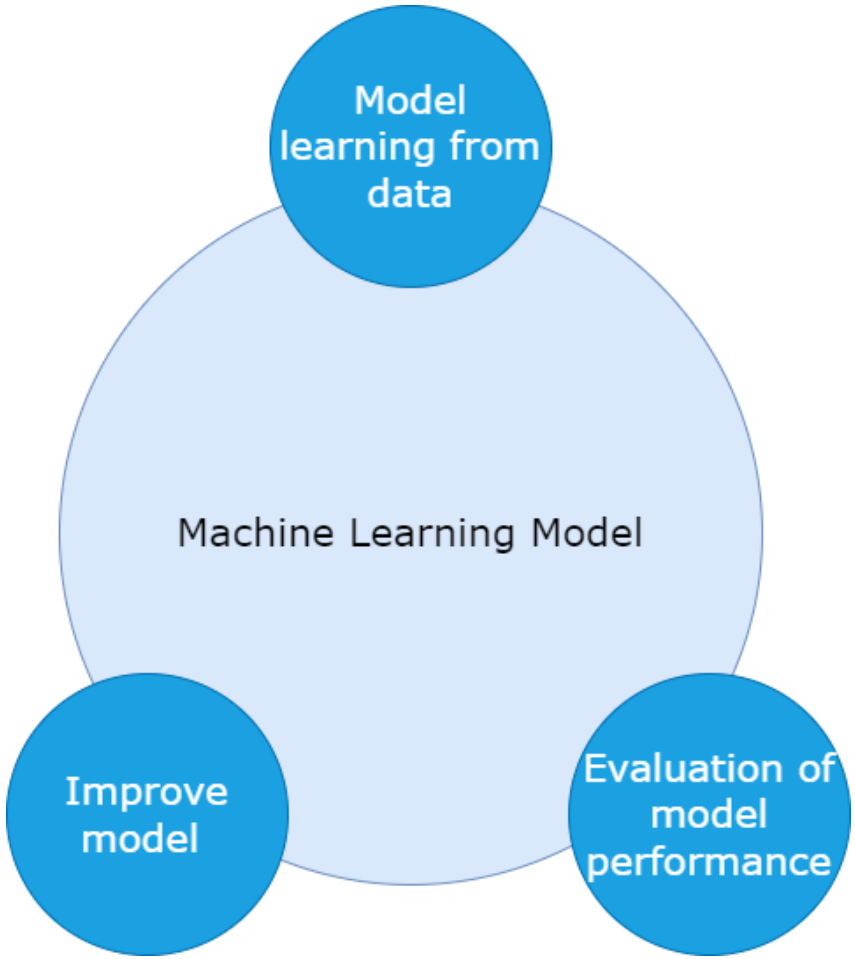


图: How machine learning from the data

机器学习模型在经济学的应用

1. 机器学习模型在经济金融学的应用又量化建模（quantitative modeling）简称Quant，广泛的应用于包括股市投资，高频交易，资产管理，风险管理，资产估值，保险，反欺诈等各个行业。

2. 很多我们经济学的同学,都有志利用自己多年所学的经济学与金融学知识成为一个量化建模师 (Quant Researcher, Quant Economist， Data Scientist and etc.)

3. 作为一个经济学人才，利用Python建立量化模型的**基本功**非常重要

为什么说量化模型对于经济学同学是基本功？

1. 作为经济学从业者，简单的分析已经不能满足行业的需求(例如：客户不但学要知道价格为什么会上升，还要知道为什么？上涨多少？)

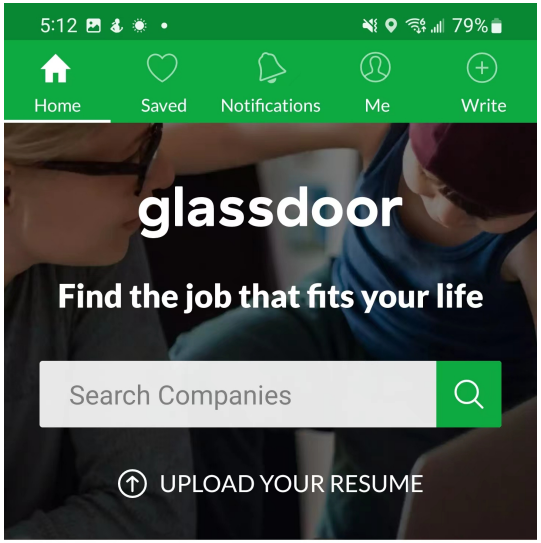
2. 经济学量化模型（包括其中的机器学习，深度学习模型）其速度远远高于人工分析（例子：房地产价格分析、股票基本面分析）

