WEALTHTECH

AND A VISION FOR THE

FUTURE OF A.I.

APPLICATIONS OF MACHINE LEARNING INSIDE A PRUDENT INVESTMENT PROCESS

GRAVITY INVESTMENTS

PORTFOLIO RE-OPTIMIZATION

Artificial Intelligence is only beginning to disrupt the investment management industry. Our industry is behind. The top companies in the world now (top six U.S. listed by market cap) are among the best in commercializing A.I. In fact, Google and Facebook is now following an A.I first strategy.

Google

Apple

amazon

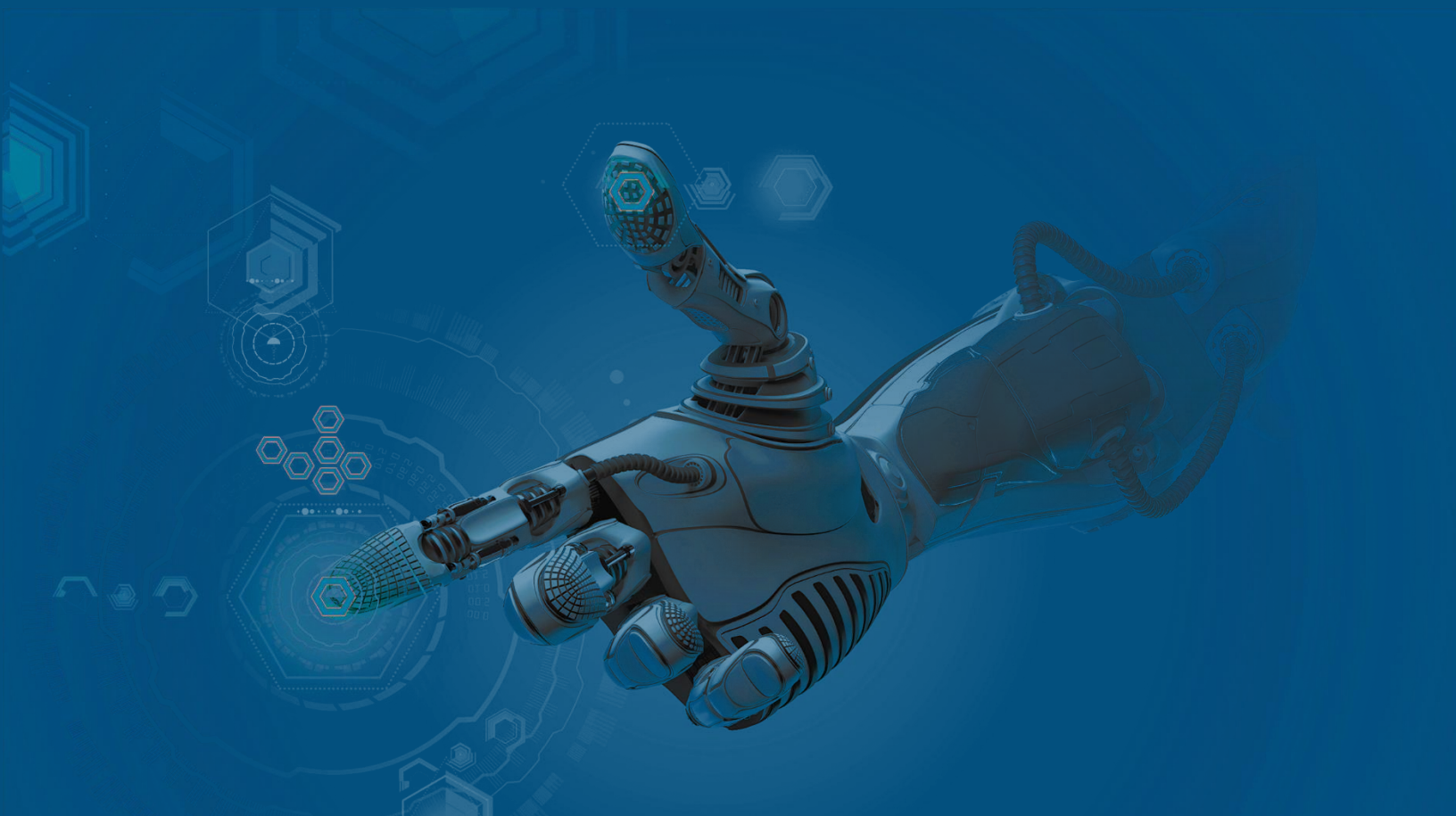
Alibaba.com

facebook.

