ADVANCED MACHINE LEARNING IN ALGORITHMIC TRADING

—

LESSONS LEARNED IN THE REAL WORLD

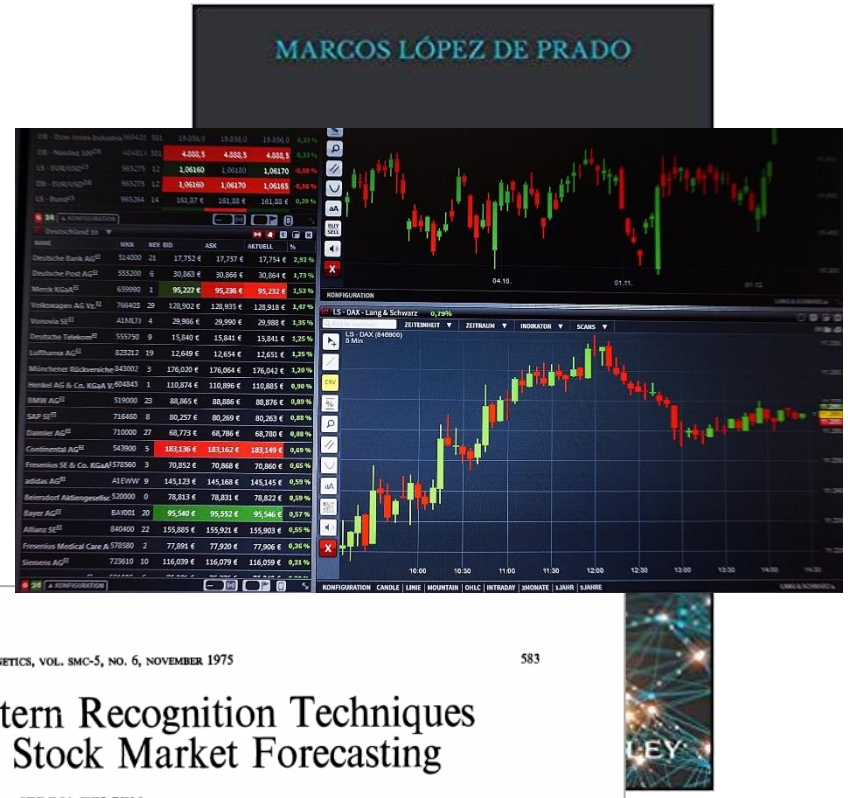
Ulrich Bodenhofer

Chief Artificial Intelligence Officer

QUOMATIC.AI

AI/ML APPLIED TO FINANCIAL MARKETS

- Since the advent of data-driven modeling approaches, predictions of financial markets have always been a highly fascinating subject.
- For decades, researchers and practitioners have been working on this subject.
- Recently, deep learning has emerged along with the availability of fantastic computing resources and the abundance and recency of all sorts of data.



IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, VOL. SMC-5, NO. 6, NOVEMBER 1975 583

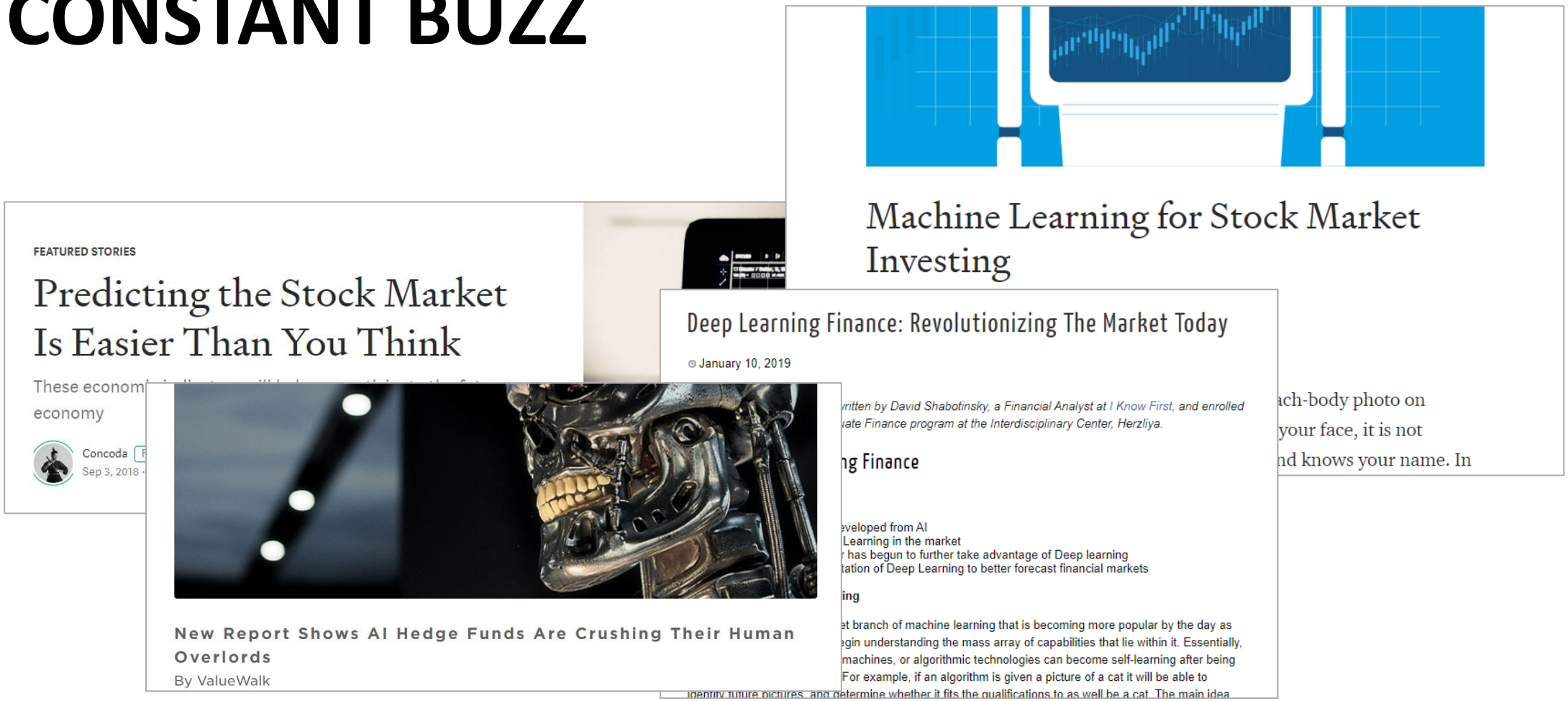
Learning Pattern Recognition Techniques Applied to Stock Market Forecasting

