# **Artificial Intelligence in Finance**

**Pycon Taiwan** Taipei, 22. September 2019





## Dr. Yves J. Hilpisch



## Introduction



http://hilpisch.com









BUSINESS SCHOOL





#### SERVICES

for financial institutions globally





#### TRAINING

about Python for finance & algorithmic trading

#### PLATFORM

for browser-based data analytics

for financial analytics

## **EVENTS** for Python quants & algorithmic traders **THE PYTHON** QUANTS CERTIFICATION **THE PYTHON** QUANTS in cooperation with university BOOKS about Python and finance **OPEN SOURCE** Python library

http://tpq.io

### 16 week program

PROGRAM DIRECTOR

5,000+ lines of code

The Python Quants GmbH 66333 Voelklingen 66333 Vola Germany T|F +49 3212 112 91 94 training@tpq.io

April 2017

The Python Quants GmbH

## **150+ hours** ofinstruction

UNIVERSITY CERTIFICATE ALGORITHMIC TRADING IN PYTHON FOR

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110

#### 1,200 pages PDF

HEPYTHON

http://certificate.tpq.io



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#### http://aimachine.io



http://certificate.tpq.io/tpq\_top\_algo\_2019.pdf

Capital Markets Outlook TOP 10 ALGO TRADING SOLUTION PROVIDERS - 2019

#### The Python Quants First University Certificate in Python for Algorithmic Trading

ython programming has become a key skill in the financial industry. In areas such as financial data science, computational finance or algorithmic trading, Python has established itself as the primary technological platform. At the same time, the level of Python sophistication the industry is expecting from its employees and applicants is increasing steadily. The Python Quants Group is one of the leading providers of Python for Finance training programs.

Among others, The Python Quants have tailored a comprehensive online training program leading to the first University Certificate in Python for Algorithmic Trading. Be it an ambitious student with intrigue for algorithmic trading, or a major financial institution, The Python Quants, through this systematic training program, is equipping delegates with requisite skills and tools to formulate, backtest and deploy algorithmic trading strategies based on Python.

The topics covered in the training programs offered by The Python Quants are generally not found in the typical curriculum of financial engineering or quantitative finance Master programs. Dr. Yves Hilpisch, the firm's founder and managing partner, explains, "There are courses out there that show students how to apply machine learning for the formulation and backtesting of algorithmic trading strategies. However, none of them explains the difficulties or the skills

required in deploying such algorithmic trading strategies in the real world. Besides providing an introductory course that teaches Python and financial concepts from scratch, we train our delegates and clients on how best to deploy algorithmic trading strategies in automated fashion in the cloud, with, among others, real-time risk management and monitoring," explains Hilpisch, an author of three books on

Dr. Yves Hilpisch

the topic, with "Python for Finance" (2nd ed., O'Reilly) being the standard reference in the field.

The organization's "Python for Algorithmic Trading University Certificate" consists of 200 hours of instruction, 1,200 pages of documentation and 1,000s of lines of Python code. In addition to offering both online and offline Python training, Hilpisch and his team also organize bespoke training events for financial institutions, hedge funds, banks, and asset management companies. "Most of the training is online since we have students and delegates from about 65 different countries in general. Most recently, we noticed that it's not just financial firms and students who want to deepen their algorithmic trading knowledge, but even professors of finance who want to get more involved in this popular topic," says Hilpisch.

While the Quant Platform is the most popular choice, especially for users in the financial sector who don't have access to a full-fledged, interactive, financial analytics environment, the team at The Python Quants is currently developing The AI Machine—a new platform which leverages artificial intelligence to formulate and deploy algorithmic trading strategies in a standardized manner. Hilpisch explains that it's relatively easy to write Python code for an algorithmic trading strategy, but the same can't be said about the deployment of such a strategy. "There are a few platforms out there that allow the formulation and backtesting of algorithmic trading strategies by the use of Python code. However, they usually stop exactly there. With The AI Machine, it is a single click on the 'GO LIVE' button and the strategy is deployed in real-time—without any changes to the strategy code itself," adds Hilpisch.