Microsoft

But in the wealth management industry A.I. seems to be kept a secret. Its insights hoarded by giant hedge funds like Renaissance technologies, AQR, D.E Shaw, Bridgewater, Two Sigma, WorldQuant and Citadel, while charging investors performance fees and management fees that are the envy of all wealth managers.

Traditional financial institutions need to up their game. Investors deserve to be on more equal footing. Democratization of the Wall Street elite is coming. A.I. can make it happen.

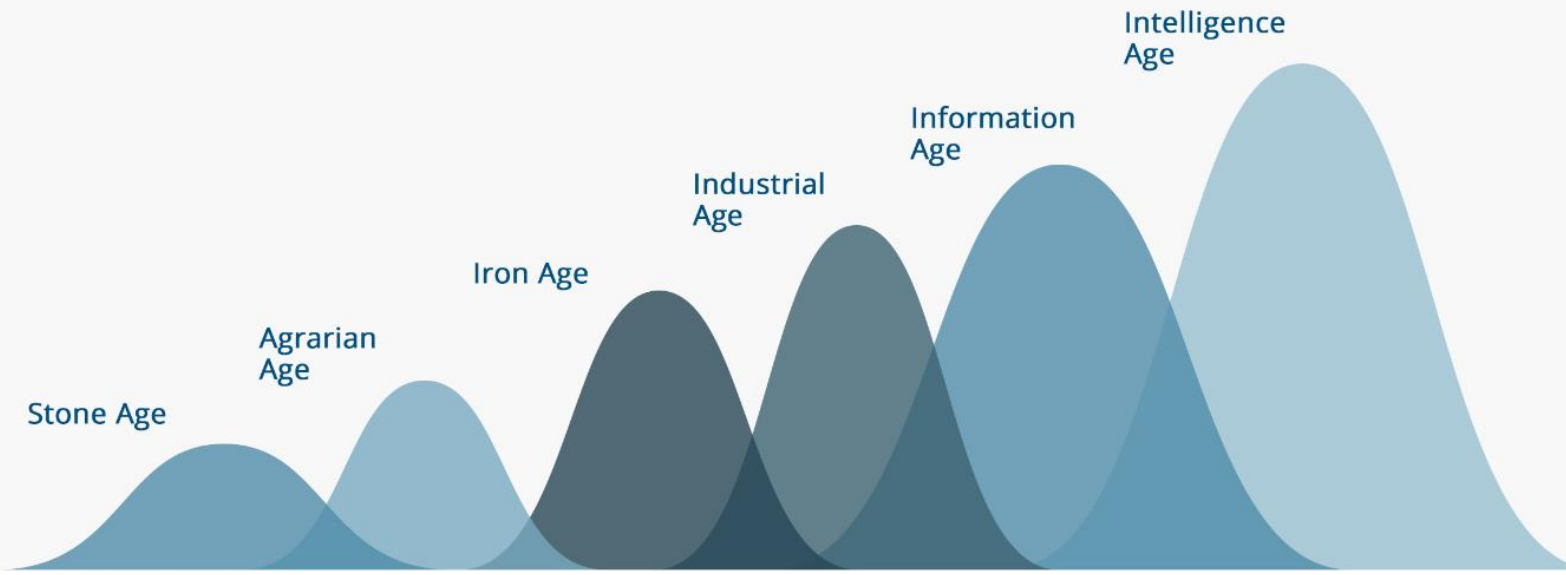


Here are a few facts to keep in mind:

- **The Amount of data created in the last 2 years exceeds the previous history of the human race and the growth of data is accelerating.** [1]
- **Growth in smart phones, connected devices, internet users, time on line and data collection practices fuel the data growth.**
- **Barely over half of the world is online in 2018.**[1]
- **There are now over two billion websites and have growth at 30% CAGR for 30 years.**[2]
- **Even after 50 years of Moore's law, it is still intact: computing power doubles every two years for the same cost.**
- **Now less than 0.5% of all data is ever analyzed and used.**[1]

This last point may be the pivotal point society is now turning on. The Information Age may be beginning to yield to the Age of Intelligence.

Ages of Civilization



That table is set. Data is pervasive, accessible, digital, indexable, organized and searchable. Seekers of intelligence can usually get answers to knowable questions in a few seconds from most anywhere on the planet. Artificial Intelligence does not have a monopoly on intelligence, but it works fast and cheap.