JERRY FELSEN, MEMBER, IEEE

Abstract—Most of investment analysis involves decision making by weighing evidence. Such decision processes can be formalized with the aid of pattern recognition (PR) techniques. Specifically, we have applied generalized perceptron-type PR techniques to both general market forecasting and investment selection. And after the investment decision system has been implemented and put into operation, its performance is then gradually improved through learning from previous decision making experiences. Iterative probabilistic learning algorithms (based on stochastic approximation techniques) have been used. Decision models for both investment selection and market forecasting have been realized

$\phi(x)$, representing a numerical encoding of the relevant economic factors, the investment news background, psychological features, and various other market factors. Through generalized *perceptron*-type PR schemes this information is then synthesized into investment decisions; and performance of the decision system is gradually improved through machine learning algorithms. We apply certain probabilistic iterative learning schemes that are

CONSTANT BUZZ



These are just random examples. There are thousands other articles like those …

EVEN SCAMS!

Algotechs

Warnings | Published: 25/04/2019 | Last updated: 12/08/2019

We believe this firm has been providing financial services or prod
authorisation. Find out why to be especially wary of dealing with
how to protect yourself from scammers.

Almost all firms and individuals offering, promoting or selling financial services or
authorised by us.

However, some firms act without our authorisation and some knowingly run inves

This firm is not authorised by us and is targeting people in the UK. Based upon in
is carrying on regulated activities which require authorisation.

Bealgo (B.A.X. LTD)

15. May 2019 I Investor Warning

The FMA may notify the public by way of publication on the Internet, or i
nationwide circulation that a named natural or legal person is not authori
banking transactions (Article 1 para. 1 BWG), provided that this person h
such action and informing the general public that is proportionate with re
disadvantages for the affected parties.

By publication in the official gazette "Amtsblatt zur Wiener Zeitung" on 1
hereby informs that

Bealgo (B.A.X. LTD)

1113 Sofia City, Sofia Disctrict (Metropolis); Metropolitan Mu

Slatina Region, R.A. Geomilev, 1 Schipchenski proh

Website: www.bealgo.com

E-Mail: support@bealgo.com

is not entitled to carry out banking transactions in Austria that require a licence. The provider is therefore neither permitted to trade on a commercial basis (Article 1 para. 1 no. 7 BWG).

