1   Mary Warner Marien, *Photography—A Cultural History* (London: Laurence King, 2006), 44–45.
2   Higher-resolution images are available to state agencies, but the regulation limiting the resolution of publicly available images was set so that they would not register the human body. Conversation with Lars Bromley (UN satellite image analyst), January 28, 2013. See also the Land Remote Sensing Policy,1992, available at http://geo.arc.nasa.gov/sge/landsat /15USCch82.html, last accessed December 2013.
3   Andrew Herscher, "Envisioning Exception, Satellite Imagery, Human Rights Advocacy, and Techno-Moral Witnessing," lecture at the Centre for Research Architecture, March 4, 2013. Herscher's lecture has been influential during the editing stage of this piece. It was included in a series of seminars on satellite imagery titled "Sensing Injustice" that Susan Schuppli organized in the context of the Forensic Architecture project. Other contributions to this series have been helpful in shaping this essay, including Lars Bromley's contribution, on November 27, 2012; John Palmesino and Ann-Sofi Rönnskog's, on January 29, 2013; and of course, Laura Kurgan's "Close up at a Distance," April 19, 2013. More information on the series is available at http://www.forensic-architecture.org/seminars /sensing-injustice/.
4   Conversation with Lars Bromley, January 28, 2013.
5   In her book *Close Up at a Distance: Mapping, Technology and Politics* (New York: Zone Books, 2013), Laura Kurgan discusses the ways in which satellite vision technologies have created a radical shift in our ability to use the spatial realm as a political, human rights, and military reference point. The bulk of this essay was written before the publication of this book; we also consulted Kurgan's website, www.l00k. org, which contains much of the information later published in the book. Andrew Herscher, in his lecture "Envisioning Exception," reminded us that the fact that these surveillance technologies are used equally by militaries and human rights organizations is not without its dangers.
6   Robert Wellman Campbell, ed., "Phnom Penh, Cambodia: 1973, 1985," *Earthshots: Satellite Images of Environmental Change*, 8th ed. (Sioux Falls, S.D.: USGS EROS Data Center, 2008), available at http://earthshots .usgs.gov.
7   Kimmo Kiljunen, ed., *Kampuchea: Decade of the Geno-cide: Report of a Finnish Inquiry Commission* (London: Zed Books, 1984). The Finnish Inquiry Commission estimated that about 600,000 people in a population of over seven million died during phase I, while two million people became refugees. For the second phase they give 75,000 to 150,000 as a "realistic estimate" for outright execution, and the figure of roughly one million dead from killings, hunger, disease, and over-work. For more about the Finnish Commission, see Edward S. Herman and Noam Chomsky, *Manufacturing Consent: The Political Economy of the Mass Media* (London: Vintage Books: 1994), 260.
8   A political debate over the interpretation of these two images emerged between the "anti-imperialists" opposed to the US bombing in Vietnam and Cambodia, who saw it as an extension of US domination— most clearly exemplified by the position of Noam Chomsky—and the "anti-totalitarians," who saw the Khmer Rouge as a totalitarian menace that called for international intervention. In the late 1970s and early 1980s, the exposure of Khmer Rouge's massacres in the name of a rural utopia, their attempt to rearrange the very fundamentals of space, and undo—once and for all—the division between cities and countryside, culminating in the evacuation of Phnom Penh, coin-cided with the publication of Aleksandr Solzhenitsyn's

The Gulag Archipelago: 1918–1956 (published in three volumes between 1973 and 1976). Each in its own way exposed the horror of totalitarian-state communism and, for many in Europe, delivered it a deadly blow. These developments accelerated the departure of a human-rights movement—anti-utopian and with limited aims—from the ranks of the radical left.
9   See the Yale Genocide Studies Program's GIS & Remote Sensing Project: Darfur, at http://www.yale .edu/gsp/gis-files/darfur/.
10 Ibid.
11 Robert Smithson, *Hotel Palenque*. More information is available at http://www.robertsmithson.com /photoworks/hotel-palenque_300.htm, last accessed December 2013.
12 Kurt Vonnegut, *Slaughterhouse-Five* (New York: Dial Press, 1999), 64.

Mayhem in Mahwah: The Case of the Flash Crash; or, Forensic Re-performance in Deep Time

Gerald Nestler

It must be the case that I have some perception of the movement of each wave on the shore if I am to be able to apperceive that which results from the movements of all the waves put together, namely the mighty roar which we hear by the sea.
— Gottfried Wilhelm Leibniz[1]

Automated Daemons

Shoot first, ask questions later.
— Eric Hunsader[2]

Figs. 1, 2. Stills from CNBS News, May 6, 2010. Images © CNBC.

When financial market prices plummeted and caused havoc on May 6, 2010, stock indices such as the Dow Jones Industrial Average and the Standard & Poor's 500 (S&P500) incurred enormous losses in record time, and even single company stock notations crashed to previously unknown low levels, only to rebound minutes later.[3] To quote but one of the many sources commenting on this global flash of financial pandemia, the event "carries the distinction for the second largest point swing, 1,010-points, and the biggest one-day point decline, of 998.5-points, on an intraday basis in the 114-year history of the Dow Jones Industrial Average."[4]

It was not just traders with open positions who were caught off guard and severely affected. What has become known as the Flash Crash simultaneously sent a shockwave through wider business circles. Live on CNBC, for instance, TV newscast presenters and commentators were discussing the financial backgrounds of the severe protests taking place in Greece as a consequence of the credit crunch and the austerity cuts; but they seemed compelled to shift their attention increasingly to a financial event whose sheer magnitude left them stunned—the immense and unexpected drop in market prices occurring

right before their eyes.[5] Clueless as to what had catalyzed the crash—economic data did not account for a blow of such ferocious violence—they resorted to idiomatic terms such as "capitulation."

Initially, the TV screen showed live footage of the Greek insurgence in Athens meshed with economic data feeds and real-time market prices (a constant presence not only in today's business media) ticking away in a smaller window below. But the live broadcast of protesters pitted against police forces gradually faded, with the discussion shifting in tone and content. Market charts began to fill the screen as the conversation plunged into an emotional debate about what specific contingency might have triggered the downward flood of transactions. The suggested speculative explanations included a "fat finger event" (a typing error), a breakdown of machines (a hardware failure), a software glitch, and rapid selling action due to the European (and especially the Greek) credit crisis. One commentator was heard reiterating recommendations to buy because of the "ridiculously low" levels of some stocks; another proposed "shock and awe" politics in order to get the economy running again. The forceful global deformations introduced by the neoliberal reformulation of self-interested profit maximization became apparent in this instant of simultaneous broadcasting of civil unrest and financial war. The live coverage of the uprising in Greece and the fall in prices, each with its accompanying visual and oral rhetoric, unintentionally evoked the stark contrast between the capitalist regime of financialization,[6] on the one hand, with its debt-induced grip on politics and the economy, and on the other hand, the effects of this regime on the notion of the public good. When the spotlight panned from the destroyed common ground in Greece to the historic instance of an algorithmic crash, market disequilibrium on a gigantic scale obscured a catastrophic failure of an even vaster extent. The Flash Crash eclipsed what has become the symbol of the ruination of the agora of commonality, epitomized by the eruption of popular protest in the site of its ancient origin in Athens.

