# HOW ALGORITHMS SHAPE OUR WORLD

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For most climbers, reaching the peak of a 7000 meter summit would be the climax. For Michael Najjar, that's only where the picture begins. Najjar took some of the photos for his *high altitude* series in the Argentinian Andes: grand peak mountains in the storied history of the photographic landscape. But the raw photographs were just the beginning. Najjar shaped the mountains with digital tools, mapping the vicissitudes of the Dow Jones and other stock market indices onto the visible terrain. The apex on the upper right indexes the peak just preceding the Financial Crisis of 2008. We live in the deep valley that follows it, or somewhere just nearby. This is art, of course, this is metaphor. But it's a metaphor with teeth.

If something could speak through those teeth, it would speak of math. It would speak of the math we've unleashed on the world. It would say that mathematics were once a natural resource. They were what we extracted and derived from the world. There is a long period in human history in which math was what we discovered, not what we made.

In Najjar's work, we see fabricated evidence that reveals this seismic shift.
To investigate this change, we must consider a specific aspect of math: the algorithm. For now, let's just say that algorithms are the type of math that computers use to make decisions. The results of a Google search are an obvious example. We know that they weren't hand-selected by a human. But we know these results were selected somehow. At best, we know that there's some kind of math underneath it. Savvy users are aware that it's Google's PageRank algorithms underneath the hood of their search results. The operations themselves remain opaque, indifferent. Like any other, over time these algorithms acquire the sensibility of truth by the simple force of repetition and human exposure. They become naturalized, they ossify and calcify. They embed themselves into reality, and shape it. But even when you recognize their presence here on earth, it's easy to mistake their territory as being confined to the glowing rectangle of a computer screen. They determine search information, and of course they determine things like pricing information for sites like Amazon. It's an algorithm that decides that a book might cost $10, and guide it up and down in response to variable demand. When an algorithm goes wrong, a book might end up costing $1.7 million dollars. And they go wrong all the time.

In 2010, a book about the genetic profile of houseflies (normally valued at around $15) reached an asking price of over $26 milllion on Amazon. This was an error, but no human error in the conventional sense of the word. It was two algorithms locked in conflict, each escalating the price above the other, with no adult supervision to suggest that $20 would be far more likely to attract a buyer. A $26 million book about flies is benevolent and amusing. No one lost. A human still needed to stand at the end of the process to click, to say yes, I'll take it. Many algorithms, however, are no longer concerned with human input. They are designed to interact with other algorithms, which is exactly why the Amazon price spiked wildly in the first place. It's one thing to cede analysis to an algorithm, and yet another to cede control. What could go wrong?

By most accounts, what could go wrong is that the stock market could lose about 10% of its value in 5 minutes, without anyone ever ordering anything to happen. Without anyone even understanding what happened – even in retrospect. Dubbed "the Crash of 2:45" or "The Flash Crash of 2010," no one knows exactly what the algorithms had in mind. And there's no way to ask all of them, because no one even knows what algorithms are in play. There's no territory in which the loss of control is more frightening than this territory that Najjar has addressed: the stock market. On Wall Street, Algorithmic Trading ("Algo trading") began in the 70s, but really escalated with the domination of the networked computer infrastructure in the 80s and 90s. Last year, over 70% of all trades in the American markets were algo trades. Just like the Amazon bookselling algorithms that produced a $26 million textbook, but no one has to say yes, I'll take it. Humans are too slow. There's an algorithm waiting to answer yes faster than we can read the question.

The image of the market floor filled with traders is defunct; to imagine the market now, imagine the silent and invisible agency of algorithms in conflict, each one looking to get an edge with no human oversight at all. This is 70% of the operating system formerly known as your pension, your mortgage, your life insurance. There on Wall Street, there are some algorithms – Iceberg Algorithms – that are simply seeking to hide in the jungle. These are enormous trades from institutional traders that would disrupt the market they are seeking to trade in if they were to announce themselves at the door. They break themselves up into thousands of tiny trades that appear to be from no-one in particular. It's obviously valuable to identify one of these in action, because an Iceberg gives a clear indication of which way a certain stock is going to go, at least for a little while. So it is that algorithms have emerged to detect algorithms, weaponized and deputized to act when they find one. Among these algo-seeking algorithms, High Frequency Trading Algorithms (HFTs) have emerged to dominate the financial ecosystem.

Several criteria determine the success or failure of HFTs. First, they have to be smart: the algorithm that seeks needs to be smarter than the algorithm that's hiding. Second, they need to be responsive to all the other algorithms that are in the jungle with it. Picture a million rats all trying to get a bite from a single apple: It's not enough just to know where the apple is. The rats that succeed will also know where the other rats are. Thus, third – and perhaps most important – is the ability to detect and act on information just a little faster than the other guy. In the markets, as in war, speed is a weapon. But it's impossible for humans to imagine the temporal scale at which market algorithms operate. Algorithms don't operate at the familiar human temporal indices like hours, minutes or seconds. HFTs live in a world of milliseconds (1/1000th of a second), microseconds (1/1000 of a millisecond) and nanoseconds (1/1000 of a microsecond). Going even deeper into microscopic temporal measurements, picoseconds, femtoseconds, and attoseconds will be meaningful next year, or perhaps a few years later.