Artificial intelligence means very different things to people inside the financial services field as compared to people inside the field of data science. A.I insiders think of artificial intelligence as one or more of a few dozen different types of learning algorithms. There is no mystery.

People outside of the computer science and data science fields seem to always think of artificial intelligence based on what the Insiders would call strong A.I.; an artificial general intelligence or superintelligence. This is the glorified and fascinating topic where machine-based intelligence could become virtually if not actually sentient or conscious. We are not aware of evidence that it exists yet, but we believe it will.

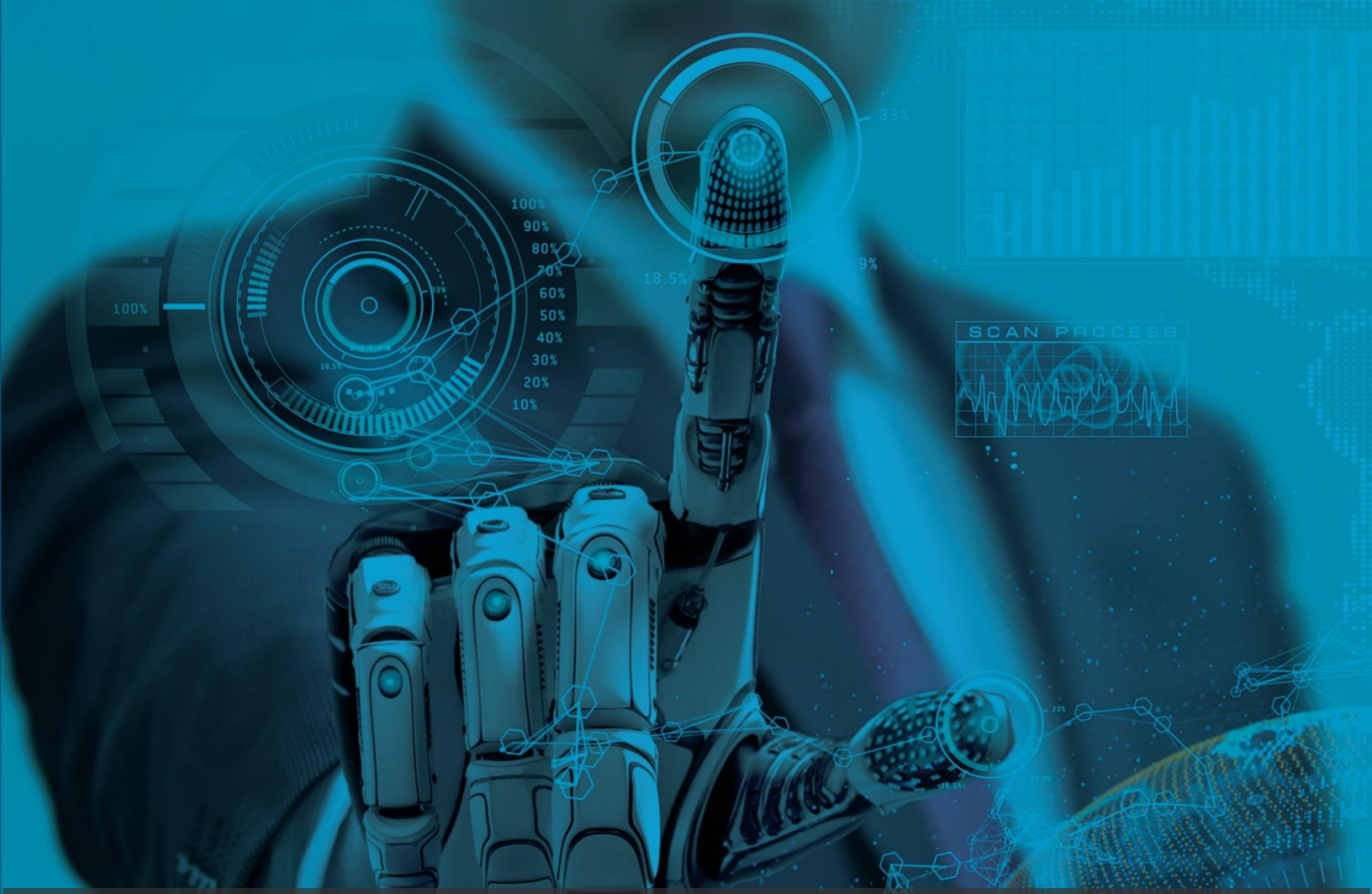
Whether it is Skynet, a virtual assistant, Strong A.I. has captured the public's imagination. Naturally, as investors, we prefer the scene from Transcendence where Johnny Depp's character becomes sentient within the machine and among his first impulses is to play the stock market. What does he want? More data! More processing power! Sounds familiar.