Below the radar of agencies that were established to monitor market activity, corporate self-interest had created an even deeper level of incorporation: it was programed into the "genetic" code of a new breed of financial agency, the automated daemons of algorithmic trading.[7] Derivatives of mathematical models, algorithms had already revolutionized the logistic infrastructure of exchanges by displacing the trading pit and thus its market makers (the human traders known as "locals") in favor of faster execution rates. Subsequently, these daemonic powers were let loose to directly negotiate with one another on computerized matching machines, exploiting trading opportunities at a speed inaccessible to their human competitors. The foundations for this radical shift were established in the early 1970s. Donald Mackenzie informs us that "financial economics […] did more than analyze markets; it altered them. It was an 'engine' in a sense not intended by [Milton] Friedman: an active force transforming its environment, not a camera passively recording it."[8] Gil Scott-Heron's 1970 "The Revolution

Will Not Be Televised" comes to mind, a politically radical poem released at about the same time when the most significant model, the Black-Scholes formula, introduced an algorithm that sparked the first derivative wave of neoliberal market revolutions that today hold sway over the world. But while Mackenzie's account is mainly concerned with "bodies" and their operations, high-frequency trading (HFT)—the generic term for computer-driven algorithmic trading, which takes place in microseconds—has in the meantime abandoned human traders for quant-coded algorithmic market making.

As collateral damage, the epitome of territorialized capitalism, Wall Street, had become a mere symbol. While the crowded trading floor of the New York Stock Exchange (NYSE) is still the undisputed televisual icon of the "market," the media presence obfuscates, more than reveals, what the market has actually become, as a result of what I term the *quantitative turn* in finance. Since 2012 the NYSE and its trading floor have been the property of Intercontinental Exchange, a provider of algorithmic trading platforms operating from Atlanta, Georgia.[9] The new pivotal architectural nodes of what has turned into a deterritorialized, informational capitalism are now the nondescript and nonrepresentative warehouse buildings, filled to the brim with computer servers and fiber optics, in suburban areas such as Mahwah, New Jersey.[10] Although in 2010 this was still future in the making, something unsettling had dawned on acute observers of the epic failure described as the Flash Crash: algorithmic daemonic powers, put in the driver's seat, had slipped away from human control. For the first time, bots had caused mayhem. Not only were automated trading desks affected,[11] but this "revolution" flashed into view as a globally televised event.

Forensics without a Forum

The past is only the impatience of the future.
— Elie Ayache[12]

Despite these potential warning signs, however, acute observation was not widespread. A joint commission of two US regulatory bodies, the Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC), undertook an investigation into the transaction matrix of this singular event:[13] its results were widely criticized as unsatisfying.[14] In a nutshell, the report came to the conclusion that human error reinforced by computer trading procedures triggered the Flash Crash. It blamed a single trader of a mutual fund representing long-term investors for causing the meltdown.

Meanwhile, a less-cited investigation conducted by a small market data feed analyst, Nanex, produced a more convincing result, which challenged the SEC report.[15] Nanex based its research methodology on what could be called a forensic archaeology of historical trading data, and reached a conclusion

that, unlike the official report, was not unwittingly streamlined to a financial elite with major vested interests in HFT.[16] As we will see in more depth below, Nanex proved that algorithmic trade execution triggered the event without human interference. The reason the two reports arrived at such divergent results cannot be attributed to a shortage of material to investigate. Rather, we can ascribe the successful approach to two crucial factors. The first is a quality of depth in investigation, or more technically, the production of quantitative camera-engines with higher resolution on the split-second time scale in which high-frequency trading is carried out. The strata to be investigated had to be discovered and discerned rather than simply considered and surveyed. Thus, algorithmic analytics devices were crucial for unearthing the archaeological evidence.[17] Its material elusiveness—which I will attribute below to a new breed of machines that turn apperception from conscious perception (when mental attention is coupled with previous experiences and conceptions) to technological cognition—hides a thick surface of myriads of data characterized by a propensity towards invisibility and a sort of "counter-perception" that easily escapes cognizability. This fact marks the second crucial aspect of the analysis, the act that made it possible in the first place: the disclosure of proprietary trading data. I will refer below to this ambiguous but essential act as a manifestation of the Janus-face of the expert witness in the field of a forensics of algorithmic and automated trading.

The SEC and CFTC based their official report on the material made available by exchanges and market participants, which showed one-minute trading intervals. This dataset would have been adequate to scrutinize trading activities before the ascent of HFT. But today, to quote the founder of Nanex, Eric Hunsader, "in the blink of an eye, the market moves what used to take humans thirty minutes."[18] With HFT and the Flash Crash—whose naming enunciates a new category of speed—a one-minute resolution view of the material composition conceals more than it reveals. The following account of the Facebook stock market launch (IPO) illustrates the order of magnitude:

ERIC HUNSADER   NASDAQ was trying to open the IPO up. By their third attempt, they're telling everybody *Wait, we'll get it at 11:05. No, we'll get it at 11:10, no we'll get it at 11:30.* So it was do or die time. […] Somebody there has the bright idea to just reboot the system. It takes NASDAQ offline a full seventeen seconds. […] When NASDAQ finally did reappear, what happened? The orders that were resting in the book all that time immediately disappeared. Like 60%–70% of all liquidity within 200 milliseconds is gone […].

CHRIS MARTENSON   So seventeen seconds of going dark for one of the largest exchanges out there. That must have been several lifetimes for these algorithms.

EH   Seventeen million microseconds.

CM   Seventeen million microseconds, that's forever.

EH   It *is* forever and that's why we see the liquidity and all these books just go—*poof*![19]

For Hunsader, the order of magnitude of microsecond timescales poses a threat to market activity per se. An instantly precipitated lack of liquidity—the disappearance of automated market orders—is the blueprint for market collapse because "algorithms prefer predictability. If something spooks them (e.g., unexpected breaking news; a delay in the market's opening), they simply stop trading. […] With no support and no bids, prices can drop dizzyingly fast. Making matters worse, the 'smarter' algos [financial lingo for algorithms] can recognize a downdraft in process and begin piling back into the market on the short side, exacerbating the price declines."[20]

But what this quotation also illustrates is the sheer pointlessness of scrutinizing market activity at one-minute intervals. The officials charged with throwing light on the background of the Flash Crash therefore examined an image that they mistook for razor sharp, unaware that it was blurred and useless. Nanex was able to escape the trap by mistrusting the superficial matrix of one-minute trading accounts. Hunsader subsequently commented that the SEC/CFTC analysts clearly "didn't have the dataset to do it in the first place. One-minute snapshot data, you can't tell what happened inside of that minute," also noting that his own analysts "didn't really see the relationship between the trades and the quote rates until we went under a second."[21]

Re-performative Forensics

In real-world systems, nothing could be less normal than normality.
— Andrew Haldane and Benjamin Nelson, Bank of England[22]

Nanex is a market research firm that supplies real-time data feeds of trades and quotes for all US stock, option, and futures exchanges. As their website states, "We have archived this data since 2004 and have created and used numerous tools to help us sift through the enormous dataset: approximately 2.5 trillion quotes and trades as of June 2010."[23] Elsewhere they declare that "Nanex's database is now more than 20 times the size of NASA's. That's right—we've got more data on the stocks than we do on space."[24] The capacity to build algorithmic machines that allow the processing of information on such a scale is fundamental to gaining a resolution capable of visualizing—and thus understanding—the trades and quotes that are executed far below the threshold of human sense perception.