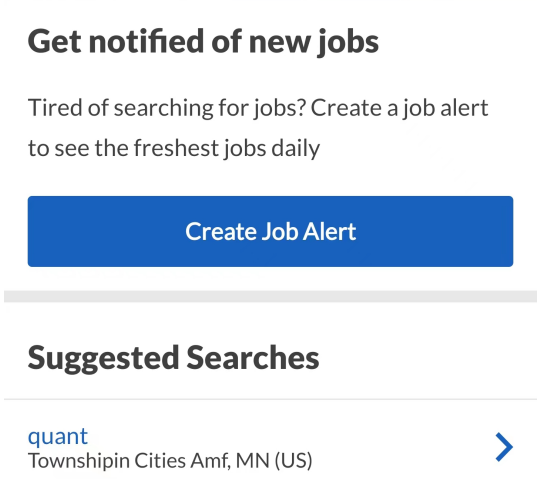
3. 优秀的量化模型（包括其中的机器学习，深度学习模型）的预测精度不逊于，甚至超过人工分析

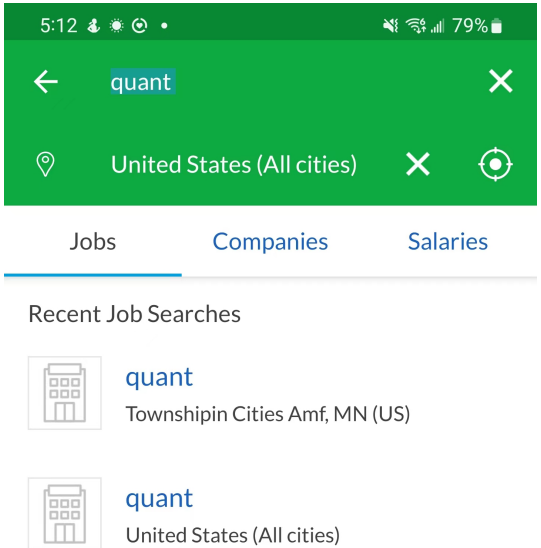
$\Longrightarrow$ 量化模型是未来经济学从业者的基本功

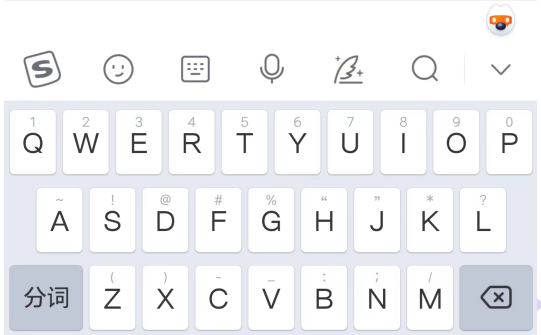
经济与金融就业市场的需求

最能反映市场趋势的就是看市场需要什么的人才。经济金融行业对量化分析师与研究员有着很高的需求。我们在Glassdoor上面去搜索一下量化建模所需要的人才与所具有的要求。