At Gravity we've been involved in artificial intelligence since our beginning in 2000. I think we are starting to get it.

What does strong A.I. has to do with the future of finance? Maybe robots battle it out in a quest to extract Alpha.

Market inefficiencies exist to be exploited. I do not believe in the efficient market hypothesis. A.I will help nudge the markets in that direction. Strong AI can mine arbitrage excess profits from the market for decades. Suppose the presence of widespread and available A.I. yielding superior performance, investors will still be slow to change. This can fuel sustained outperformance. Do you think John Bogle will suddenly decide that Vanguard has it all wrong and he goes whole hog on A.I? Probably not.

At Gravity, we've applied machine learning techniques from the very beginning. Not because it was cool, we had to. As Gravity Founder, James Damschroder recalls, “We were caught by the curse of dimensionality, where the complexity of problems explodes with the size of the data. I had just modeled the core algorithm of Diversification Optimization™ and then needed to solve that problem. I could solve it with Microsoft Excel’s built in solver but only with 10 or less assets in the portfolio. To make a commercially viable optimizer I needed something that could scale. I tried a dozen different routines and began to think I quit my program trading job too soon when all these traditional optimization methodologies failed.”



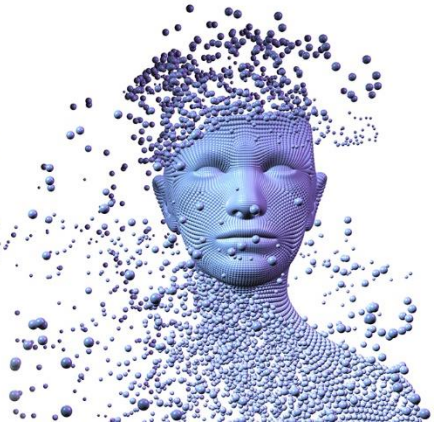
"I was fortunate to discover genetic algorithms.

Genetic algorithms form the core of our portfolio modeling approach and enable www.gsphere.net users to visualize, measure and optimize portfolio diversification. We create smart geometric explanations of the portfolios and the smart geometry induces the asset allocation.

I realized then that these A.I. techniques needed to be part of my skill set as a quantitative portfolio engineer and I have stayed active in the space ever since.

Too many times I've seen data scientists have the attitude, "have data will A.I.". This scares me. A data-driven machine learning application has extra risks of overfitting, bias and mis-modeling. These tools are best handled with people having the domain skills. Let's have the portfolio manager drive the machine learning application. Portfolio managers will have to extend their skills and tech companies need to continue to become easier to use."

Types of AI Algorithms used in finance



1 **Genetic algorithms** are just one of many machine learning algorithms we use in investment management. It is based on developing genomes which are typically trial solutions, Genomes combine, repropagate and mutate as they descend various generations, each successive generation yielding more accurate solutions until the optimal is found or the algo is terminated. We use this to take a high dimensional correlation matrix then reduce and transpose that matrix to solve for a coordinate set that best explains the portfolio. You can learn more about that here **http://gravityinvestments.com/diversification-weighted-performance/**

2 **Random forests** A promising technique that uses regression trees to find combinations of data features where the combinations proved to be more useful than the individual features. This has promise because working with individual features is too difficult to generally produce sustained Alpha. For example, if you only invested in low price to earnings companies, you might think that you're getting great value and thus setting the table for better future returns. But price to earnings ratio themselves are not meaningful because usually there's a very good reason why the market values the company cheaply. With random forests we can see that companies with low price to earnings ratio shows which also have growing revenues and low debt ratios provide a higher probability of delivering greater returns.

3 **Neural networks:** Probably the most popular tool, used to find relationships and using those relationships to make predictions. These are usually turned loose on databases of fundamentals, stock prices and economic indicators. Now too, contextual sentiment data from social media and directly from the companies can provide a trading edge. Mining these data sets in this way is the majority of A.I in investment today. We are a few generations deep with these tools.