Nevertheless, Nanex did not see this data as sufficient to account for the Flash Crash because they could not match it to its respective sources. As the former HFT trader David Lauer remarked:

> The markets and the interplay in the industry between all theses firms with all these very complicated and complex technology systems and how they interact makes the entire system of exchanges, high-frequency, brokers and the interaction between the technology, it makes it a complex system. […] There is no cause and effect that you can point to. What caused the Flash Crash is a nonsense question. […] And, if you were to replay the same sequence of events, identically, there's no guarantee that it will cause a Flash Crash again. That's the nature of complex systems.[25]

The next step, therefore, was to apply a different strategy, or rather to extend the approach. Discontented with the official report, Nanex resorted to an investigation accomplished not only after the fact but also *after the investigation*: they asked the party blamed (though not identified) in the official report, the mutual fund Waddell & Reed, to grant access to their trading data. In line with the capitalist proprietary regime, it is quite plausible that the fund would have declined this request if it had been made before they were blamed. But by the time the Nanex analysts were conducting their investigation, Waddell & Reed would have had a keen and vested interest in clearing their name, such that they were prepared to disclose their trading data from the time of the Flash Crash. Hence, the incorporation of the "source code" of a proprietary dataset allowed Nanex to classify the data and deliver an account of the actual events that happened in microtime.[26] The analysis relies on an apparatus that pairs the following three different custom-made quantitative frameworks in an effort to deliver a sufficient approximation of trading operations: firstly, Nanex's enormous and ever-extending archive of financial data; secondly, their adaptive quantitative resolution devices, which allow the investigation of these data sets; and finally, the algorithmic trading data of a proprietary participant. This framework allowed them to produce the groundbreaking narrative that subsequently brought to light the cybernetic regime of HFT. Borrowing a linguistic
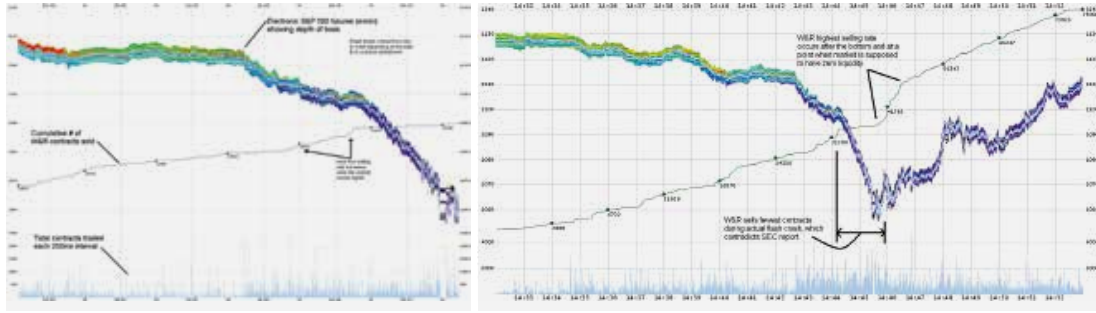
Fig. 4. (left) 250 millisecond interval chart. Both charts show eMini S&P 500 index depth and cumulative Waddell & Reed contracts sold. Images © Nanex, LLC.

Fig. 5. (right) 1 second interval chart.

Nanex's findings contradict the official report with regard to the catalyst of the Flash Crash by showing that the bulk of the mutual fund Waddell & Reed's trades "occurred after the market bottomed and was rocketing higher—a point in time that the SEC report tells us the market was out of liquidity." "May 6'th 2010 Flash Crash Analyses: Continuing Developments: Sell Algo Trades," Nanex, October 8, 2010.

term that is widely used in computing, econometrics, and quantitative finance, we can outline this process as the parsing of the trading performance after the fact (the proprietary dataset provided by Waddell & Reed) by performative cameras that not only analyze but craft a narrative representation (the analysis accomplished by Nanex).

The final representation of the event is composed of an abundance of colorful simulations produced to visualize and flesh out the activities that took place in microseconds. This is a techno-aesthetics that counters the fundamentally iconoclastic situatedness of quantitative informational sign machines which do not communicate with humans. The vision-enhancing sensors that detect the time-blurred traces and help to mark discriminations in a highly complex environment deliver information that has to be "digested" in a separate stage in order to raise it to the surface of visibility and comprehensible representations. Thus, the forensic analysis is neither fully embodied nor defined by the abstract representations of data traffic. Rather, the methodology directing the analysis is situated, i.e., constructed, in between the juncture of performance as the actual presence of an event taking place (exemplified by the occurrence of the Flash Crash) and representation as providing "visual collateral" of a performative re-animation of the original obscured presence after the fact. From this, we can now outline a sharper distinction which will help us to grasp what is at play in the documentation and evaluation apparatus. Artificial sense organs reach into deep time by increasing the resolution bandwidth in order to revisit the otherwise insensible "scene of the crime." The forensic analysis is thus an intricate and extensive cybernetic undertaking characterized by a process of re-mapping, re-modeling, re-visioning, and re-narrating a specific past that happened at near-light speed—a performance *ex post* that *was* the occurrence of a future event. As this approach re-enacts the *performance* of the event, the methodology can be specified as *re-performance*. The technological, calculative aspect of sifting data to come up with evidence—enacting the reperformance—becomes explicit in the sheer enormity of the material Nanex examined:

> May 6th had approximately 7.6 billion […] records. We generated over 4,500 datasets and over 1,200 charts before uncovering what we believe precipitated the swift 600 point drop beginning at 14:42:46 and ending at 14:47:02. In generating these data sets we have also developed several proprietary applications that identify the conditions described in real time or for historical analysis.[27]

While the ground layers of the disaster zone that led to the blaming of the usual culprit—a human agent—showed nothing but detritus, only rigorous research into the deeper, less perceptible strata of microscopic time revealed the actual material matrix. What emerges is an excavation that entails an inversion of the relation between time and space: while the common notion

of archaeology entails entering into concrete and thick space cautiously (as when employing technologies of surveying, probing, and classifying, for instance), in order to extract the material witness of a former era, a forensic archaeology of finance, in contrast, probes into the imperceptible materiality of time to detect patterns and recover artifacts whose existence is derived from financial models and built on technologies of miniaturization, automation, and infrastructure aligned with politics of securing, excluding, and enclosing. The story of the Flash Crash unfolds in the immensely extended realm of trading bandwidth in which what becomes apparent is a techno-political regime of exclusion/inclusion that clearly prioritizes the algorithmic "aesthetic and mode of thought" of a tiny but superior elite of HFT traders, or, more precisely, HFT quants.[28] ("Quant" is financial lingo for the quantitative analysts that develop algorithms.) In attempting to illustrate the complex background of the impact, Nanex resorted to metaphor: "The SEC report uses an analogy of a game of hot-potato. We think it was more like a game of dodge-ball among first-graders, with a few eighth-graders mixed in. When the eighth-graders got the ball, everyone cleared the deck out of panic and fear."[29]

The Liquidation of Liquidity

Shit happens, don't judge me.
— Suhail Malik[30]

With this in mind, it is not surprising that sociologists of finance, such as the London School of Economics' Daniel Beunza, speak of the Flash Crash as a watershed event in the history of markets. The official narrative has up to the present day not seen fit to abandon the usual scapegoat of the human actor, presumably due to a reluctance to lay the blame upon technologies and infrastructures that have seen massive investment in recent years, including high-end quantitative engineering, fiber optic networks, and data collocation systems, as well as the security infrastructure (the global real-time network architecture of financial markets).[31] Yet the actual analysis of the Flash Crash produces a picture saturated with a violence whose perpetrators evidentially were neither human agents nor human-robot interactions (as the SEC report concluded) but massive robot-robot interactions materialized in trading quotes. In the era of algorithmic trading, distinguishing between quotes (bids or offers) and actual trades (when a bid and an offer are matched and deliver a price) is crucial because in comparison to quotes only a smaller amount of market action delivers trades. Nanex provides esti-

Fig. 6. (left) Chart showing the (lack of) growth of high frequency trading.