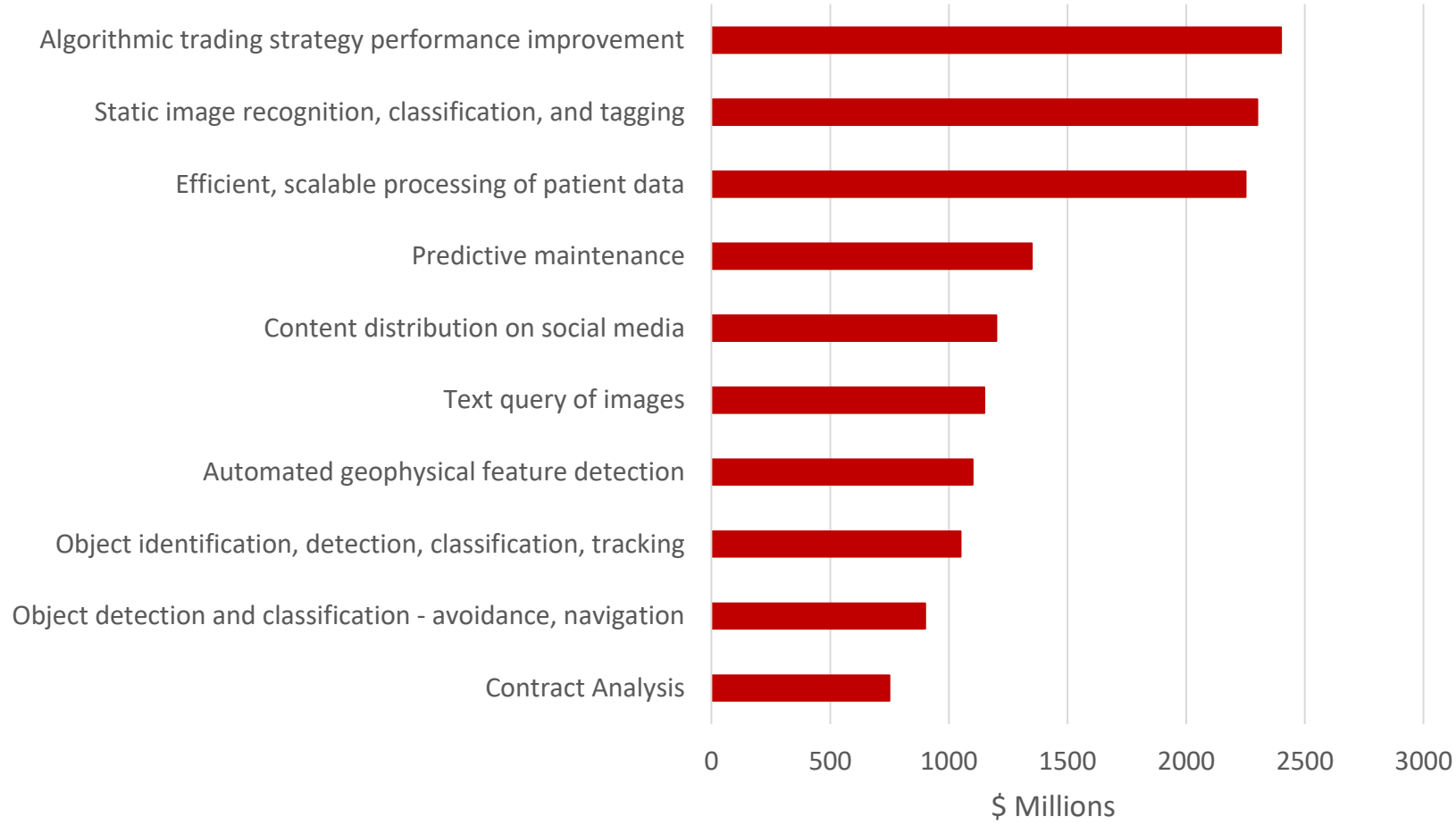
Elon Musk left Tesla, to make way for a new company that he said will change the world's "Automated Trading System"a new redistributive technology and plan the world's wealth. Basically, take the top 0.1% and return to 99.9%.

anarcho-pirate (54) in technology • 2 years ago (edited)

#OpChangeTheWorld2 Elon Musk

Real life ironman - Elon Musk, has just announced that he is about to quit his position in Tesla in order to make room for a new business venture which he believes will change world more than Tesla, SpaceX and Solar City ever could. His new venture is an Automated Trading System and, although he didn't come up with the idea, he invested $72 Million in it which allowed him to control all of the Automated Trading System decisions.

AI TOP TEN USE CASES 2025 [*Source: Tractica Research*]



ALGORITHMIC TRADING

Definition: *Algorithmic trading* is a method of executing orders using automated pre-programmed trading instructions […].

Almost needless to say, algorithmic trading is a perfect “playground” for **artificial intelligence (AI) / machine learning (ML) algorithms**.

— SCAMS ASIDE—WHY AREN'T WE ALL RICH?

(1) Financial markets are extremely difficult to predict.

(2) Not everybody can win.

AI Hedge Funds Got Crushed the Worst Ever During Selloff: Machines Learned the Wrong Things in One-Way Market

by Wolf Richter • Mar 12, 2018 • 39 Comments • Email to a friend

But Cryptocurrency hedge funds fell off a cliff.

Artificial intelligence and machine learning are everywhere, in your smartphone, when you're on Amazon or Netflix where they decide what you might be interested in next, in online advertising to determine what ads you'll see…. They're in ordinary devices that adjust to your preferences, and billions of dollars get poured into it every year because this is the next Holy Grail that's going to revolutionize the way we live.