In 2019, The Python Quants will be introducing a new university certificate titled "Python for Computational Finance," which will focus more on original quantitative finance topics,

> such as option pricing, Monte Carlo simulation, and hedging. As financial institutions begin to perceive Pythonbased analytics as a prerequisite skill, the organization will continue to provide an "efficient and structured way of mastering all the tools and skills required in Python for Financial Data Science, Algorithmic Trading, and Computational Finance."CM

Wiley Finance Series

## Derivatives Analytics with

# Python

Data Analysis, Models, Simulation, Calibration and Hedging

YVES HILPISCH

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**O'REILLY** 





MASTERING DATA-DRIVEN FINANCE

# NEW book project: Artificial Intelligence in Finance - A Python-based Guide RINCH ECHILION

Wiley Finance Series

# **Listed Volatility** Variance erivatives

A Python-based Guide

**YVES HILPISCH** 

http://books.tpq.io

for Finance

Yves Hilpisch





## Python Key Skill in Finance

**Yves Hilpisch** @dyjh

JPMorgan's Athena has 35 million lines of **#Python code**, and won't be updated to Python 3 in time tek.io/2Nbv7K0 via @techrepublic #Finance

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JPMorgan's Athena has 35 million lines of Python code, and won't be updated... With 35 million lines of Python code, the Athena trading platform is at the core of JPMorgan's business operations. A late start to migrating to Python 3 coul... & techrepublic.com

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& techrepublic.com

JPMorgan Chase & Co

#### JPMorgan's requirement for new staff: cod lessons

Hundreds of new investment bankers and asset managers undergo mandatory training

Laura Noonan, in New York OCTOBER 7, 2018

JPMorgan Chase is putting hundreds of new investment bankers and asset managers through mandatory coding lessons, in a sign of Wall Street's heightened need for technology skills.

All 300 analysts joining JPMorgan's asset management division this year have been through mandatory coding training under a new pilot scheme. About a third of the analysts and associates at JPMorgan's corporate and investment bank were also put through the programme.

With technology, from artificial intelligence trading to online lending platforms, shaping the future of banking, financial services groups are developing software to help them boost efficiency, create innovative products and fend off the threat from start-ups and tech giants.

> sets and interpret unstructured data such as free language text. Next year, the asset management division will expand the mandatory tech training to include data science concepts, machine learning and cloud computing.

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The coding training for this year's juniors was based on Python programming, which will help them to analyse very large data

Masters in Finance



# Graduates with tech and finance skills in high demand

The workforce will have to adapt as companies use artificial intelligence for more tasks



Opportunity knocks: tech is creating new career paths for finance graduates © Getty

Seb Murray JUNE 16, 2019

By 2030, some 400,000 full-time jobs in capital markets — including asset management, investment banking and brokerage — will be lost as technology and artificial intelligence (AI) supplant humans, <u>predicts Opimas</u>, a research consultancy.

But there are opportunities for masters in finance (MiF) graduates. The blend of technological and financial knowledge is a sweet spot, as is a growing Asian economy and new opportunities in areas such as risk management.

"Computer programming skills are becoming a must-have," she says. "Don't bother putting Excel or PowerPoint on your résumé. Financial institutions are looking for R, Python or another programming language."





## **Data-Driven Finance**

#### FINANCIAL TIMES

ohamed El-Erian

Torturing Theresa Boris Johnson's bid to dictate May's Brexit strateav



#### Las Vegas reels from worst US mass shooting

A casualty is carried from the sce fter a gunman opened fire on concer goers in Las Vegas on Sunday night. More than 58 people were killed and over 515 wounded, making it the deadli Las Vegas police said the suspe

the US president, called the shooti



#### Catalan president urges Brussels to mediate in independence clash

• Region seeks to avoid 'traumatic split' from Spain • EU says dispute is 'internal matter'



an anti-austerity government.- PAGE : • Uber's UK head quits as chief flies in Jo Bertran, Uber's UK boss, has quit the company a day before a visit to London by Dara to meet regulators over a threat prevoke the ride-hailing app's