Fig. 7. (right) Chart showing the growth of high frequency quoting. Images © Nanex, LLC.
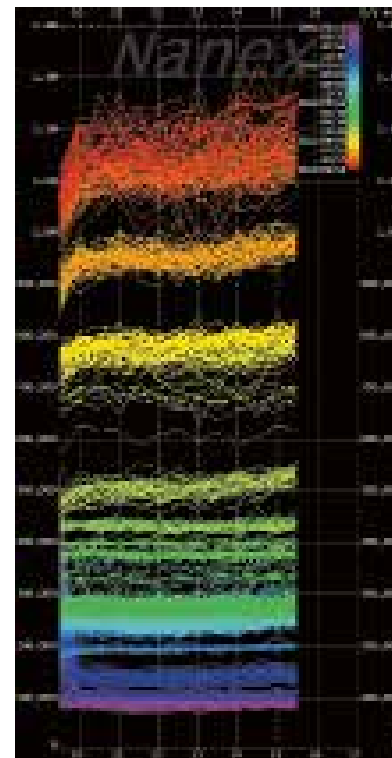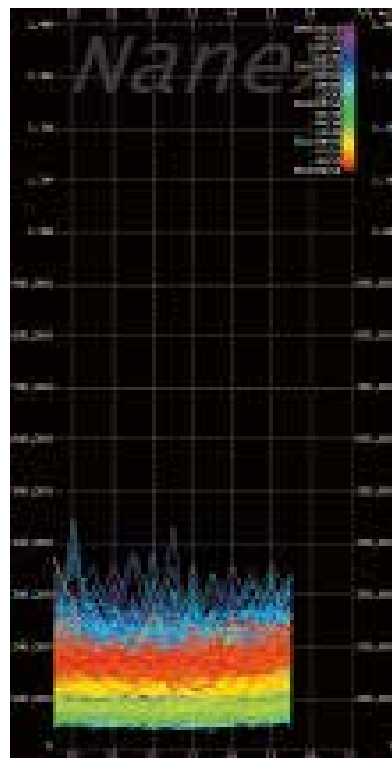
mates that tell the story in full: more than 70 percent of exchange trades are due to algorithms; but exchange quotes surpass this figure to a degree that lends the term "capitulation" a new meaning—99.9 percent.[32] These figures prove that a bot almost always partners a transaction.

Hence, algorithmic trading adds to market liquidity,[33] as advocates of HFT never get tired of emphasizing.[34] The irony, though, is that they are more than right on this point—in actual fact, algorithmic trading *is* the liquidity of the market. The obvious conclusion is that trading machines have taken over. High-level investment strategies are shifting from human decision making to machine decision making. Wilkins and Dragos argue that "algorithms are no longer tools, but they are active in analysing economic data, translating it into relevant information and producing trading orders."[35] With algorithms calculating probability and deciding on entry and exit strategies as well as execution, an *event* (for instance bad news about the economy or political incidents, etc.) might easily stop their action and massively drain the market of liquidity, as the incident of Facebook's IPO illustrates.[36] Which human market maker on one of the few remaining trading floors would dare to take competitive issue with bots acting in microseconds, knowing that "shit happens"—that bot quotes can disappear in a flash or a bot strategy can trigger a huge amount of actions by other bots that will reinforce the event? As a result of speed, the market forum is deserted in a flash (by human standards) when a Flash Crash (by algorithmic standards) is born.

The evidence procured by Nanex's exacting application of forensic data gathering and analyses, to a degree seldom experienced in the context of financial markets, reveals that trading technologies and procedures today shape markets beyond both the intellectual and political grasp of officially installed regulatory bodies.[37] These facts point to a space of (trans)action which not only surpasses human trading and regulatory surveillance capabilities; the incompetence of governance—technologically as well as intellectually—also has obvious effects on the political leverage of policy makers and, in turn, of constituents. This is exacerbated by the fact that we are dealing with a field in which the eyewitness is invalidated because these processes are beyond the cognitive ability of the human brain.[38] No one is present at the scene, No one observes what is happening. As one commentator put it, quoting the trader and author Sal Arnuk: "It's not just that humans are less and less involved in trading; it's that they can't be involved. 'By the time the ordinary investor sees a quote, it's like looking at a star that burned out 50,000 years ago.'"[39]

From an imaginary perspective of algorithms (or algos), humans live in a backward corner of the galaxy. From a human perspective, algos are out of direct reach and the remote control unit has been lost in the bedlam of deregulation,

political stalemate, and the "irrational exuberance" of economic boom times.[40] These shortcomings are not only detrimental in an economic sense. They stifle the potential for delivering judgment through the processes of political dissent, debate, and control (for recovering remote control, as it were), as they already relegate informed political and legal action to the level of nontransparency with regard to business procedures. The "liquidity" essential for policy making—the availability of all information required for informed decision making—is liquidated as well. The public forum introduced to deliver evidence after the fact has capitulated while forensic analysis capable of establishing collected evidence has seldom been heard.

Algorithmic Apperception

All consciousness is a matter of threshold.
— Gilles Deleuze[41]

The distinct narratives that were constructed around the Flash Crash and its investigations illustrate to what extent a forensics of financial markets already encounters difficulties in the phase of collecting evidentiary statements. Obtaining such data from the black boxes of proprietary trading firms is notoriously hard.[42] Moreover, investigations are seldom brought before a legal forum, as they already meet insurmountable obstacles at the level of networked governance. A detailed examination of this case—an endeavor that would go beyond the constraints of this article—would show that this is not simply a technical question but is rooted in the interests of incorporated stakeholders.[43] Adopting the viewpoint of ecological economics, Wilkins and Dragos address this issue the following way:

At the bottom there are the basal species—slaves, serfs, proletarians, free labor, consumers, account holders, etc. These strata are preyed on by those further up the food chain—pension funds, insurance companies, mutual funds, retail banks; and they in turn feed larger financial institutions, such as hedge funds, brokers, investment banks, propriety trading HFTs, etc. Each financial actor exploits the inefficiencies of the prey species and in the process produces new inefficiencies, further ncreasing the information gradient. Within this complex ecology there is a gradual stabilisation of predator-prey relationships, but unlike an actual ecosystem, the financial system has a much higher rate of change, leading to more abrupt singular events like flash-crashes evolving according to an accelerated rate of punctuated equilibria, with multiple black swans and mass extinctions.[44]