ML IN FINANCE ≠ ML IN OTHER DOMAINS (1/2)

EVEN IF YOUR BACKTEST IS FLAWLESS, IT IS PROBABLY WRONG

Section heading in *Advances in Financial Machine Learning* by M. Lopez de Prado (Wiley, 2018)

Text book knowledge:

- Data drawn independently from the same distribution
  - performance estimates using test sets or cross validation

Finance:

- Data characteristics change over time (non-stationarity); WTF is independence?
  - Selection of training and test samples/periods is crucial
  - Strong risk to overfit to certain periods or even single “unicorn” trades
- More noise than signal
- Biases / class imbalances (e.g. long bias)

ML IN FINANCE ≠ ML IN OTHER DOMAINS (2/2)

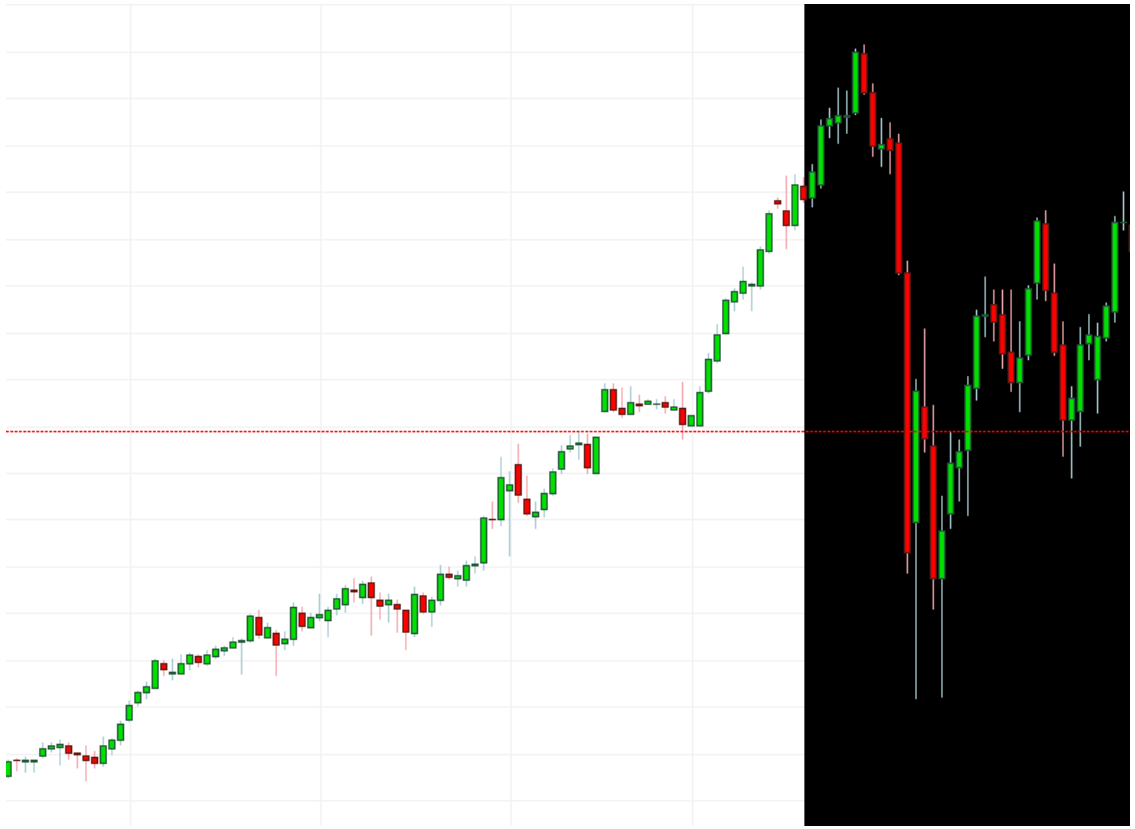
Text book knowledge:

- Repertoire of standard performance measures:
  - Accuracy, area under the ROC curve, cross entropy, mean squared error
- Optimization via gradient descent often possible

Finance:

- Accuracy is pointless! All other traditional measures are of limited value, too.
- True objectives: return, Sharpe ratio
  - Based on discrete buy/sell signals → not differentiable

GUESS!



ML IN FINANCE: OFTEN APPLIED NAIVELY

- To have better-than-random predictions is not the solution, but only a start!
  The reasons are:
  - Limited liquidity
  - Trading costs
  - Slippage
  - Market impact
- To devise a successful trading strategy often ignores the above points. Additional issues that have to be taken into account are:
  - Allocation
  - Risk management
  - Non-stationary market behavior vs. limited data

WHY AM I TELLING YOU THIS?

(1) I once was a victim of believing that machine learning can give you a quick win.