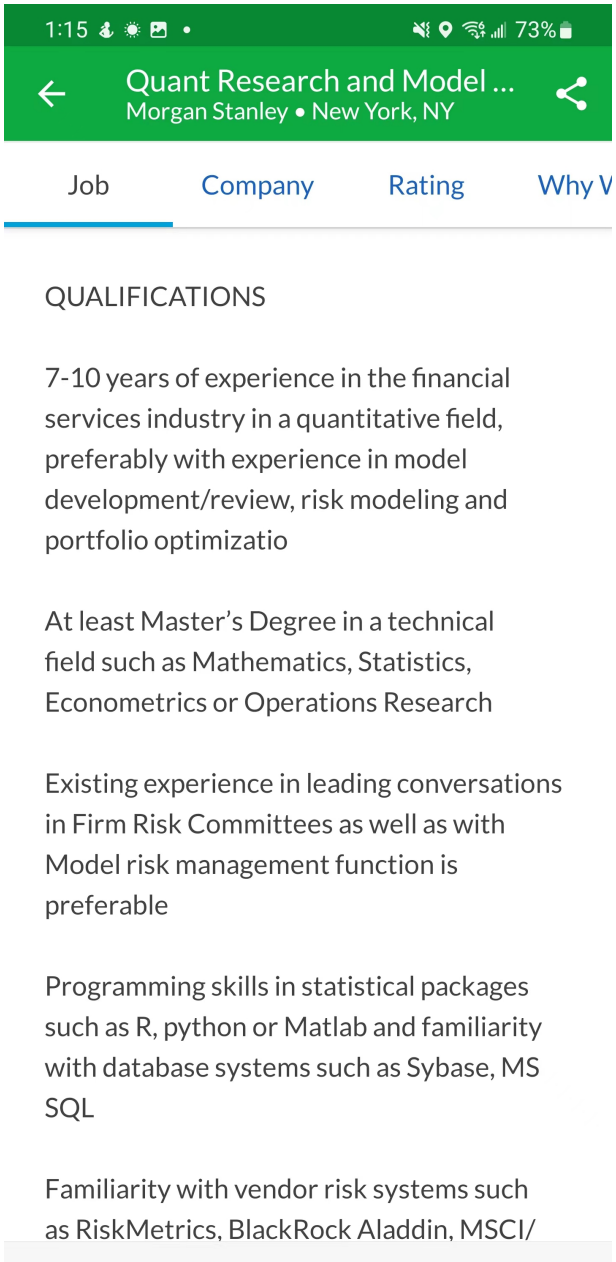








量化人才需求案例1，2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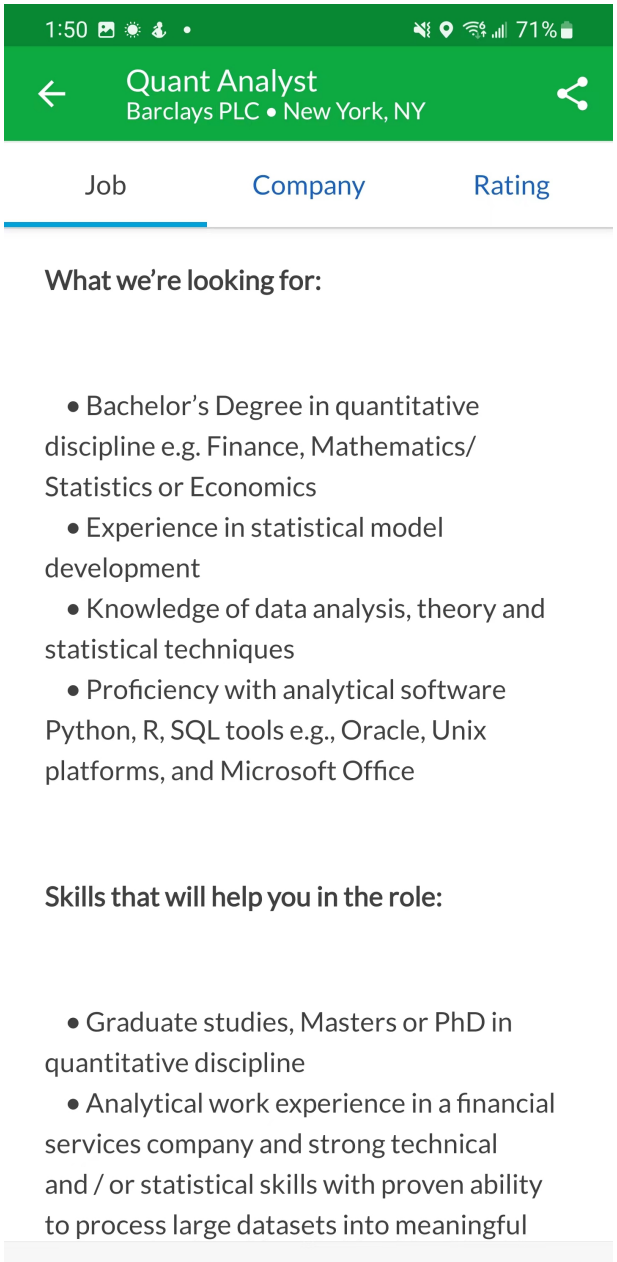
Quant Research and Model ...
Morgan Stanley • New York, NY
Job
Company
Rating
Why V
QUALIFICATIONS
7-10 years of experience in the financial services industry in a quantitative field, preferably with experience in model development/review, risk modeling and portfolio optimizatio
At least Master's Degree in a technical field such as Mathematics, Statistics, Econometrics or Operations Research
Existing experience in leading conversations in Firm Risk Committees as well as with Model risk management function is preferable
Programming skills in statistical packages such as R, python or Matlab and familiarity with database systems such as Sybase, MS SQL
Familiarity with vendor risk systems such as RiskMetrics, BlackRock Aladdin, MSCI/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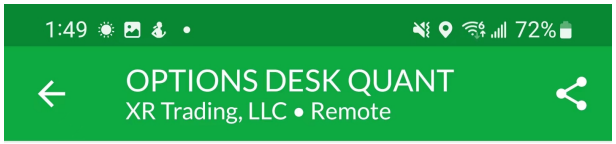
71%
Quant Analyst
Barclays PLC • New York, NY
Job
Company
Rating
What we're looking for:
• Bachelor's Degree in quantitative discipline e.g. Finance, Mathematics/ Statistics or Economics
• Experience in statistical model development
• Knowledge of data analysis, theory and statistical techniques
• Proficiency with analytical software Python, R, SQL tools e.g., Oracle, Unix platforms, and Microsoft Office
Skills that will help you in the role:
• Graduate studies, Masters or PhD in quantitative discipline
• Analytical work experience in a financial services company and strong technical and / or statistical skills with proven ability to process large datasets into meaningful