Algorithmic bots quote in microseconds. But a quote is just an offer to buy or sell, not a transaction. On the one hand, as mentioned above, quoting provides liquidity for transactions to happen (there is "always" a quote that matches your order and thus renders a transaction and a price). On the other hand, enormous amounts of quotes flood the matching machines of exchange places. Quotes are often placed without the intention to execute. In such instances, their objective is not to facilitate transaction, i.e., to trade; rather, as hidden searchlights in the "dark time" beyond human perception, they prey, for instance, on inefficiencies in the ways large block orders are executed by institutional investors that are rebalancing their huge portfolios.[45] There is little doubt that such aggressive conduct would be considered a crime if we were to translate it to human behavior. But the latest breed of financial daemons seem to be accorded special allowances in this regard, as Jerry Adler has suggested:

Many [quotes] were never meant to be executed; they are there to test the market, to confuse or subvert competing algorithms, or to slow trading in a stock by clogging the system—a practice known as quote stuffing. It may even be a different stock, but one whose trades are handled on the same server. On the Internet, this is called a denial-of-service attack, and it's a crime. Among quants, it's considered at most bad manners.[46]

Doyne Farmer, codirector of the program on complexity economics at Oxford's Institute for New Economic Thinking, notes that "under price-time priority auction there is a huge advantage to speed."[47] As perception and decision must also be in touch under microtime conditions, in order to avoid acting purely at random (or rather to implement the random indeterminacy of contingencies), quants have consequently been programming decision making into financial algorithms. Farmer's statement therefore leaves room for an interpretation that points to an incentive to implement hurdles for competitors and other insiders (such as regulators) alike. Keeping them in the dark about algorithmic processes not only results in unfair competitive advantage, but ultimately leads to a technological politics of segregation that amounts to the survival of the fittest quant.[48] Felix Salmon, a financial blogger for Reuters, comments: "Inevitably, at some point in the future, significant losses will end up being borne by investors with no direct connection to the HFT world, which is so complex that its potential systemic repercussions are literally unknowable."[49] It is safe to say, therefore, that such a development extends the predator-prey logic of capitalist market competition to a new order of magnitude, which incidentally makes a mockery of the judiciary.

The crucial question is not that of the (in)equality of investment opportunities—to which the predator-prey metaphor would provide an answer. The more radical effects are "borne" by decision-making processes: we cannot make a decision on something that we do not perceive. Recognition in at least one of its many manifestations—be they visual, textual, technological,

algorithmic, or other—is conditional for apperception and decision making. Michel Serres's concept of the parasite/host seems more apt for delineating the new capitalist hegemony that becomes apparent in the interleaving of the black box of time fractions and the black box of proprietary technology, in which even the ideology of the "free market" is reduced to utter absurdity, with proprietary artificial sensing organs capable of penetrating into the dark kept undisclosed by their owners as if their possession were an inalienable right. Given the sheer influence of capitalist markets on society and the power of decision making exercised by financial over public interests—a situation we have been witnessing over and over again in recent years—this not only applies to those individual investors that bots feed off directly (Salmon's concern) but also to the trillions of people who are "invested" as resources in a parasitic system that is at the same time the host.

A Parasite Host

This is truly the brave new world we are trying to regulate.
— CFTC Commissioner Scott O'Malia[50]

The cross-fade on CNBC that slowly followed the turn of attention from the live footage of the Greek insurrection to the uncanny intrusion of increasingly volatile market data is not simply a random coincidence of events or an unfortunate accident. Rather, the Flash Crash constitutes the proof of concept of the power of quantitative decision-making circuits. HFT has not suffered in the aftermath of the collapse. Quite to the contrary, it has gained a competitive advantage over other market participants. Furthermore, it has become evident that it is obscure to those commissioned to regulate these practices. In other words, the regulators are not in a superior position; to the contrary, the decisive superiority of HFT corporations over political supervisory bodies was effectively confirmed by SEC representatives when they conceded that the task of building and installing a data feed from scratch, which would allow them to monitor market activity, proved too complex. Thus the SEC had to resort to subscribing to the homegrown data collection system of an HFT company. "The wide gulf in technical prowess between the regulators and the regulated became painfully clear that year [of the Flash Crash], prompting the SEC to explore hiring an outside firm that could gather up-to-the-minute market feeds from the public exchanges."[51] Although this policy move was welcomed, the deal highlights a paradoxical politics that follows the logic of the lesser evil: the data provider commissioned by the SEC, Tradeworx, is one of the foremost HFT trading firms.[52] Their CEO, Manoj Narang, is one of the industry's most outspoken champions of data-driven decision making.[53]

The game that is visually represented by changing numbers on TV screens all over the world today has in fact become invisible and beyond the knowledge even of insiders, as parasitic circuits use technology to conceal their profit opportunities. As Eric Hunsader remarks, "We allow people with faster connections to place and remove offers or bids faster than the speed of light can deliver that information to the other market participants."[54] Thus such practices derail the backbone of capitalist market logic, the allocation of resources based on supply and demand; in an ironic turn, Adam Smith's "invisible hand" makes new sense. In the aftermath of the technology-based quantitative turn in finance, access to a data-stream service alone is not the solution to reaching and staying on the same level as corporate HFT units. Technological development leaps forward and so does knowledge production. In this field of techno-politics, critics lament, regulators lag far behind even though steps have been taken to come up to par. In 2010, the SEC, which until then had mainly employed lawyers, started to hire more technically oriented staff. But as one newly drafted specialist, economist Rick Bookmaster, concedes in a *Washington Post* article, the stakes are high and the gamble could well be lost due to the disadvantages of competition:

> This job cannot be done by SEC lawyers or career government workers. […] We need to entice market professionals into government service who are on par with those in industry. […] The challenge […] is in recruiting undergraduate computer science wizards who might otherwise […] trade for hedge funds. We have to rely on public spiritedness as opposed to dollars to pull them here.[55]

This attests to the degree of perversity inherent in the financial system. Having first been lured away with big salaries from the less affluent fields of science and production, engineers, mathematicians, and physicists are subsequently subject to attempts to persuade them to help take action against the new hegemony. This reflects the overexposure of markets in society: a more twisted, if not false, version of public spiritedness would be hard to find. Although this boils down to drafting in renegades willing to "sacrifice" for a greater good, financial capitalism per se is not challenged. Such a "greater good" seems a far cry from, for example, the common good that would be effected by dissolving the debt bonds set up by markets and financialization.

Hence, the complex, self-generating, self-replicating, self-referential registers of algorithms are part of a larger medium of information circulation. Geared towards exploiting miniscule inefficiencies (in financial terms, arbitrage), what has been termed an "arms race to zero" (the competitive battle to achieve the technological means of trading at speeds approaching the speed of light) is directed towards deeper levels of exploitation that connect these low latency (i.e., extremely rapid delay processing) machines

to the slower computer networks of the financial infrastructure, and from there to wider social nets. In terms of the logistics inherent in HFT, distribution is paramount. Automation not only produces material items (bids and offers, in our example) but also manipulates the conditions of delivery by distorting the "field homogeneity" of the financial matching network. In other words, equal access to the matching machines of exchange places tends to be squashed where HFT rules. Automated spreading of quotes, for example, is not about benefitting from market liquidity by the generic matching process of supply and demand (bids and offers), which is reflected in prices. Rather, these schemes *make* the address by attracting and decoying technologically less privileged order frames and thus construct prices by distorting supply and demand. As producers of noise (the myriads of quotes that serve as liquidity traps), these parasites are only the first in a line, feeding off a host that is in turn a parasite exploiting arbitrage opportunities, and so on. "In the parasitic chain, the last to come tries to supplant his predecessor."[56]

Battled out between corporate vested interests that can afford the escalating expenses, the transactions delivered by the infrastructure of trading engines create the impression of a virtual if not immaterial battlefield subject to only minor material restraints. Nevertheless, the pivotal factor in leveraging this speed war is geographical location. As mentioned before, the less space between the proprietary trading and the exchange's matching engines, the faster the process and consequently the bigger the competitive advantage for whoever is thus optimizing the logistics of HFT automation.