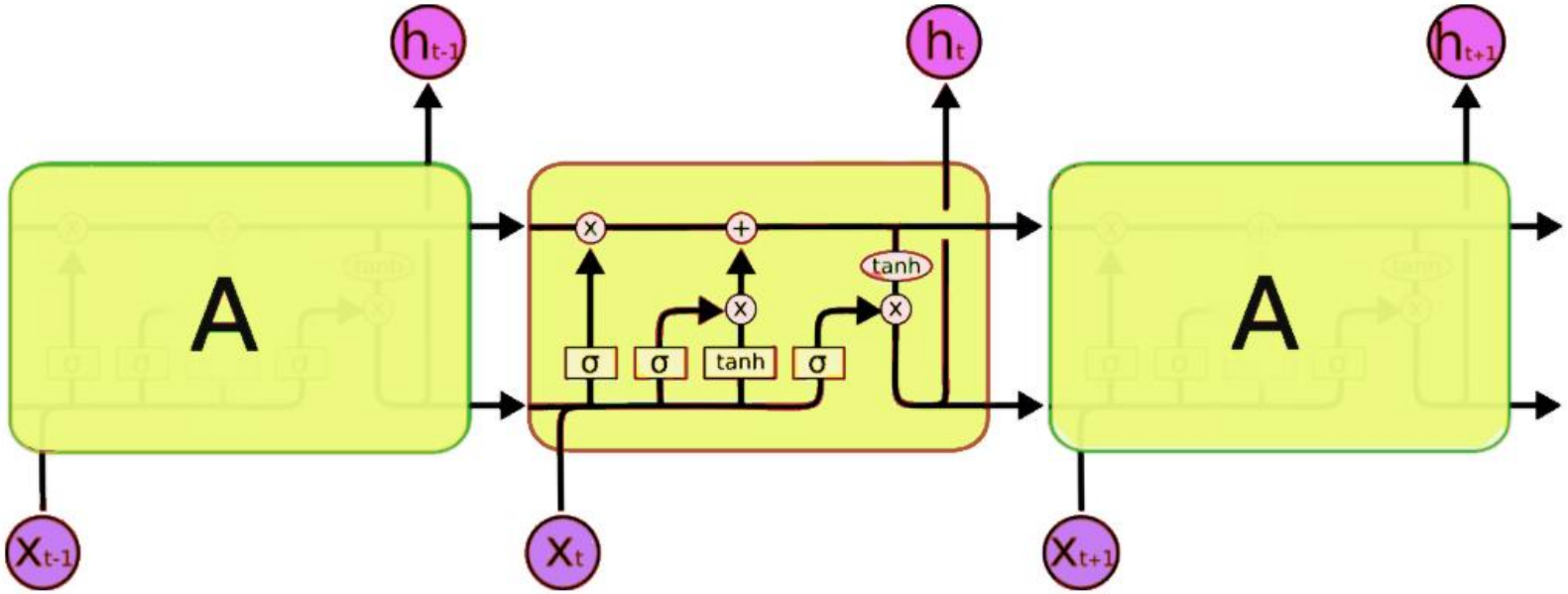
(2) We (colleagues at QUOMATIC.AI and me), however, managed to develop and implement a successful system.

GENERAL APPROACH

- Use market sentiment from various sources
- Use ensembles of recurrent neural networks (LSTM) for short-term price predictions; hyperparameter selection: random search
- Employ custom trading strategy that exploits prediction signals
- Optimize parameters of trading strategy using stochastic optimization
- Continuous re-evaluation and re-training of system

- Implementation of training pipeline and signal generation system in R with Keras/TensorFlow

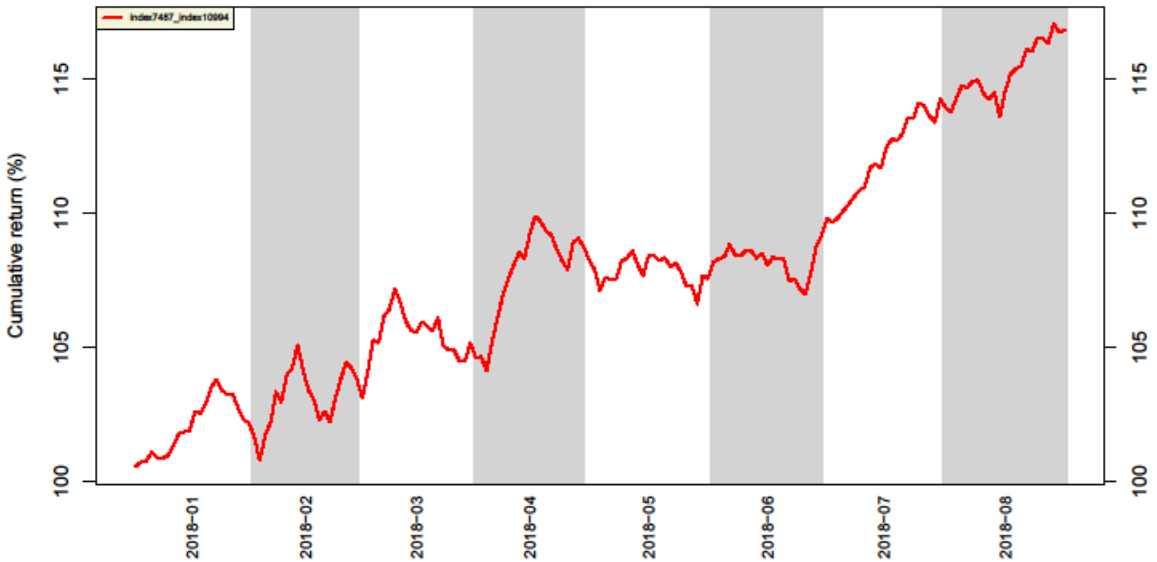

LONG SHORT-TERM MEMORY [Hochreiter & Schmidhuber, 1997]