量化人才需求案例3,4

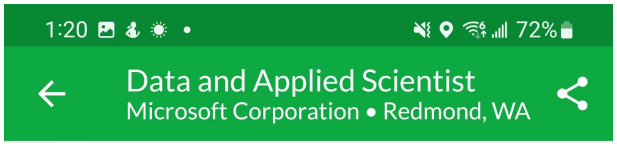


Required Skills

- Strong mathematical aptitude
- Fluency in statistical methods and modeling
- Coding skills in Python (C++ familiarity is a plus)
- Exposure and familiarity with machine learning techniques
- Values teamwork but capable of thinking independently
- Works on own Initiative / hustle – takes a pragmatic approach
- Effective communication with all levels of professional experience
- Ability to retain information and then teach others what you have learned

Required Experience

- Familiarity and interest in options and



Required:

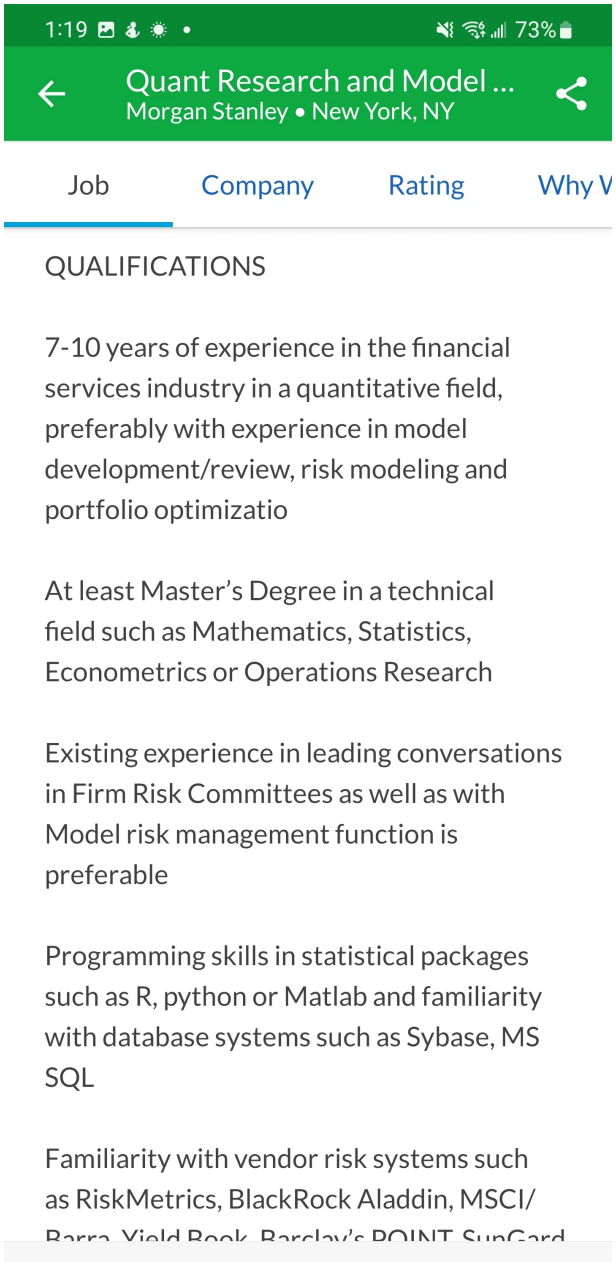
- A bachelors or higher degree in computer science, machine learning, statistics, math, economics, business or other scientific or quant-focused field

- Programming skills (esp. related to data technologies like Python, Java, C#, etc.)
- 2 or more years of experience using data/ML/AI to impact critical product or business decisions

Preferred:

- Experience with hypothesis testing, graph theory and experiment design
- A proven track record of collaborating across organizational boundaries and