4 **Reinforcement Learning:** This is not prevalent in finance yet. But we think it will be. Have you seen those videos where the computer teaches itself to play old video games? That's reinforcement learning: Mushrooms and coins are good, crashing is bad, and lives are a constrained resource. If you have not seen it check out this video here https://www.youtube.com/watch?v=qv6UVOQ0F44. Astute observers may say that the program author says he used genetic algorithms to evolve a neural network. Bingo! In this case the Reinforcement learning is built using other machine learning methods as sub routines. This is also getting popular in the self-driving car space.

What a great analogy for investments!

//Profitable investment good, losing investment bad, money is a constrained resource. Execute program//.

OK. Maybe it is a little more complicated, but the natural feedback of investment performance and performance versus indices or benchmarks is perfectly suited for strategy optimization with reinforcement learning. This is our strategy for investment process step # 7 (see below in report)

Ray Kurzweil, the futurist and author of the New York Times bestseller The Singularity Is Near, is an influential technological visionary. He has a newer book called, How to Create a Mind, in it he takes this exploration to the next step: reverse-engineering the brain to understand precisely how it works, then applying that knowledge to create vastly intelligent machines. Here is his Ted talk: https://www.youtube.com/watch?v=RIkxVci-R4k

This is the book excerpt from amazon.com…

"Drawing on the most recent neuroscience research, his own research and inventions in artificial intelligence, and compelling thought experiments, he describes his new theory of how the neocortex (the thinking part of the brain) works: as a ***self-organizing hierarchical system of pattern recognizers****. Kurzweil shows how these insights will enable us to greatly extend the powers of our own mind and provides a road map for the creation of super-intelligence—humankind's most exciting next venture. We are now at the dawn of an era of radical possibilities in which merging with our technology will enable us to effectively address the world's grand challenges."*

Emphasis to this point:

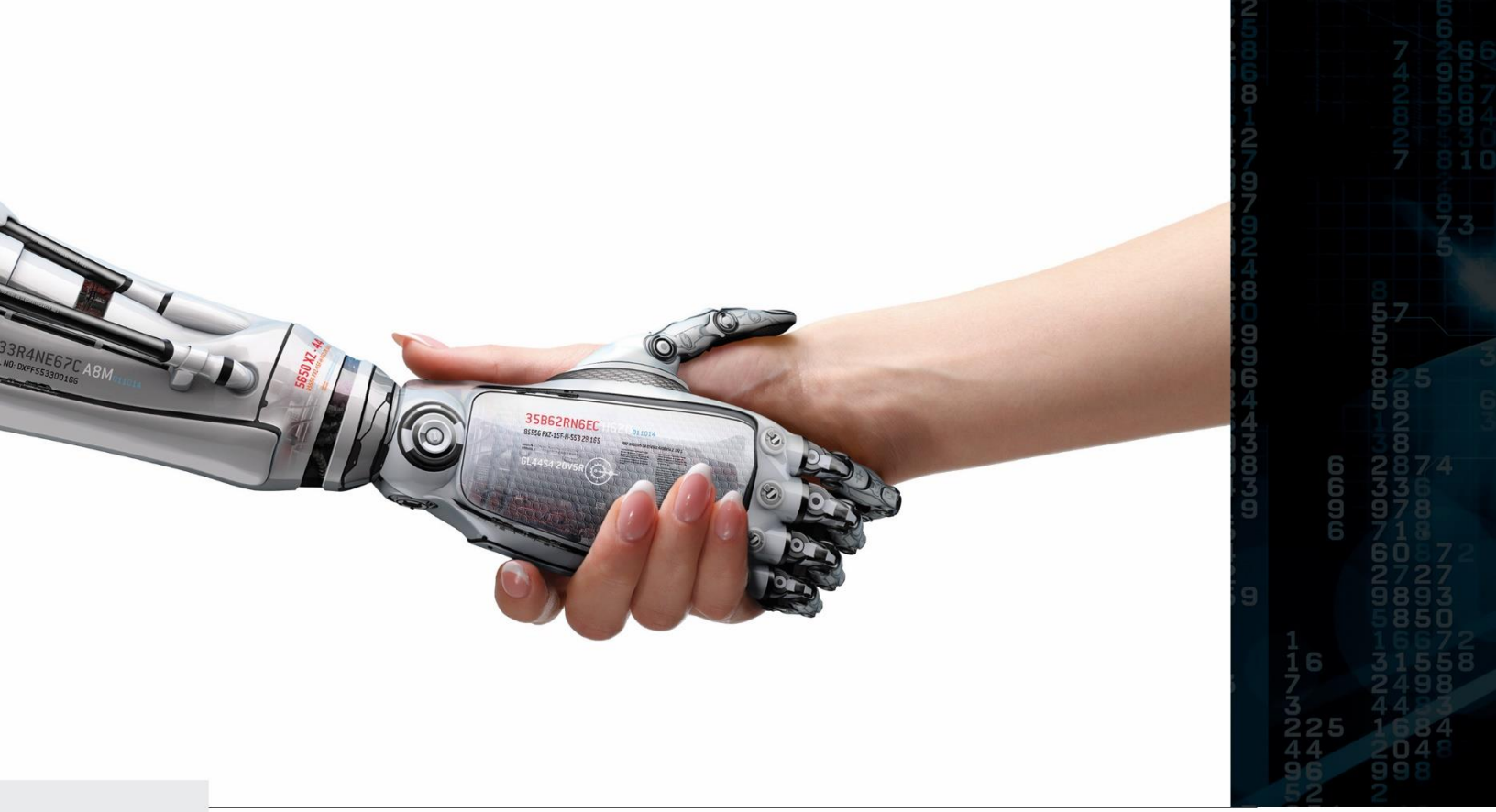
"self-organizing hierarchical system of pattern recognizers."