▶ Koike faces Japan election dilemma okyo governor Yuriko Koike is under pressure stand in Japan's general election later this month amid fears she and her party lack the resources to beat Shinzo Abe, the prime minister.-- PAGE 4

Equifax defends silence over hack Credit reference agency Equifax has claimed ahea of a hearing at the US Congress later today that disclosing that it had been hacked would have ncouraged "copycat" cyber attacks.- PAGE 13 ▶ Western envoys warn on Kenya re-run

Western ambassadors have condemned President Uhuru Kenyatta and Raila Odinga, opposition eader, for undermining the electoral commission pility to restage its election this month.- PAGE 4

▶ Huawei beats Apple as top China choice uawei has for the first time beaten Apple to top spot for intended smartphone purchases in China





Smith & Wesson said profi 6, as gun sales slow from eir recent torrid pace. **B2** Pacific trade talks adjourned vithout a deal amid discord be ween the U.S. and Japan. A17 Italy pulled out of a two ear contraction in the thir uarter, posting flat GDP. A Three Swiss banks agreed to participate in a U.S. tax-eva sion-disclosure program. C5

■ LightSquared can proceed with a suit against Dish over a debt purchase, a judge ruled. B3 Monsanto is teaming up with a Danish firm to develop \* \* \*

World-Wide

Congressional negotiat struck a budget deal that v allow more domestic and r ary spending and include def it-cutting measures. A1, A8 Ukrainian forces storn protesters' encampment in Kiev, hours after Western dip-omats called for a nonviolent end to the political crisis. **A13** ■ Obama's disapproval rate hit 54%, the high for his presi-dency, amid the flawed health law rollout, a Wall Street Journal/NBC poll found. A4

World leaders gathered to nor Mandela. In a rare en th Cuba's Raúl Castro. A12 Senate Democrats con-

rmed an Obama appeal ourt pick and the head o A key Senate Democrat lelay new Iran sanctions. A17

Bank Rule Supreme Court justi Challenges proach to air polluti crosses state lines. A Wall Street An AIDS group called for a

probe to see if HIV-infected pa ients were discouraged from enrolling in health plans. A6 By Justin Baer And Julie Steinberg ■ Uruguay's Senate voted to legalize marijuana. The presi-dent plans to sign the bill. A15 A broad new government rule

France's leader flew to the ral African Republic afte o French troops died. A13 Singapore police charged



China Spins New Lesson From Soviet Fall

REST IN PEACE: A boy attended the memorial service for former South African President Nelson Mandela at a soccer stadium in Johannesburg on Tuesday that drew celebrities and dozens of heads of state, including President Obama, along with thousands of other mourners. A12

PARTY DISCIPLINE

 BY JEEDING
 The Community Party boss in castern China's Jiangsu province summond local officials recently to a compulsory study advantary on the Soviet Union's collarge.
 fall apart because of the communist system trayed it, especially Mikhail Gorbache.
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 The fill makes rational analysis, is maint indicated the lessors of history."

 The fill m's message: The Soviet Divisors of the low office and the lessors of history."
 The spread of Western ideas to more charge of Wr. Soviet political and popular culture.
 The office in charge of Mr. Xi's campaig didn't respond to questions about the fill the rate and a factory in the soviet political and provide the soviet political soviet political and provide political system rather than limit the party powers. Party insiders and academics say it in did a defending the Staling stystem sin indig a cademia and popular culture.

Here's Your Holiday Bonus, Now Start Running \* \* \*

At a time of year when n

Workers Win All-They-Can-Grab Sprees From Companies; 'Supermarket Sweep'

BY RACHEL FEINTZEIG A broad new government rule to limit risk-taking by Wall Street mill force banks to rethink virtur ally every aspect of their trading activities, setting the targe for more tumult at the largest U.S. financial institutions. The so-called Volker rule, ap proved by five financial regula, but his employer, coupon website for a company to the setting to the set of the set of the set of the set or a called volker rule, ap proved by five financial regula, but his employer, coupon website for a company to the set of the set of the set of the set of the set or a called volker rule, ap

iShares Core ETFs US Stocks US Bonds Every investor is unique That's why there's iShares Core. Find out why 9 out of 10 large profe choose iShares for their ETFs.<sup>1</sup> 🚺 iShares by BLACKROCK