量化人才需求案例5,6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Quant Research and Model ...
Morgan Stanley • New York, NY
Job
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Why V
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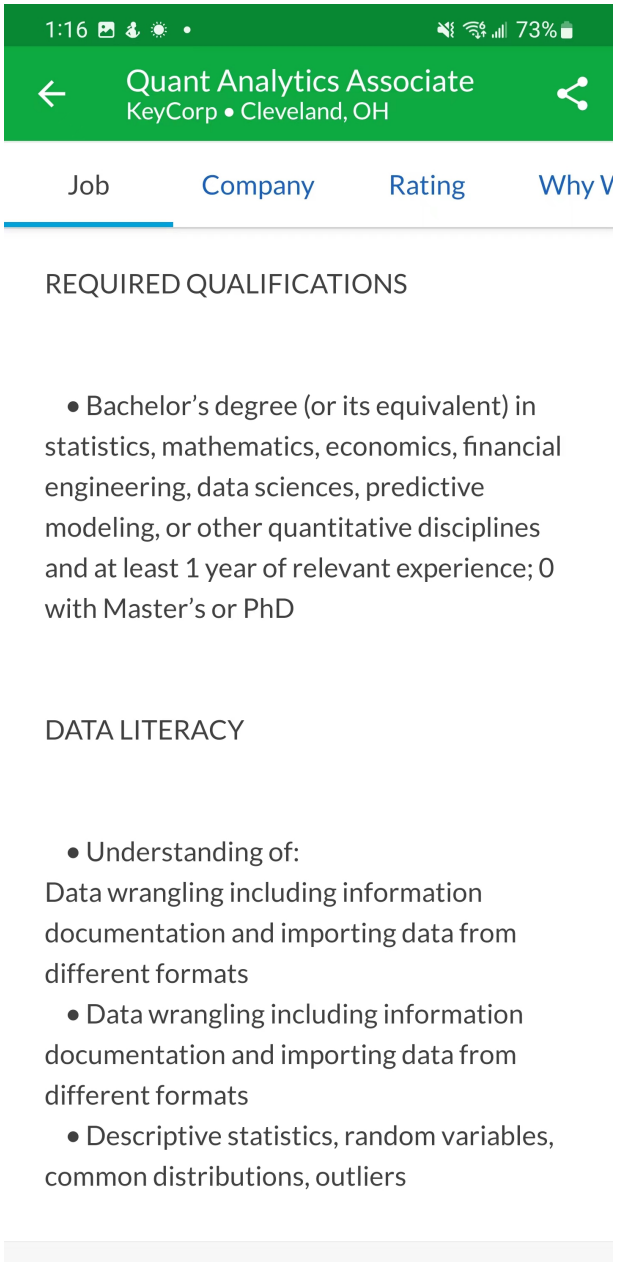
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Quant Analytics Associate
KeyCorp • Cleveland, OH
Job
Company
Rating
Why V
REQUIRED QUALIFICATIONS
• Bachelor's degree (or its equivalent) in statistics, mathematics, economics, financial engineering, data sciences, predictive modeling, or other quantitative disciplines and at least 1 year of relevant experience; 0 with Master's or PhD
DATA LITERACY
• Understanding of:
Data wrangling including information documentation and importing data from different formats
• Data wrangling including information documentation and importing data from different formats
• Descriptive statistics, random variables, common distributions, outliers

量化建模所需人才的关键字

我们通过上述量化岗位的人才需求信息，可以得出两个跟我们密切相关的关键词：1）经济学与2）python。

- 经济学（Economics）：在现如今的金融市场中，经济学常常被归类为量化学科（STEM），要求毕业生有很好的数量统计与分析能力。并且具有很好的编程能力。就像上述大公司的招聘广告要求的一样，经济学学生的数理统计能力需要和统计学与数学的学生比肩。并且拥有很好的编程能力。

- Python：python是当今量化建模所使用的最热门编程语言。

经济学量化建模所需的知识库

1. **经济学 Economics**: economics is a social science concerned with the production, distribution, and consumption of goods and services

2. **量化建模 Quantitative**: using econometrics & machine learning skills to build model to explain and solve the economic problems

3. **Python**: trending computer language in building the quantitative models

经济学量化建模是三种知识的有机结合

这门课的内容不仅仅是Python:

- 会用Python $\neq$ 会应用经济学预测
- 会应用经济学预测 $\neq$ 会应用量化建模
- 经济学量化建模 $=$ Python $+$ 经济学 $+$ 机器学习模型

业界量化模型师的具体分类与工作流程

量化模型的构建并不简单，有着严格的模型精准度与模型质量管理流程。模型的质量管理流程比算法本身更重要。

1. 一线建模型研究员（1st line modeler）：沟通Business获取需求，沟通数据组获得数据资源，通过数据与Business需求量化建模，沟通developer，将模型应用于business

2. 二线建模型研究员（Model validating）：负责检查一线模型的问题，提出模型的不足与提升意见

3. 三线建模型研究员 (Model auditing) ：负责检查一线模型与二线模型的问题，检查模型合规与法律问题

学习经济学量化建模的人群

针对人群：

1. 有志于在业界从事量化研究的同学（未来的量化经济学家，数据科学家，etc.）
2. 有志于在学界从事研究的同学(经济学，金融学PhD, 经济学，金融学，金融工程Master)
3. 有志于研究Policy Making的同学们
4. 甚至是有志于创业当老板的同学们

教材

- Quantecon.org (founded by Thomas Sargent)
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow(`https://github.com/ageron/handson-ml`) offline
- Greene, Econometric Analysis, 8th Edition

提升能力：读模型说明书（White Paper）与论文（Paper）

- 模型的说明文件可以帮助同学们快速熟练使用模型（如：`https://xgboost.readthedocs.io/en/stable/tutorials/model.html` offline ）。渠道：模型的官网 or github。
- 论文可以去更深层次的去了解模型的内部结构（如：https://arxiv.org/abs/1603.02754）。渠道：google scholar，Arxiv

遇到不会的问题怎么办 (Coding Questions)

- Search Engines such as Bing
- StackOverflow
- help function in Python

遇到不会的问题怎么办 (For Example)