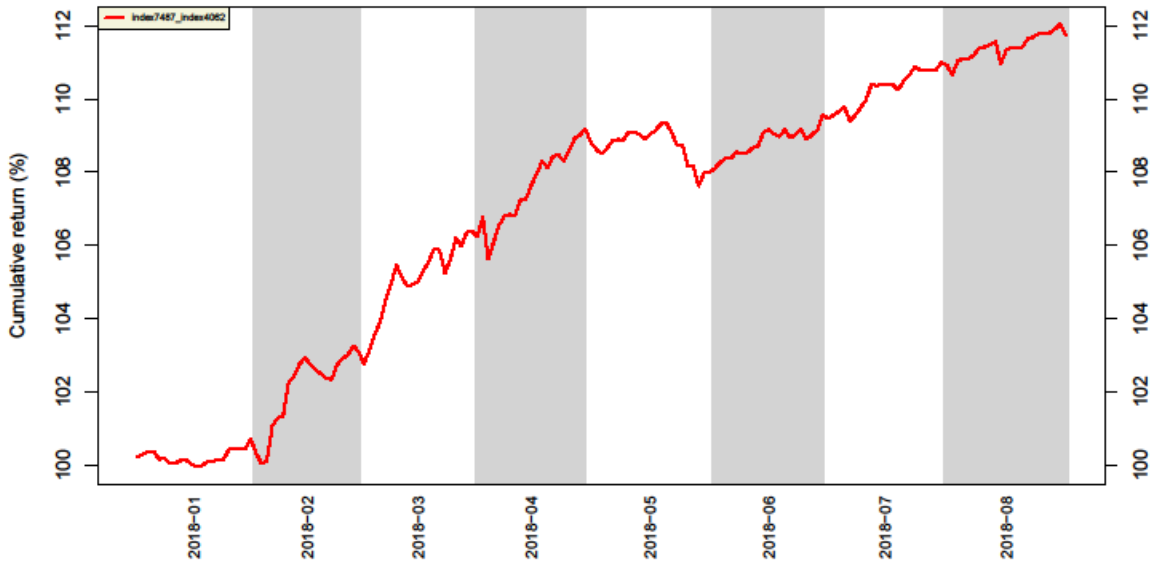


SPECIAL TRICKS

- Moving window aggregates (15-60 min.) evaluated minute-wise
- Use multiple time series of correlated instruments and commodities
- Train models specifically for different levels of volatility
- Proper normalization of data
- Symmetrize data to avoid long bias
- For judging predictions, optimize for ROC-AUC
- Simulate transactions
- Take trading costs into account
- Apply explicit risk/money management
- Meta-selector that chooses models according to previous (hypothetical performance)

EXAMPLES


index7487_index10994
Cumulative return (%)
100
105
110
115
2018-01
2018-02
2018-03
2018-04
2018-05
2018-06
2018-07
2018-08


index7487_index4062
Cumulative return (%)
100
102
104
106
108
110
112
2018-01
2018-02
2018-03
2018-04
2018-05
2018-06
2018-07
2018-08

CONCLUDING REMARKS (1/2)

- ML in finance is highly challenging, but can be successful.
- ML textbook knowledge cannot be used naively in finance.
- To overcome this domain gap, seamless integration of finance and ML competences is mandatory!

CONCLUDING REMARKS (2/2)

- Avoid shark ponds (like day-trading) — better watch out for niches!
- Since AI/ML is heavily used now, there is no advantage of applying AI/ML per se anymore!
- Predictive patterns utilizing market inefficiencies quickly become void as soon as competing market participants use them too.
- However, the crucial advantage is — and has always been — to know more and to be faster than competitors, regardless of whether AI/ML is involved!

ADVANCED SALES ANALYTICS WITH *AI*

Use cases:

- Recommendations
- Guided selling
- Demand forecasting
- Churn Prediction
- **Lead scoring = prediction if lead will turn into customer**
- **Opportunity scoring = prediction if quote will turn into an order**