Speed is of the essence. This is why with HFT the "information gradient" discussed by Wilkins and Dragos above is basically a speed gradient. "A trend that began with pigeons ends with subatomic particles, carrying data that is outdated almost before it arrives at its destination."[57] Even if there is an absolute limit to these developments, a divide has opened up, a gaping but invisible abyss: by exploiting timescales beyond the threshold of perception a new class of enclosures has found the means effectively to hide its machinations from slower competitors and public influence alike. In this field, Gottfried Wilhelm Leibniz's notion of apperception has ceased to be a conception of conscious experience emerging from small, unconscious perceptions. The myriads of mathematically constructed small perceptions (of which these camera-engines are not at all "unconscious") define a virtual field of machine apperception where those who do not command the latest cyborg infrastructure are captured or blocked. The financial-market architecture with its proprietary algorithmic logistics has become a black box not only with regard to the parameters of official inquests, but also in terms of knowability much more generally. Thus, what the black box emits is not information but noise. This *technowledge* (to craft a term for the fusion of technology and knowledge beyond human apperception) exerts influence not only on much of the industry but of necessity cripples the public forum as a whole. We encounter a global system that acts not only in the dark but "in the dark of time."

While the past is a random figure, a deficient but nonetheless highly valued stochastic reservoir of historical data calibrated to model future probabilities, the future has turned into a becoming that eclipses the very notion of the moment. In the horizon of human experience, a violence has taken hold that is unnamable, as the flashes of its *now* have no opening. It only strikes collateral. When *that* instant leaks into a moment (the same moment yet a fraction after the micro-instant) and noise starts inflating into a bubble, the abyss of the market crash opens to a bottomless pit of "capitulation" on all fronts.[58] Suddenly, this helpless idiom expressed on CNBC Live reveals its pathological purport: it manifests an assault on a defenseless public—capitulation is nothing else than the cry for bailout. The parasite takes hostage, blackmailing with debt. Thus, the true derivative—that which is dependent on and at the same time fundamental for risk markets—is not a tradable risk product but the public as last resort. We are the ultimate hedge.

The Future Forum and the Double Figure of the Expert Witness

Those who exercise power always arrange matters so as to give their tyranny the appearance of justice.
— La Fontaine[59]

If it weren't for the sheer mathematical abstraction, iconoclast "imagery" and legal nondisclosure arrangements that occlude these closed microsecond sessions from almost any investigation,[60] let alone inquest, the violence exerted and the pains suffered would arguably not so easily slip under the cover of the hegemonic ideology of the free market as social institution. In the war over miniscule trajectories of future events (risk potentials) and inadequacies happening in moments that can only be noticed by bots (arbitrage opportunities), all those who are not invested in the latest breed of cyborg engines lack apperception and speech—and thus the means for conscious and experienced perception and expression. Furthermore, as we have learned, microsecond manifestations escape inquest and litigation. One could make the case that a violence that violates below the threshold of political forums (including that of jurisdiction) undermines the economic as well as political frameworks set up to keep regimes of power in check. Bot coding is about a relational apperception constituted in an idiom of risk sensitivity, measure, and production that is not constructed to communicate with humans directly.

The artificial life world of financial automation, unsurprisingly perhaps, is not about freedom and equality. It is about a struggle for competitive advantage, if not monopoly, battled out on a surface on which humans cannot tread. The live audio recording of the Flash Crash from one of the few

remaining trading floors where human traders still serve as market makers delivers striking proof of the intermittent uninhabitability of the trading environment.[61] It also resonates with the Nanex metaphor cited above: "When the eighth-graders got the ball, everyone cleared the deck out of panic and fear." Despite the near elimination of the eyewitness from the scene (who as market maker is an expert witness at the same time), the paradigmatic shift to electronic exchange (in most markets) gives rise to the cognate notion of a subtly different kind of witness, one who would be capable of challenging this calculative rape: the *traitor*, the *informant*, the *renegade* who transgresses the unwritten laws of complicity and secrecy. By providing material from undisclosed or classified sources on a broad range of subjects, this figure of the whistleblower has in recent years turned the principal witness for the public, procuring otherwise unavailable evidence of violence. In the financial context, this particular manifestation of the witness—who does not testify on the basis of real presence—becomes the medium of forensics by a logistics of redirection (e.g., the leaking of confidential material that cannot—must not—speak for itself). This witness is not a plain informant. The financial renegade who presents objects as subjects-of-debate is an expert witness as much as the scientific analyst ally who subsequently (re)constructs the forensic narrative by composing the facts. The story of the Flash Crash offers an example of paradigmatic and at the same time ambiguous significance for the possible production of future forums, depicting in all its complexity the horizon of an exposed and discontinuous self-regulating force against the boundless utopia of a self-regulating market.

This Janus-faced configuration of the doubled expert witness might indeed be a figure that resonates with the complex situations encountered by forensics, in which "only the criminal can solve the crime."[62] The notion of the expert witness as one who was originally involved in the event under investigation seems to highlight the Achilles' heel of the particular mode of calculative oppression that works through HFT as part of the paradigm of the neoliberal market. The intricate problem of the resolution of the Flash Crash demonstrates the ambiguity contained: the participation of an insider or even (alleged) perpetrator is required in order to unearth evidential data that was buried in fractions of a second. This is reflected in the SEC's strategy of employing figures with firsthand experience of and expertise in the activities they want to uncover:

> Michael Fioribello, 38, might know more about derivatives than anyone else at the agency. Before going to the SEC, he worked at AIG for nearly a decade, helping to manage the company's derivatives operation. [… He] has provided colleagues with insights into how financial players structure derivatives to conceal something that could be illegal. […] "There can be bells and whistles done to reduce transparency or otherwise circumvent federal securities laws."[63]

In addition to hiring renegades, a further ambiguous but vital objective is to accelerate technological advancement in order to come up to par with perpetually evolving industry standards.[64] In contrast to espionage or surveillance, exploring and surveying an as-yet-unknown environment bears a similarity to cybernetic *reconnaissance*. The military analogy reveals a problematic approach in the regulatory body's perpetual chase after a glimpse behind an ever-moving frontline, as the aforementioned subscription to the data feed of HFT's leading proponent Tradeworx by the SEC illustrates.

Finally, another ambiguity suggests itself: the *only way out* for policy makers, lawyers, activists, and the public in general—the only route forward to the public forum and away from the dominance of boundless and unregulated (i.e., self-regulating) markets—entails, at least for the time being, actively encouraging and supporting the disclosure of proprietary financial data to the public—a criminal offense, except where the source is the owner. Only *renegade solidarity* aimed against the pathological deformation of cognoscibility in this vital field of contemporary power relations seems capable of delivering the relevant information that is fundamental, to paraphrase the quotation from Leibniz which opened this paper, for apperceiving the "mighty roar" of financial markets. In all its ambiguity, re-performative forensic analysis, performed by the double figure of the cyborg expert witness, is a productive force in facilitating a body of accurate performative translations that incorporate the nucleus of the future forum. Instead of resorting to simple answers (the human factor) it enters directly into complex power relations.