If our intelligence is self-organizing hierarchical system of pattern recognizers, then shouldn't good Artificial Intelligence be the same thing?

This is not the musings of an eccentric visionary. Giant chip manufacturers including Intel and IBM are rushing to roll out a new CPU architecture called Neomorphic Chips. Why? Because a better hardware reproduction of the way the human brain works may be the next step in the evolution of computing, an advancement perhaps comparable to transistors going from vacuum tubes, to printed circuitry and then again to silicon wafers.

A.I. is not a magic bullet. It is fastidiously programmed. Thoughtfully layering in multiple techniques (pattern recognizers) as part of an investment process and then governing that process (self-organizing) may deliver on the promise of A.I. It is the approach my company www.gravityinvestments.com is taking.

These days we have expanded our digital advice platform to embed our optimization within a robust rules engine. We've created a powerful portfolio backtesting engine that any investment professional can use, without knowing any programming that allows for combinations of the portfolio management process to be tested, and once the user is satisfied, we can provide Robo advisory services to fully automate the execution of these portfolio strategies.



The combination of the intuitive rules engine with the optimization engine allows for portfolio managers and analysts to test different combinations of rules.

For Gravity, we see these combinations of rules as the next big advancement in our use of machine learning.

In our system a portfolio manager could probably create a new strategy back test every 10 minutes. Let's say we have 50 different rules which govern the portfolio construction, not including security selection. Let's say that with 50 rules and each rule applied independently, this gives us 50 factorial combinations of rules. That's a 3 with 64 zeros behind it. Finding the optimal combinations is impossible for a human. Here is a strong case to reap the rewards of machine learning.

Fiduciaries need to be well diversified. Diversification offers a straight path to risk reduction and consequently greater returns. So, I offer no conversation about popular A.I applications like trading systems, options pricing, fraud detection or high frequency trading. Our focus is clear:

How can Artificial Intelligence assist a simple Prudent Investment Process?

Every Investor should have an Investment Policy Statement and follow the investment process which it induces. Additional fiduciary regulations are probably still coming. In this light, a systemic, repeatable and documented process is a good for everyone. We follow this approach in Gsphere, but there are ways we plan to improve with more A.I. As you can see, narrow A.I can assist in various ways at each step.

A prudent investment management process contains several steps and we show how artificial intelligence can assist throughout the process:

1 Risk Profiling and Investor Customization

Risk profiles are often based on a questionnaire. Many of these can provide unintended results. For example, when asking the investor about their willingness to take risk, does the investor think risk mean losing money, does the investor associate risk with positive returns or negative returns? Does the behavioral archetype of the investor suit her strategy? Connecting the advice platform to her banking and spending accounts could help pattern match investors and strategies. The consequences of failure on this point often result in abandoning the strategy at an inopportune time. Because the strategy adapts to the investor, she can expect a lifelong relationship with her invest-o-bot.

In Gsphere, we combine diversification with a utility metric to optimize the portfolio. We think investor utility extends far beyond risk and return. We include income, diversification, consistency, capital preservation, and market exposure as alternative objectives that investors may prioritize to better quantify utility. A smarter optimization target is a more efficient portfolio. A smart, machine-based agent could be trained to determine the derivation of any investor's utility by gathering the investor's financial planning, social and account data. The smart agent together with cloud-based API's and a little automation can keep the investor on their personal, optimal track.