DETROIT—General Motors Co. tapped product chief Mary Barra as its next chief executive, smash-ing a century-old gender barrier while choosing a longtime insider who grew up steeped in Detroit's car culture. Ms. Barra will succeed Dan Ak-seren oc CC0 next weath and he

Ms. Barra will succeed Dan Ak-erson as CEO next month and be-come the first woman to run a major global auto maker. The 51-year-old joined GM 33 years ago as a college intern, eventually be-coming an engineering manager before running one of its big U.S. assembly plants. She got global experience managing human re-sources and, more recently, the company's world-wide product development group. evelopment group. She will become the 22nd nan currently running a Fo Please turn to page Al

Milestone is hailed, but worr continue to face obstacles.....
 Heard on the Street.......



Yves								
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BUSINESS SUMMARY >		PRICE PERFORMANCE >						
Apple Inc. designs, manufactures and markets mobile communication and media devices, personal computers	and portable	Open			AAPL 0 115,190000		Price	
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products and services include iPhone, iPad, Mac, iPod, Apple Watch, Apple TV, a portfolio of consumer and pro	ofessional	Turnover         Volume         Short Interest       0.90%				105.00		
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23:33:16 Reuters Insider - Tech stocks could take the Dow to 20k	CNBC	Outstanding	5.33B	Share Cla	SS	∆ Today	-0.07%	
23:32:28 Reuters Insider - History suggests Dow could hit 20k by Friday: Technician	CNBC	IPO Date 4	12-Dec-1980	Lot Size		∆ 1 Week	-0.074	
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24-Feb-2017 » 28-Feb-2017	T TRUE	Operating Margin			25.10%	(11.59%) 4Q	5.75%	

Yves								
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Overview News & Research Price & Charts Estimates Financials Events Ownership Det	ot & Credit Peers	s & Valuation	Derivatives	Filings	360 Menu			۵ 🛃
BUSINESS SUMMARY >		PRICE PERFOR	MANCE >					
Apple Inc. designs, manufactures and markets mobile communication and media devices, personal computers	and portable	Open				AARL 0 115 190000		Price
digital music players. The Company sells a range of related software, services, accessories, networking solution	ons, and third-	Prev. Close				AAPL.0 115.190000		USD
party digital content and applications. The Company's segments include the Americas, Europe, Greater China, of Asia Pacific. The Americas segment includes both North and South America. The Europe segment includes	Japan and Rest European	Bid / Ask					M	115.00
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NTS O1 2017 Apple Inc Earpings Poloses	1000	Gross Margir	1			38.02%	(4.71%) 4Q	38.91%
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In [33]:	<pre>storyId = news[</pre>	<pre>'storyId'][0]</pre>							
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# **IPython**



# pandas





## **AI-First Finance**

## scientific method

#### noun

a method of procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses. "criticism is the backbone of **the scientific method**"

"Machine learning is the scientific method on steroids. It follows the same process of generating, testing, and discarding or refining hypotheses. But while a scientist may spend his or her whole life coming up with and testing a few hundred hypotheses, a machine-learning system can do the same in a second. Machine learning automates discovery. It's no surprise, then that it's revolutionizing science as much as it's revolutionizing business."



MARCOS LOPEZ DE PRADO

## ADVANCES inFINANCIAL MACHINE LEARNING

WILEY

"Econometrics might be good enough to succeed in financial academia (for now), but succeeding in practice requires ML."

"The essential tool of econometrics is multivariate linear regression, an 18th-century technology that was already mastered by Gauss before 1794 ... It is hard to believe that something as complex as 21st-century finance could be grasped by something as simple as inverting a covariance matrix."

"... what if economists finally started to consider nonlinear functions?"

"An ML algorithm can spot patterns in a 100-dimensional world as easily as in our familiar 3-dimensional one."



## **Financial** Markets

X

"normative economics = assumptions, axioms, etc."