Step1： Use key words to search your coding questions

遇到不会的问题怎么办 (For Example)

Step2： find your answers or templates from the professional website such as the StackOverflow

9 Answers

Sorted by: Highest score (default)

388

Use `GroupBy.sum`:

```
df.groupby(['Fruit','Name']).sum()

Out[31]:
               Number
Fruit   Name
Apples  Bob        16
        Mike        9
        Steve      10
Grapes  Bob        35
        Tom        87
        Tony       15
Oranges Bob        67
        Mike       57
        Tom        15
        Tony        1
```

数据资源1：Scikit-learn自带数据

优点：方便，一行代码读取 缺点：数据量小，不利于真实建模,仅仅用于简单演示

sklearn.datasets: Datasets

The `sklearn.datasets` module includes utilities to load datasets, including methods to load and fetch popular reference datasets. also features some artificial data generators.

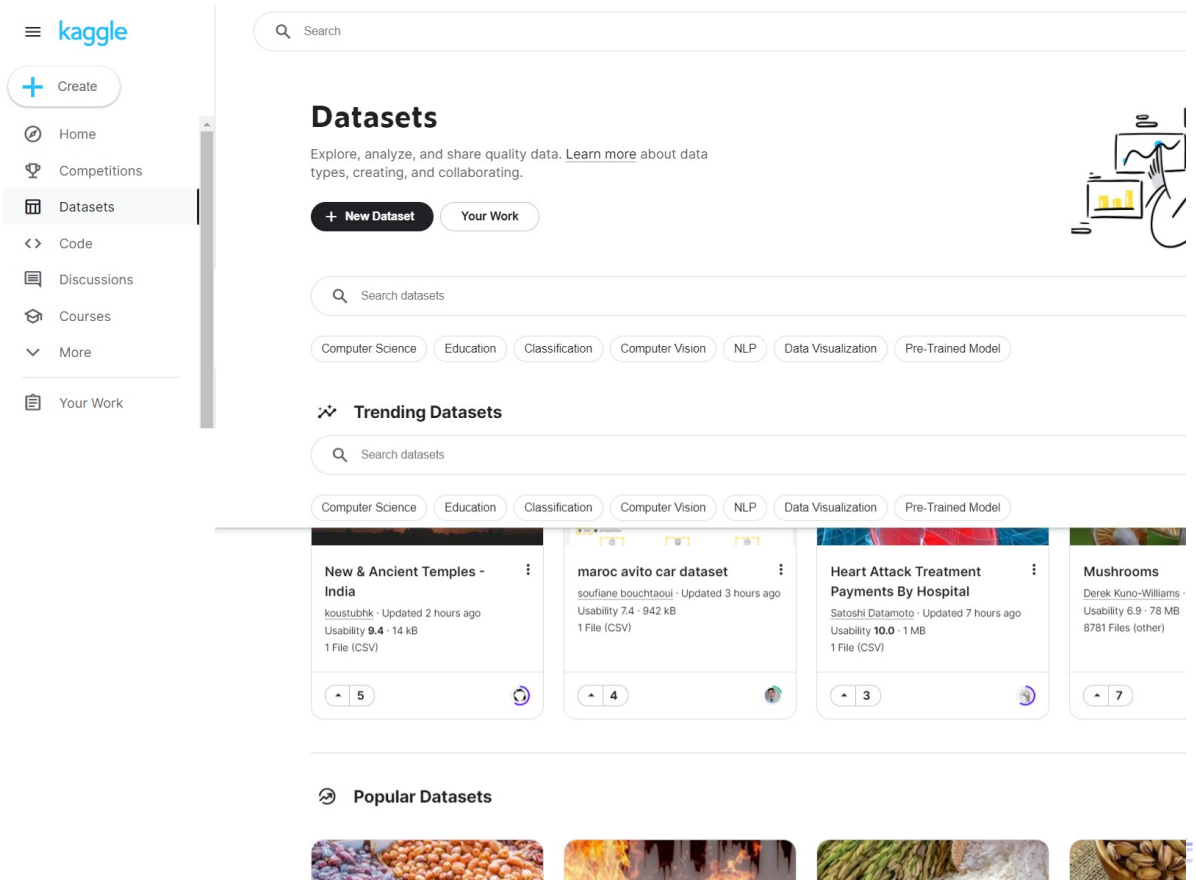
User guide: See the Dataset loading utilities section for further details.