Definition:
OPPORTUNITY = Business opportunity = **offer/quote**

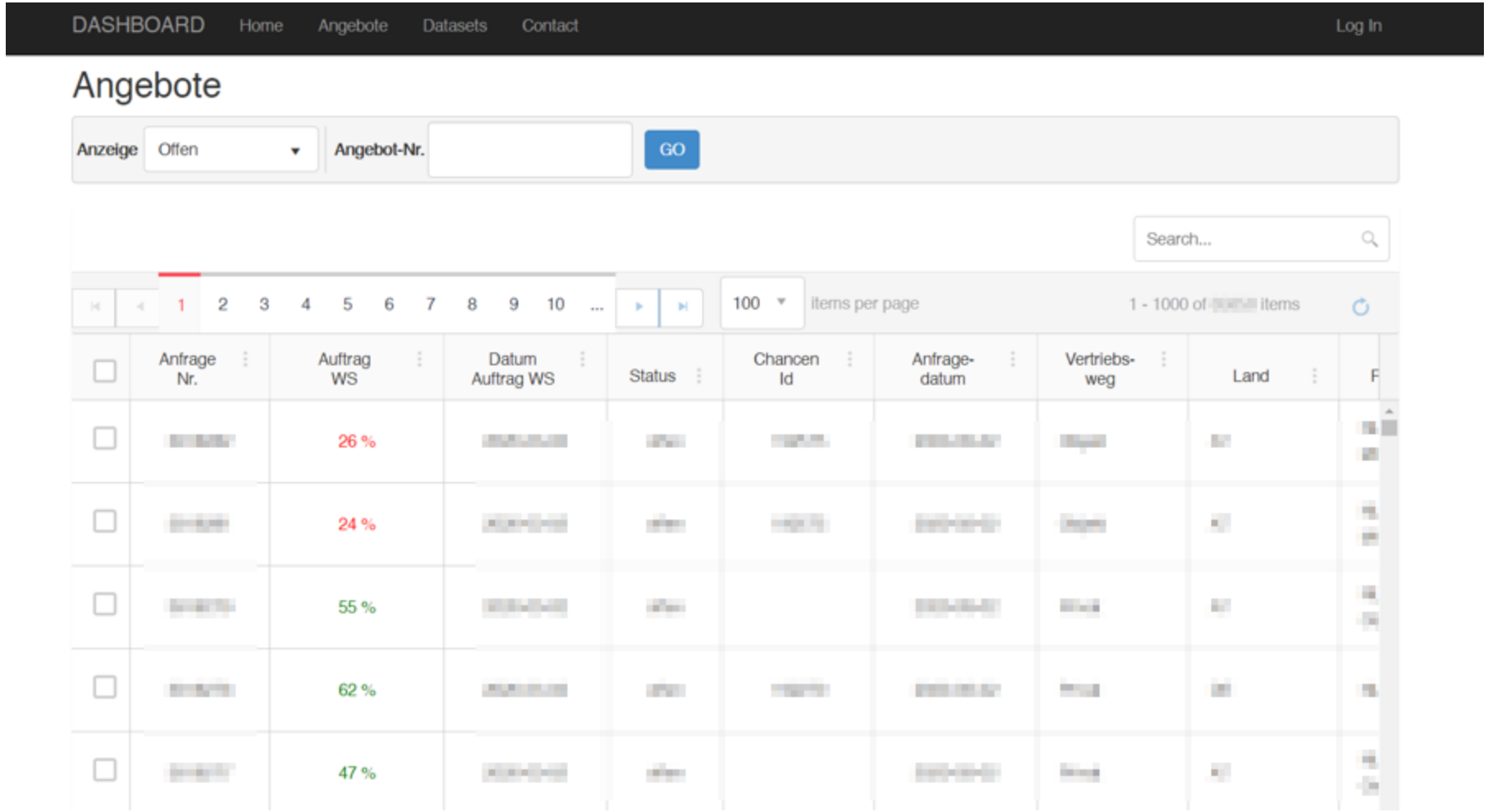
OPPORTUNITY SCORING WITH *AI*

- Many vendors/service providers offer their goods/services in a strongly individualized manner.
- Quotes can be **diverse and complex**.
- Many vendors/service providers have **large volumes of data** from previous years.