2 Idea Generation

Ideas can come from anywhere. Humans are great idea generators, but machine learning is closing the gap. Algorithms that analyze economic and fundamental data as well as semantic information from the company's online presence are capable of Alpha production. Investors have poured billions into strategies focused on A.I. based stock selection. Imagine a self-learning stock screener!

3 Security Forecasting

With attractive Investments sourced, we need to quantify the opportunities for these Investment ideas. Quantification can go far beyond quantifying simply just the expected return. Some of this can be reasonably estimated from historical data, the least of which is typically the return. Here the opportunity for neural networks, random forest algorithms, support vector machines and the like can gain a material edge to the investment process.

Same thing with measuring risk. Rather than a simple standard deviation, risk for a position can be better estimated using pattern recognition of past companies having been recognized to match the fundamental, social and economic profile.

4 Portfolio Optimization

Our genetic algorithm creates a geometric model, which determines the efficient assets, discards any inefficient assets and assembles the portfolio to create the optimal balance of diversification, risk and return or other measures of investor utility.

5 Execution and Trading

Here, using time and price data together, a portfolio manager can evaluate the effectiveness of trading orders of their execution strategy and evolve that strategy to best serve the investor.

6 Monitoring and Risk Management

With the portfolio built and executed, the work is not done, it is just beginning. Machine learning algorithms can monitor the performance of the assets versus expectations considering the market conditions. Using machine-learning classification techniques applied to historical price data, we can adjust our estimations, take profits, cut losses and consider replacement candidates.

State classifiers can monitor the economic conditions and adapt the portfolio accordingly. Is inflation picking up? Perhaps energy stocks are resampled with data from the last inflation cycle. Is the market treading water? The system can shorten the re-optimization interval to enable greater volatility capture.

Portfolio rebalancing seems to be a strong candidate for A.I. based improvements. Portfolio rebalancing provides us a consistent way to help the performance of portfolios. But it's dumb. We're going to give it intelligence. Machine learning algorithms can classify whether the variation in the assets' relative weight is a function of random noise and variance and thus a strong candidate to be rebalanced, or if the deviation is non-random, predictive and diminishes our interest in rebalancing that that security.

7 Investment Process Evaluation and Evolution

Imagine if a super intelligent system was the user of the system that manages the first 6 steps in the process. Each of those steps benefiting from narrow application of A.I. Now this A.I. bot super user is programmed with a more expansive mission. It is self- learning.

At Gravity we are pioneering portfolio re-optimization. This means that this investment process happens repeatedly; over and over again. Repeatable processes lend themselves to evolutionary dynamics. Portfolio performance and expectation convergence can easily be measured as an objective evaluation metric for judging the various policies used to create the strategy. This is powerful with enough time to accumulate data, but with this learning system applied across all portfolios and all strategies, strategies can learn from one another. Investment policy offering more favorable outcomes may be automatically recommended to similar investors.

Assume a profile of a one-billion-dollar wealth management firm. With industry average clients and fully-customized investment strategies, this firm could be running 13,333 unique strategies. The strategies are, of course, automated and fully documented. Now think of 13,333 machine bot advisors, each representing one single investor, learning from the other 13,333. Each advisor bot has perfect knowledge of the assets, rules, policies, objectives and performance of all the other strategies. **It is the ultimate investment committee!**

In this way, the entire portfolio strategy is continually optimized and evolved, adapting not just to changing market and regulatory conditions, changing investor preferences, changing company's financials and fundamentals, but also the very evolution of our platform itself.

We think this touches on an overlooked aspect of diversification. If you recall that diversification is a technique to reduce risk; we typically think about diversification only from an investments and allocation perspective, but what about diversification of the investment process itself? We have seen several reasonably well-designed portfolio strategies be totally corrupted with some homogenizing factor. In this vision, we apply numerous machine learning techniques to complementary parts of the investment process each seeking to gain an independent advantage. It might not be as sexy as Ex Machina's beautiful robots, and it sure won't pass a Turing test; but this vision of a practical, systematic, holistic A.I. assisted investment strategy will serve investors well for decades to come. We are betting on it.

What about sales and marketing?

It is said that financial services are sold not bought. But who's to say the Bots can't do the selling?