Loaders ¶

`datasets.clear_data_home`([data_home])	Delete all the content of the data home cache.
`datasets.dump_svmlight_file`(X, y, f, *[, ...])	Dump the dataset in svmlight / libsvm file format.
`datasets.fetch_20newsgroups`(*[, data_home, ...])	Load the filenames and data from the 20 newsgroups dataset (classification).
`datasets.fetch_20newsgroups_vectorized`(*[, ...])	Load and vectorize the 20 newsgroups dataset (classification).
`datasets.fetch_california_housing`(*[, ...])	Load the California housing dataset (regression).
`datasets.fetch_covtype`(*[, data_home, ...])	Load the covertype dataset (classification).
`datasets.fetch_kddcup99`(*[, subset, ...])	Load the kddcup99 dataset (classification).
`datasets.fetch_lfw_pairs`(*[, subset, ...])	Load the Labeled Faces in the Wild (LFW) pairs dataset (classification).
`datasets.fetch_lfw_people`(*[, data_home, ...])	Load the Labeled Faces in the Wild (LFW) people dataset (classification).
`datasets.fetch_olivetti_faces`(*[, ...])	Load the Olivetti faces data-set from AT&T (classification).
`datasets.fetch_openml`([name, version, ...])	Fetch dataset from openml by name or dataset id.
`datasets.fetch_rcv1`(*[, data_home, subset, ...])	Load the RCV1 multilabel dataset (classification).
`datasets.fetch_species_distributions`(*[, ...])	Loader for species distribution dataset from Phillips et.
`datasets.get_data_home`([data_home])	Return the path of the scikit-learn data directory.
`datasets.load_boston`(*[, return_X_y])	DEPRECATED: `load_boston` is deprecated in 1.0 and will be removed in 1.2.
`datasets.load_breast_cancer`(*	Load and return the breast cancer wisconsin dataset (classification).

数据资源2：Kaggle Datasets

- Kaggle, a subsidiary of Google LLC, is an online community of data scientists and machine learning practitioners.
- 网址：`https://www.kaggle.com/datasets` offline
- 优点：真实大数据、数据比较新、与经济与金融学相关数据比较多



相关文献

- Chen, Tianqi, and Carlos Guestrin. "Xgboost: A scalable tree boosting system." Proceedings of the 22nd acm sigkdd international conference on knowledge discovery and data mining. 2016.
- Gu, S., Kelly, B., & Xiu, D. (2020). Empirical asset pricing via machine learning. The Review of Financial Studies, 33(5), 2223-2273.
- Leippold, M., Wang, Q., & Zhou, W. (2021). Machine learning in the Chinese stock market. Journal of Financial Economics.
- Chernozhukov, V., Chetverikov, D., Demirer, M., Duflo, E., Hansen, C., & Newey, W. (2017). Double/debiased/neyman machine learning of treatment effects. American Economic Review, 107(5), 261-65.
- Wager, S., & Athey, S. (2018). Estimation and inference of heterogeneous treatment effects using random forests. Journal of the American Statistical Association, 113(523), 1228-1242.

First Project: Python Installation

- 通过Jupyter安装Python：
  `https://www.anaconda.com/products/individual`
  `https://jupyter.org/try`
- Jupyter是最流行的Python操作环境，大的金融，科技企业，政府机构都在用这个操作环境
- 方便大的团队与项目合作（一线Quant团队，二线Quant团队，EE团队与Business团队）
- 方便介入云计算（企业级：AWS，MS Azure and Data Brick，个人使用：Google Colab
  `https://colab.research.google.com/`）