→ Prediction model for probability that a quote turns into an order

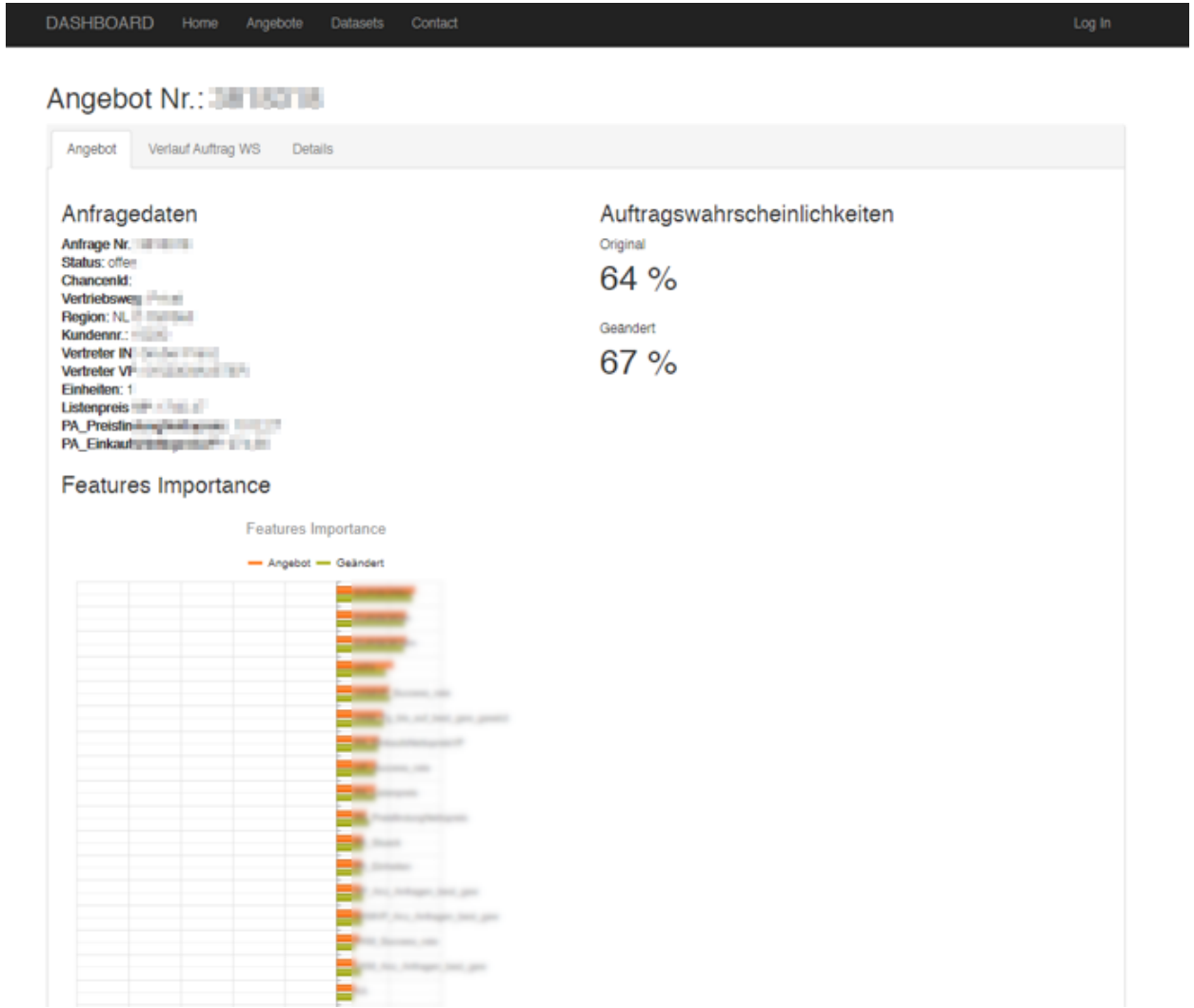
→ Identification of relevant parameters

OPPORTUNITY SCORING



OPPORTUNITY SCORING

1. **Influence diagram:** analysis of pos./neg. influences on order probability
2. **What-if analysis:** how do changes in the offer change the order probability?



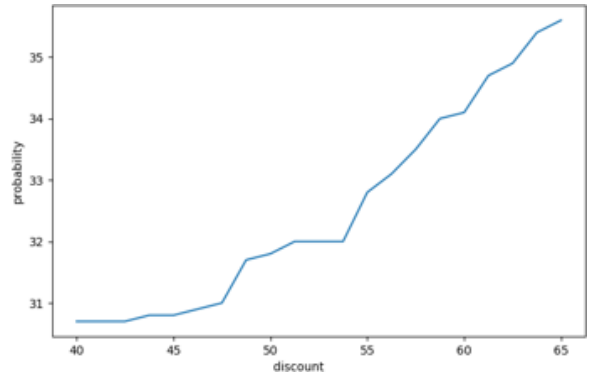
WHEN IS THIS APPROACH APPLICABLE?

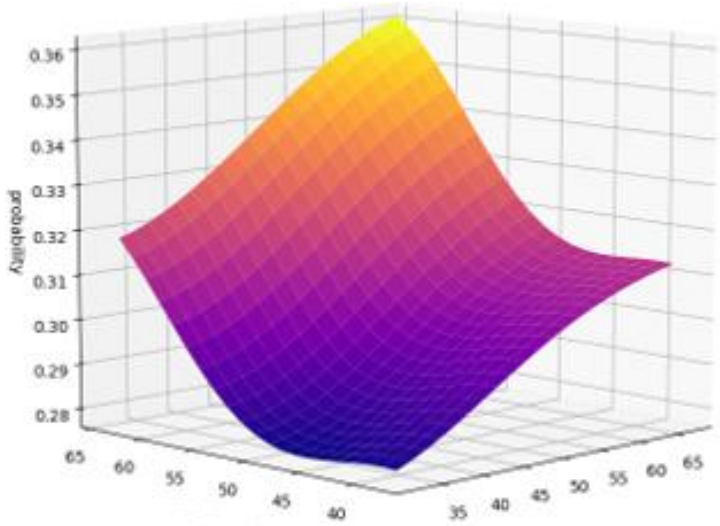
1. **Sufficient data** about quotes in the past.
2. It is known (and electronically available) **which quotes have been successful**.
3. **Sufficient variability** of quotes
4. Mapping of quotes into a structurized, **tabular data format** is possible.

VISION — QUOTE OPTIMIZATION

- Identify influences
  → **CONTROL influences**

- Examples:
  - Targeted campaigns
  - **Dynamic pricing**





QUOMATIC.AI — USPs

- Newest AI methods
- „**Explainable** AI“
- Highly precise models
- **Seemless integration** of solutions into customers‘ systems
- **Continuously learning systems**

- Rapid deployment using salesmatic suite