To put things in a human perspective, it takes 500,000 microseconds for a human to click a mouse. An HFT can process and act on more information in that single interval than a human might read in their entire life.

The science historian George Dyson has pointed out that computers don't have time so much as sequence. They have a series of operations that they are seeking to complete as quickly as possible, within any boundaries of regulated speed. Those boundaries are the constraints of manufacturing and physics. The rough dynamics of "Moore's Law" mean that chips get faster and faster here in the landscape of human time (integrated circuits will double in performance every 18 months) . But those advantages are easily commoditized. As soon as a faster chipset is available, every algorithm runs on it. The competitive edge lies in the speed at which the algorithm accesses and operates on information in the field. Where humans are still constrained by mouseclicks of 500,000 microseconds, any algorithm that can get information three microseconds quicker can enjoy enormous market advantages.

In this search for speed, financial algorithms return finally to earth. They return to an earth we recognize. This is the planet that Michael Najjar photographed: snow and rock and mountain. Here on earth, algorithms are constrained primarily by the speed at which information travels through fiberoptic cable. Data travels over pipes: in existing fiber composites, this is about 800 million kilometers per hour. That's fast enough for anything a human can possibly imagine, except when a human has to imagine what HFTs have to consider. HFTs have to consider the distribution of the network. This is barely perceptible to human senses. From a human perspective the internet is everywhere – or at least wherever we hang out – and within the landscape of networked architecture, it is more or less evenly distributed. The internet compresses distance to zero; we can skype with China or Argentina and we understand this space to be simultaneous, instant, flat.

This is the planet that Najjar captured in his *netropolis* series (2003 - 2006): the experience of accretion and compression, of a city made of all other cities. This is the fairy tale of our networked world. The cables distribute all of us to all of us, simultaneously, all the time. But then, where it's distributed, the internet isn't distributed evenly. There is still real terrestrial distance between points A and B. Even if information travels at 800 million kilometers per hour, there are still places that it has to travel to, and there's still the distance that it takes to get there. There are vast submarine cables to bring it across oceans, there are deep tunnels to route it through cities. Like a real nervous system, it has specific clusters and points where the nerves concentrate; it's easier for tiny branches to connect if there's one central point to get to. In cities, the most vital points in networks are called "Carrier Hotels," where the major telecommunications networks meet to exchange data directly. Here in New York City, there's one at 60 Hudson Street, but if you're reading this in a city, there's one right near you.

Carrier hotels don't look like much, unless you are an algorithm. But if you are an algorithm, they look like the city's most valuable natural resource: the direct pipe to the network. At 800 million kph, you don't need to do any math to know that if you're 10 city blocks closer to that pipe, that can't possibly add up to much. But if you're an HFT algorithm, the advantage of accessing information two microseconds quicker than another algorithm … those microseconds are the distance between gaining and losing, living and dying. The algorithms have human partners. As partners, we look to gain as many advantages for ourselves as possible, and so we've given weight and priority to carrier hotels, and anywhere else the internet clusters. We see that real estate values spike near network nodes, that urban topography begins to mirror network topology. Algorithms have neighborhoods. In these neighborhoods, architects are modifying buildings near carrier hotels to accommodate racks of internet servers. Servers are heavier than the people who used to work there, so architects run steel through the floors to reinforce them. This adaptation is not merely at the scale of the building or even the scale of the city. Between cities, networks were specifically designed to promote circuitous redundancy, instead of depending on central straight routes that are vulnerable to failure. Thus, if you are an algorithm traveling from the market in NYC to the market in Chicago over pedestrian networks, you're traveling through small towns, winding across railroad tracks and curling around mountains. If you could run a single straight line between those two cities, you could shave off 100 miles along the way. If you're moving at 800 million kph, that would save you three milliseconds every time you exchange data. For financial algorithms, the value of those three milliseconds is incalculable.

To provide that value to the algorithms of New York and Chicago, Jim Barksdale (the former CEO of Netscape) funded a company called Spread Networks. Spread ran a one inch cable across the United States to shave those 100 miles, .003 seconds. On a map, they drew a single straight line between the two cities, and that line was a blueprint for a trench. Using rocksaws and dynamite, Spread blasted through 800 miles of mountains and dirt, all for a one inch pipe to carry information that no human would ever be able to understand. Landscapes being sculpted and reshaped, all for a few algorithms to be able to operate a little faster than the other algorithms they compete with. The Spread Networks trench is only one year old. But it's just the latest iteration of one of America's oldest ideas: Manifest Destiny. If information is empire, if financial markets are empire, they will seek to expand with their own criteria. The terrain between the markets takes time to move through, and time has quantitative value. That space in the middle has negative value, and we will conquer it. There are theories and ideas about how to conquer the oceans, too, to cross the globe and rewire the planet. If you're an algorithm, the future is bright.

And if you simply imagine the world from an algorithm's point of view, and return to Najjar's High Altitude, you see these photos with different eyes. You see these images of the Andian mountains reshaped by the financial markets, and you see that they are no metaphor at all. They are prophecy. Najjar is making pictures of the landscape to come. Mountains shaped by iceberg algos, shifting with real-world seismic effects. Landscape shaped not just by the uneasy collaboration between man and nature, but also by the math we've unleashed on the world. This is a math we have written but can no longer read. It's a math that is no longer derived from nature, but rather one that rewrites nature – as Michael Najjar does.