In concert with a specific public (in neoliberal lingo, stakeholders), this insurrection against an increasing hegemony of algorithmic daemon powers may facilitate leverage (as ample proof alone is apparently not sufficient) to resurrect both the legal forum of corporate litigation and the political forum of legislation. Renegade solidarity, however, exceeds the finance-state complex. It invigorates the fundamental principles of democracy by directly addressing the public for the common weal.[65] The future forum becomes apparent in manifestations that counteract the neoliberal zeal to redirect the bottomless volatilities of crises from shareholders to society by absorbing the public into competing stakeholder groups. Thus, the future forum in excess of calculation exceeds demand for justice.[66] It will act to dismantle parasitic proprietary enclosures, foster decision making on and in a resurrected agora of communality, and give voice to those whose inalienable rights are truly exploited.

1 Gottfried Wilhelm Leibniz, correspondence with Arnould, October 9, 1687, in *Philosophical Writings*, trans. M. Morris (London: J.M. Dent & Sons, 1934), 85.

2 Eric Hunsader, "Coexisting without Colocating," *HFT Review* (Hunsader's blog), October 18, 2011, http://www.hftreview.com/pg/blog/erichunsader/read/12033/coexisting-without-colocating.

3 The *Wall Street Journal* published a more detailed summary one day after the slump on May 7, 2010. See Tom Lauricella and Peter A. McKay, "Dow Takes a Harrowing 1,014.14-Point Trip," *Wall Street Journal*, May 7, 2010.

4 Gary Dorsch, "The Forgotten 'Flash Crash'—One-year later," *Global Money Trends*, May 2, 2011, http://www.sirchartsalot.com/article.php?id=152.

5 See "FLASH CRASH May 6, 2010 CNBC," http://youtu.be/IJaeozwoiyU, last accessed September 2013.

6 Wikipedia summarizes "financialization" succinctly as "a term that describes an economic system or process that attempts to reduce all value that is exchanged (whether tangible, intangible, future or present promises, etc.) either into a financial instrument or a derivative of a financial instrument." http://en.wikipedia.org/wiki/Financialization, last accessed September 2013.

7 The website of the Linux-based operating system Arch has a short and comprehensive definition: "A daemon is a program that runs as a 'background' process (without a terminal or user interface), commonly waiting for events to occur and offering services. A good example is a web server that waits for a request to deliver a page. […] While these are full featured applications, there are daemons whose work is not that visible." Wikipedia, s.v. "financialization," last modified January 3, 2014, https://wiki.archlinux.org/index.php/Daemons, last modified July 2, 2013.

8 Donald Mackenzie, *An Engine, Not a Camera* (Cambridge, MA: MIT Press, 2006), 12.

9 Javier E. David, "ICE to Buy NYSE for $8.2 Billion, Ending Era of Independence," CNBC, December 20, 2012, http://www.cnbc.com/id/100330589.

10 "The data center of NYSE Euronext, the international conglomerate that includes the New York Stock Exchange, is in a building in suburban Mahwah, New Jersey, 27 miles from Wall Street." Jerry Adler, "Raging Bulls: How Wall Street Got Addicted to Light-Speed Trading," *Wired*, August 3, 2012.

11 Coincidentally, Automated Trading Desk LLC pioneered automated HFT in the wake of the 1987 market crash. They state on their webpage: "Welcome to the future of automated trading. […] A world where only those that can move fast enough to predict market shifts are able to compete at the highest level." http://www.atdesk.com, last accessed October 2013.

12 Elie Ayache, *The Blank Swan: The End of Probability* (Chichester: Wiley, 2010), 421.

13 CFTC/SEC, *Findings regarding the market events of May 6, 2010* (September 30, 2010), http://www.sec.gov/news/studies/2010/marketevents-report.pdf.

14 For an example of criticism concerning the report's findings, see Tyler Durden (alias), "SEC Releases Final Flash Crash Report—Waddell And Reed Blamed As Selling Catalyst," *ZeroHedge*, October 1, 2010, http://www.zerohedge.com/article/sec-releases-final-flash-crash-report-waddell-and-reed-blamed-selling-catalyst; and for harsh criticism even before the official presentation of the report, Christopher Steiner, "Searching For Flash Crash Culprit, The SEC Fingers Wrong Man," *Forbes*, September 9, 2010, http://www.forbes.com/sites/christophersteiner/2010/09/09/searching-for-flash-crash-culprit-the-sec-fingers-wrong-man.

15 Nanex's final statement, titled "Flash Crash Mystery Solved," March 26, 2013, can be found with links to its research at http://www.nanex.net/aqck2/4150.html.

16 A statement by Nanex, however, points to a different conclusion: "The email exchange [with one of the co-authors of the official report] was very disturbing because the explanation was basically a new and bizarre definition of liquidity [… that] states that if a High Frequency Trader (HFT) aggressively buys contracts by executing against existing orders posted by a seller, then the HFT could be classified as a liquidity provider, and the seller classified as a liquidity taker. […] It is exactly opposite of the industry accepted understanding of liquidity, not to mention, basic common sense. It's like saying *up* is down and *down* is up. It seems they were trying to fit the data to match a foregone conclusion. […] To base any future regulations on either of these papers would be ill-advised and reckless. Someone needs to do some serious house cleaning at the SEC and CFTC." "The SEC Redefines Liquidity (when it's convenient)," Nanex Research, April 12, 2012, http://www.nanex.net/aqck/2977.html.

17 "Analysis of the 'Flash Crash,'" Nanex, June 18, 2010 (since updated), http://www.nanex.net/20100506/FlashCrashAnalysis_Intro.html.

18 Transcript of Adam Taggart, "Eric Hunsader: Investors Need to Realize the Machines Have Taken Over. The Blink of an eye is a lifetime for HFT algos," *Peak Prosperity*, October 6, 2012, http://www.peakprosperity.com/podcast/79804/nanex-investors-realize-machines-taken-over.

19 Ibid.

20 Ibid.

21 "U.S. 'flash crash' report ignores research—Nanex," Sify Finance, October 5, 2010, http://www.sify.com/finance/u-s-flash-crash-report-ignores-research-nanex-news-insur ance-kkfiEjeciij.html.

22 Andrew G. Haldane and Benjamin Nelson, "Tails of the unexpected," paper presented at the conference "The Credit Crisis Five Years On: Unpacking the Crisis," held at the University of Edinburgh Business School, June 8–9, 2012, http://www.bankofengland.co.uk/publications/Documents/speeches/2012/speech582.pdf, at 20.

23 "Analysis of the 'Flash Crash.'"

24 Andy Mills, "Fast Cash Dash Flash Crash Clash: Hear and See Some Super Trading," *Radiolab*, February 6, 2013, http://www.radiolab.org/story/267356-fast-cash-flash-crash-mad-dash-clash/.

25 David Lauer in Marijke Meerman, dir., *The Wall Street Code* (Netherlands, 2013), 50:30, http://youtu.be/kFQJNeQDDHA, at 46:00–46:48.