(too) "simple and elegant theories"



"hardly any supporting empirical evidence"

"non-linear, complex, changing"









# TensorFlow

## Are Markets Predictable?

## Myth 1: Technical Analysis



"CFDs are complex instruments and come with a high risk of losing money rapidly due to leverage.

73.5% of retail investor accounts lose money when trading CFDs with this provider.

You should consider whether you understand how CFDs work and whether you can afford to take the high risk of losing your money."

http://oanda.com



#### Myth 2: Normality

#### PORTFOLIO SELECTION\*

#### HARRY MARKOWITZ The Rand Corporation

THE PROCESS OF SELECTING a portfolio may be divided into two stages. The first stage starts with observation and experience and ends with beliefs about the future performances of available securities. The second stage starts with the relevant beliefs about future performances and ends with the choice of portfolio. This paper is concerned with the second stage. We first consider the rule that the investor does (or should) maximize discounted expected, or anticipated, returns. This rule is rejected both as a hypothesis to explain, and as a maximum to guide investment behavior. We next consider the rule that the investor does (or should) consider expected return a desirable thing *and* variance of return an undesirable thing. This rule has many sound points, both as a maxim for, and hypothesis about, investment behavior. We illustrate geometrically relations between beliefs and choice of portfolio according to the "expected returns—variance of returns" rule.

One type of rule concerning choice of portfolio is that the investor does (or should) maximize the discounted (or capitalized) value of future returns.<sup>1</sup> Since the future is not known with certainty, it must be "expected" or "anticipated" returns which we discount. Variations of this type of rule can be suggested. Following Hicks, we could let "anticipated" returns include an allowance for risk.<sup>2</sup> Or, we could let the rate at which we capitalize the returns from particular securities vary with risk.

The hypothesis (or maxim) that the investor does (or should) maximize discounted return must be rejected. If we ignore market imperfections the foregoing rule never implies that there is a diversified portfolio which is preferable to all non-diversified portfolios. Diversification is both observed and sensible; a rule of behavior which does not imply the superiority of diversification must be rejected both as a hypothesis and as a maxim.

1. See, for example, J. B. Williams, *The Theory of Investment Value* (Cambridge, Mass.: Harvard University Press, 1938), pp. 55-75.

2. J. R. Hicks, Value and Capital (New York: Oxford University Press, 1939), p. 126. Hicks applies the rule to a firm rather than a portfolio.



## "Mean-Variance" "Risk-Return"

<sup>\*</sup> This paper is based on work done by the author while at the Cowles Commission for Research in Economics and with the financial assistance of the Social Science Research Council. It will be reprinted as Cowles Commission Paper, New Series, No. 60.

### Myth 2: Normality



## Theory

## Reality



#### Myth 3: Linearity

#### The Journal of FINANCE

Vol. XIX

September 1964

No. 3

#### CAPITAL ASSET PRICES: A THEORY OF MARKET EQUILIBRIUM UNDER CONDITIONS OF RISK\*

#### WILLIAM F. SHARPE<sup>†</sup>

#### I. INTRODUCTION

ONE OF THE PROBLEMS which has plagued those attempting to predict the behavior of capital markets is the absence of a body of positive microeconomic theory dealing with conditions of risk. Although many useful insights can be obtained from the traditional models of investment under conditions of certainty, the pervasive influence of risk in financial transactions has forced those working in this area to adopt models of price behavior which are little more than assertions. A typical classroom explanation of the determination of capital asset prices, for example, usually begins with a careful and relatively rigorous description of the process through which individual preferences and physical relationships interact to determine an equilibrium pure interest rate. This is generally followed by the assertion that somehow a market risk-premium is also determined, with the prices of assets adjusting accordingly to account for differences in their risk.

A useful representation of the view of the capital market implied in such discussions is illustrated in Figure 1. In equilibrium, capital asset prices have adjusted so that the investor, if he follows rational procedures (primarily diversification), is able to attain any desired point along a *capital market line*.<sup>1</sup> He may obtain a higher expected rate of return on his holdings only by incurring additional risk. In effect, the market presents him with two prices: the *price of time*, or the pure interest rate (shown by the intersection of the line with the horizontal axis) and the *price of risk*, the additional expected return per unit of risk borne (the reciprocal of the slope of the line).