Maybe data scientists will not train computers with Zig Ziglar's top 12 closing techniques. But what about anticipating the investors needs and providing a timely solution or offer. If you don't think digital advice platforms are taking over wealth management then you have not sufficiently contemplated this.

Good A.I. is often invisible to the users of the system. This is definitely the case for personal finance. When the portfolio strategy is properly connected to other aspects of the investors life, financial institutions can improve service using pattern recognition at a recommendation engine in a number of ways. Does the bank show that the direct deposits are coming from a new source? Does the investor have a new job? The machine says, yes. It sends a text message to the investor letting them know that we have already adopted their asset allocation to diversify their income source in your new industry.

Is money in their primary transaction account running low? Have there been extraordinary expenses?

Financial institutions could automatically trigger liquidity requests where the portfolio automatically sells those positions offering the least utility given the very latest in the adapted assumptions.

Has a Liquidity event, inheritance, lottery proceeds, social media sentiment or other change in the investors situation precipitated a recommendation?

Maybe the change in circumstance should require a change in the investor objectives. Strategy simulations for the new dynamic hedging policy, show favorable results when applied to the investors custom strategy. The results are automatically sent to the investor. This time it requires their approval because the dynamic hedging policy costs an extra 20 basis points.

Has the most recent financial data reported through the account aggregation system potentially changed the status of the investor to that of an accredited investor?

A Congratulations is in order! A.I. is an education about the new product opportunities now available. Click here and we will email you the research and a comparison report on the impact of our investment committee's top manager selections integrated into your existing strategy.

Does the investor need a second opinion?

Click here to access your custom investment policy statement. Is there something in the IPS which needs to be changed? No problem; it is Interactive! Make your updates, we will automatically propagate your changes, recompile the strategy and send you a notice for authorization.

Thanks for reading about my vision for A.I. investment technology. What do you think? Drop me a note.

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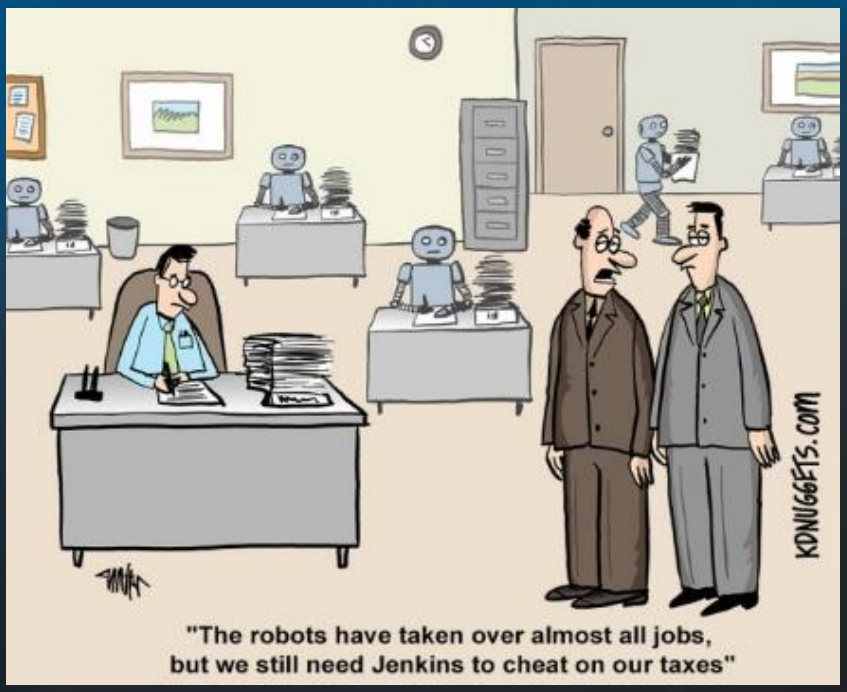
James Damschroder is the founder of Gravity Investments, a portfolio ReOptimization company. Since 2000, James has lead the growth and development of the platform with the fortune of designing a new model of investments from the ground up. That model sprouted a rules engine and now as a digital advice platform can diagnose, optimize, backtest and automate most any strategy. His patents for diversification measurement, optimization and visualization are leading the science of diversification out of the stone ages. James has been in fintech for two decades where he straddles the line between investments and technology. Before his fintech startup James was a program trader, investment advisor and one of about 3 people who brought a suitcase to work on the floor at the Chicago Mercantile Exchange.



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