Jupyter

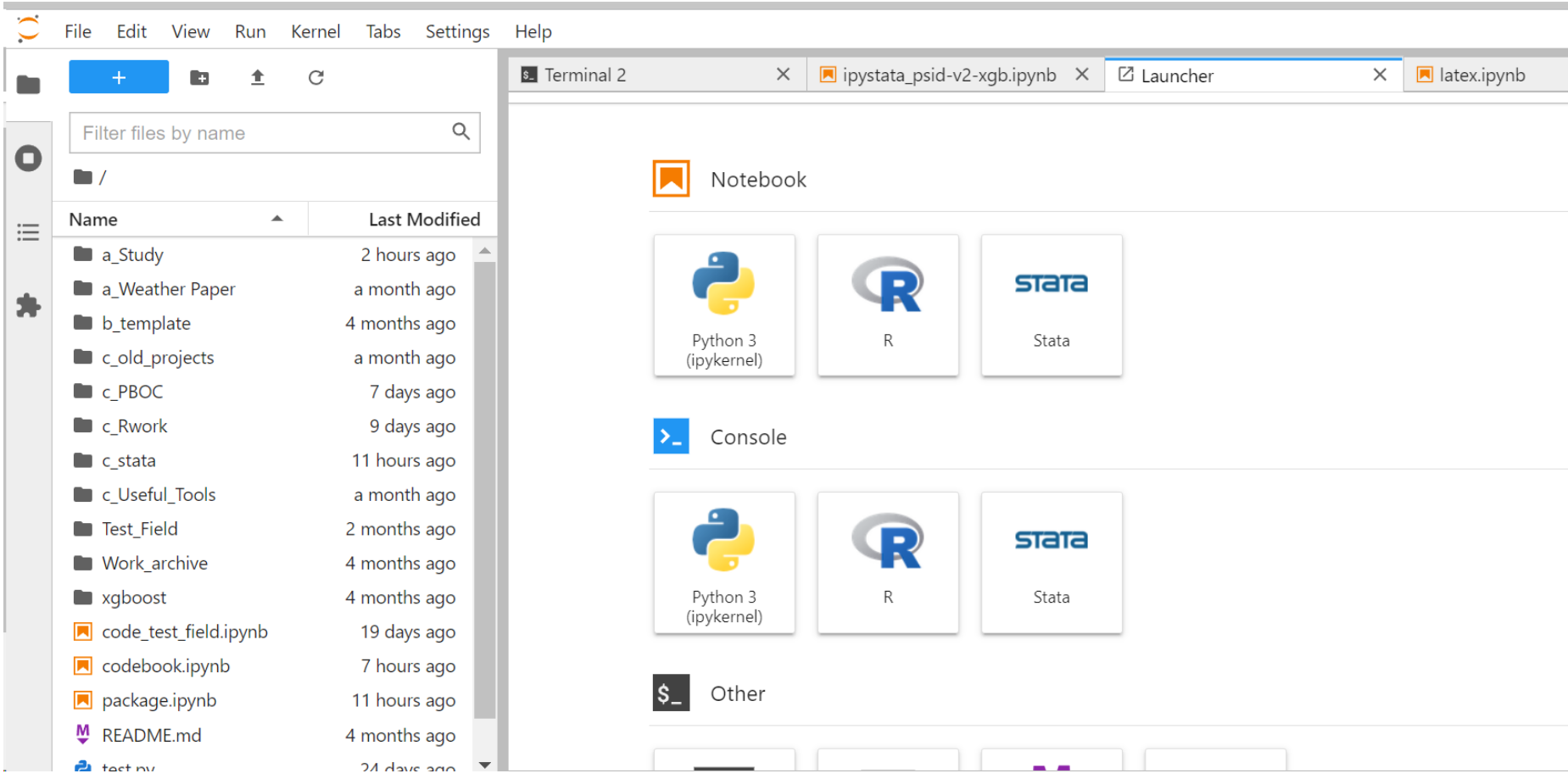


图: Jupyter操作平台

安装机器学习建模所需的python packages

安装xgboost、scikit-learn、pandas、Tensorflow

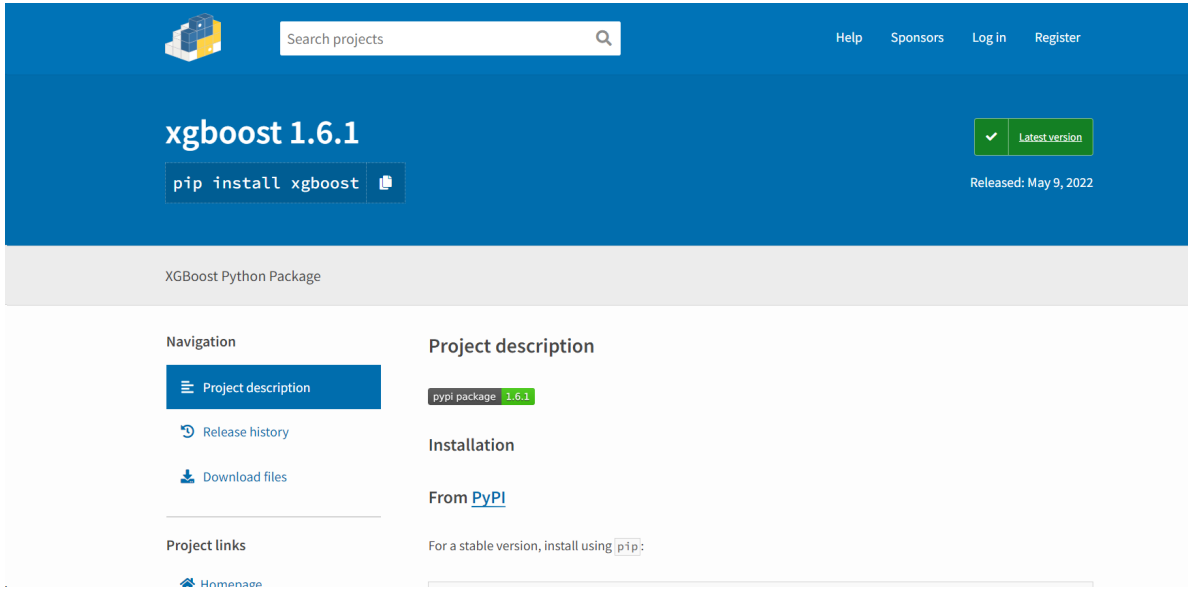


图:

不负平生所学

各位同学过去十几年勤学苦练的技能得到发挥。比如:英文能力、计量经济学能力、经济学能力、编程能力、更重要的是创造力与智慧。

1. **Math skills**
2. **English reading skills**
3. **Coding skills**
4. **Economics skills**
5. **Young talents**