\* A great many people provided comments on early versions of this paper which led to major improvements in the exposition. In addition to the referees, who were most helpful, the author wishes to express his appreciation to Dr. Harry Markowitz of the RAND Corporation, Professor Jack Hirshleifer of the University of California at Los Angeles, and to Professors Yoram Barzel, George Brabb, Bruce Johnson, Walter Oi and R. Haney Scott of the University of Washington.

† Associate Professor of Operations Research, University of Washington.

1. Although some discussions are also consistent with a non-linear (but monotonic) curve.

# $\mu_i = r + \beta_i(\mu_M - r)$

## "Market Risk" "Idiosyncratic Risk



1965-1974

#### **Random Walks in Stock Market Prices**

Eugene F. Fama

r many years economists, statisticians, and teachers of finance have been interested in developing and testing models of stock price behavior. One important model that has evolved from this research is the theory of random walks. This theory casts serious doubt on many other methods for describing and predicting stock price behavior-methods that have considerable popularity outside the academic world. For example, we shall see later that if the random walk theory is an accurate description of reality, then the various "technical" or "chartist" procedures for predicting stock prices are completely without value.

In general the theory of random walks raises challenging questions for anyone who has more than a passing interest in understanding the behavior of stock prices. Unfortunately, however, most discussions of the theory have appeared in technical academic journals and in a form which the non-mathematician would usually find incomprehensible. This article describes, briefly and simply, the theory of random walks and some of the important issues it raises concerning the work of market analysts. To preserve brevity some aspects of the theory and its implications are omitted. More complete (and also more technical) discussions of the theory of random walks are available elsewhere; hopefully the introduction provided here will encourage the reader to examine one of the more rigorous and lengthy works listed at the end of this article.

#### COMMON TECHNIQUES FOR PREDICTING STOCK MARKET PRICES

In order to put the theory of random walks into perspective we first discuss, in brief and general terms, the two approaches to predicting stock prices that are commonly espoused by market professionals. These are (1) "chartist" or "technical" theories and (2) the theory of fundamental or intrinsic value analysis.

The basic assumption of all the chartist or technical theories is that history tends to repeat

itself, i.e., past patterns of price behavior in individual securities will tend to recur in the future. Thus the way to predict stock prices (and, of course, increase one's potential gains) is to develop a familiarity with past patterns of price behavior in order to recognize situations of likely recurrence.

Essentially, then, chartist techniques attempt to use knowledge of the past behavior of a price series to predict the probable future behavior of the series. A statistician would characterize such techniques as assuming that successive price changes in individual securities are dependent. That is, the various chartist theories assume that the sequence of price changes prior to any given day is important in predicting the price change for that day.'

The techniques of the chartist have always been surrounded by a certain degree of mysticism, however, and as a result most market professionals have found them suspect. Thus it is probably safe to say that the pure chartist is relatively rare among stock market analysts. Rather the typical analyst adheres to a technique known as fundamental analysis or the intrinsic value method. The assumption of the fundamental analysis approach is that at any point in time an individual security has an intrinsic value (or in the terms of the economist, an equilibrium price) which depends on the earning potential of the security. The earning potential of the security depends in turn on such fundamental factors as quality of management, outlook for the industry and the economy, etc.

Through a careful study of these fundamental factors the analyst should, in principle, be able to determine whether the actual price of a security is above or below its intrinsic value. If actual prices tend to move toward intrinsic values, then attempting to determine the intrinsic value of a security is equivalent to making a prediction of its future price; and this is the essence of the predictive procedure implicit in fundamental analysis.

#### THE THEORY OF RANDOM WALKS

Chartist theories and the theory of fundamental analysis are really the province of the market

**Eugene F. Fama (1965):** "For many years, economists, statisticians, and teachers" of finance have been interested in developing and testing models of stock price behavior. One important model that has evolved from this research is the theory of random walks. This theory casts serious doubt on many other methods for describing and predicting stock price behavior—methods that have considerable popularity outside the academic world. For example, we shall see later that, if the random-walk theory is an accurate description of reality, then the various "technical" or "chartist" procedures for predicting stock prices are completely without value."—Eugene F. Fama (1965): "Random Walks in Stock Market Prices"

### No Myth?

Reprinted from Financial Analysts Journal (September/October 1965):55-59.

### No Myth?

#### Key Hedge Fund Facts in 2018:

- since 2008 (-18.10%).
- exceed 5.00%.
- performance in 2008.
- just 8% thought they had exceeded them.
- surpassed the number of launches (609) for the first time since Pregin began tracking.
- In fact, 2018 marks the fifth consecutive year in which launch activity has fallen.

time. While there were 15,947 active funds at the end of 2017, there were 15,837 at the end of 2018.

The Pregin All-Strategies Hedge Fund benchmark finished the year at -3.42%, the worst performance year

Losses were widespread: 20% of funds saw losses between 0.01% and 5.00%, while **39% saw their losses** 

By contrast, just 21% of funds saw gains of 5.00% or more, compared to 67% that made such gains in 2017. This surpassed the losses seen in 2011, the last year the benchmark was negative, and is exceeded only by

#### The majority (55%) of investors felt their hedge fund investments fell short of expectations in 2018, while

The industry also saw a small contraction in the number of active funds, as the number of liquidations (746)

As a result, the growth in the number of active funds has slowed in recent years, and has fallen for the first time. While there were 15,947 active funds at the end of 2017, there were 15,837 at the end of 2018.



#### An Overview Of Artificial Neural Networks for Mathematicians

#### Leonardo Ferreira Guilhoto

#### Abstract

This expository paper first defines what an Artificial Neural Network is and describes some of the key ideas behind them such as weights, biases, activation functions (mainly sigmoids and the ReLU function), backpropagation, etc. We then focus on interesting properties of the expressive power of feedforward neural networks, presenting several theorems relating to the types of functions that can be approximated by specific types of networks. Finally, in order to help build intuition, a case study of effectiveness in the MNIST database of handwritten digits is carried out, examining how parameters such as learning rate, width, and depth of a network affects its accuracy. This work focuses mainly on theoretical aspects of feedforward neural networks rather than providing a step-by-step guide for programmers.

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#### ML/DL to the Rescue?

"In the mathematical theory of artificial neural networks, the universal approximation theorem states that a feed-forward network with a single hidden layer containing a finite number of neurons can approximate continuous functions on compact subsets of R<sup>n</sup>, under mild assumptions on the activation function. The theorem thus states that simple neural networks can represent a wide variety of interesting functions when given appropriate parameters; however, it does not touch upon the algorithmic learnability of those parameters."

-https://en.wikipedia.org/wiki/Universal\_approximation\_theorem





Can Machine Learning algorithms beat typical investment/trading benchmarks? (long only, short only, random positions)

*Interactive Demo — Jupyter Notebook* (no transaction costs, perfect markets)

## **The AI Machine**

Algorithmic Trading								
Data	Features and Labels	Machine & Deep Learning	Backtesting	Deployment				
EUR/USD exchange rate	time series features	support vector machine & DNN classifier	vectorized backtesting	online algorithm				
1 minute bars	economic indicators	training & testing	event-based backtesting	cloud deploymen				
August & September 2018	directional movement	validation	visualization	monitoring & risk management				







Standardized deployment of AI-powered algorithmic trading strategies.

#### Algorithmic Trading

#### Machine & Deep Learning

#### Backtesting

#### Deployment

# The Al Machine











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#### **Prediction Engines**

**Technical Rules Statistical Methods** Machine Learning **Deep Learning Automated ML** 

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**Data Streaming Transaction Streaming Position Management Profit & Loss Calculation** Visualization Logging & Reporting

 $\bullet \bullet \bullet$ 

#### The AI Machine

#### **Deployment & Execution**

**Decision Rules** 

**Entry Rules Stop Loss Trailing Stop Loss Dynamic Stop Loss Take Profit Position Sizing Capital Allocation** 

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#### The Python Quants The Al Machine

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