26 See, for example, "May 6th 2010 Flash Crash Analysis: Continuing Developments Sell Algo Trades," Nanex, October 8, 2010 (since updated), http://www.nanex.net/FlashCrashFinal/FlashCrashAnalysis_WR_Update.html.

27 See the "About" page on Nanex's website, June 18, 2010, http://www.nanex.net/20100506/FlashCrashAnalysis_About.html.

28 Luciana Parisi, preface to *Contagious Architecture: Computation, Aesthetics, and Space* (Cambridge, MA: MIT Press, 2013), x. Parisi traces the "logic of *computation* and its ingression into culture" (ix) in architectural and interaction design. Although she does not respond directly to finance, her characterization of digital algorithms is also applicable to financial algorithms, insofar as she describes them as "performing entities: actualities that select, evaluate, transform, and produce data" (ix) which "are not simply representations of data, but are occasions of experience insofar as they prehend information in their own way" (xii–xiii).

29 "May 6th 2010 Flash Crash Analysis: Final Conclusion," Nanex, October 14, 2010, http://www.nanex.net/FlashCrashFinal/FlashCrashAnalysis_Theory.html.

30 This quip was intended to illustrate the state of contemporary art. Suhail Malik, lecture given at the California Institute of the Arts (CalArts), April 2, 2013, http://vimeo.com/71058588, at 36:33–36:36. The relationship between contemporary art and finance, and their underlying dependence on indeterminacy rather than uncertainty, are addressed in a forthcoming text by the author.

31 For accounts of the background of the Flash Crash and algorithmic trading respectively, see Marije Meerman, dir., *Money & Speed: Inside the Black Box* (Netherlands, 2013), 49 min., http://youtu.be/H4BzsevJthw; and Meerman, *The Wall Street Code*.

32 "The Rise and Fall of the HFT Machines," Nanex Research, http://www.nanex.net/aqck/2804.HTML, last accessed September 2013.

33 Liquidity is essential for price discovery. It constitutes trading opportunity at an asked price (with minor variance) because of the availability of a buyer or seller respectively. Thus, it implies a constant exchange of information and trades. Loss of liquidity implies unacceptable prices that could ultimately lead to a crash.

34 See, for example, Bryant Urstadt's feature on the quant entrepreneur Manoj Narang, "Trading Shares in Milliseconds," *MIT Technology Review*, December 21, 2009, http://www.technologyreview.com/featuredstory/416805/trading-shares-in-milliseconds.

35 Inigo Wikins and Bogdan Dragos, "Destructive Destruction? An Ecological Study of High Frequency Trading," *Mute*, January 22, 2013, http://www.metamute.org/editorial/articles/destructive-destruction-ecological-study-high-frequency-trading#.

36 Tyler Durden (alias), "Nanex: Investors Need to Realize the Machines have Taken Over," October 6, 2012, *Zero Hedge*, http://www.zerohedge.com/news/2012-10-06/guest-post-nanex-investors-need-realize-machines-have-taken-over.

37 See more in "U.S. 'flash crash' report ignores research."

38 See Parisi, *Contagious Architecture*.

39 Adler, "Raging Bulls."

40 The expression "irrational exuberance" was used by the former Federal Reserve Board Chairman Alan Greenspan to describe the dot-com boom and its possibly detrimental results. "Remarks by Chairman Alan Greenspan," Annual Dinner and Francis Boyer Lecture of the American Enterprise Institute for Public Policy Research, Washington, DC, December 5, 1996, http://www.federalreserve.gov/boarddocs/speeches/1996/19961205.htm.

41 Gilles Deleuze, *The Fold: Leibniz and the Baroque*, trans. Tom Conley (Minneapolis: University of Minnesota Press, 1993), 64.

42 This problem is often the basis of complaints voiced by sociologists of finance like Donald Mackenzie and others. See also note 60.

43 As regards the Flash Crash, Nanex's final statement on the case ends with the following remark: "The HFT lobby will vehemently deny any blame for causing the flash crash and will use a number of straw man arguments, eventually enlisting the SEC final flash crash report which named Waddell & Reed as the cause (W&R). […] This is a very complex subject and lobbyists will use that to bamboozle you." Nanex, "Flash Crash Mystery Solved."

44 Wilkins and Dragos, "Destructive Destruction?"

45 Trading ahead of index fund rebalancing exploits algorithmic program trading by institutional investors who split big orders into smaller trades in order to manage risk. Thus, algo traders parasitically prey upon investors' returns. For detailed descriptions of the diverse strategies used by algo traders, see Scott Pattersen, *Dark Pools* (New York: Crown Business, 2012).

46 Adler, "Raging Bulls."

47 J. Doyne Farmer, "The impact of computer based training on systemic risk," paper presented at the London School of Economics, January 11, 2013, 11, http://www.lse.ac.uk/fmg/events/conferences/Systemic-Risk-Centre/Foresight-Report_110113/Papers-and-slides/Doyne-Farmer.pdf.

48 As mentioned above, financial regulation is to a great extent conducted by the industry itself.

49 See Will Knight, "Watch High-Speed Trading Bots Go Berserk," August 7, 2012, http://www.technologyreview.com/view/428756/watch-high-speed-trading-bots-go-berserk.

50 Scott O'Malia, quoted in Kambiz Foroohar, "Trading Pennies Into $7 Billion Drives High-Frequency's Cowboys," Bloomberg, October 6, 2010, http://www.bloomberg.com/news/2010-10-06/trading-pennies-into-7-billion-profit-drives-high-frequency-s-new-cowboys.html.

51 Dina El Boghdady, "SEC going high-tech with real-time trade data," *Washington Post*, December 24, 2012.

52 See http://www.tradeworx.com/.

53 See Urstadt, "Trading Shares in Milliseconds."

54 Quoted in Laurence Knight, "A dark magic: The rise of the robot traders," BBC News, July 8, 2013, http://www.bbc.co.uk/news/business-23095938.

55 Quoted in Zachary A. Goldfarb, "SEC is hiring more experts to assess complex financial systems," *Washington Post*, June 15, 2010.

56 Michel Serres, *The Parasite* (Minneapolis: University of Minnesota Press, 2007), 4.

57 Adler, "Raging Bulls."

58 Noise—as the opposite of information—was first elucidated as a theory of pricing by Fischer Black in "Noise," paper given at the 44th Annual Meeting of the America Finance Association, New York, December 20–30, 1985, published in *Journal of Finance*, vol. 41, no. 3 (July 1986): 529–43.

59 La Fontaine (1668).

60 Andrew Lo, the director of the Laboratory for Financial Engineering at the MIT Sloan School of Management, addressed this problem at a conference on systemic risk and data issues in 2011, referring to a study he conducted on a "quant meltdown" in 2007: "We felt a bit odd about this because […] you know for a fact that there are people out there that know what actually happened but they're not talking. So in fact, this entire paper could be science fiction or it could be dead on, we have no idea. To this day we don't know because nobody is talking. They are not allowed to talk because that would disadvantage their shareholders." Video available at http://youtu.be/nuDIoBeNwDo (see 13:20–13:55), last accessed September 2013.

61 In the thick of the hostile moments of the Flash Crash, Ben Lichtenstein, the "voice of the CME S&P futures pit" exclaimed (to take a single example): "This will blow people out in a big way like you won't believe," Traders Audio, "May 6 2010 Stock Market Crash," May 12, 2010, http://youtu.be/1mC4tu1NhUA.

62 This is the subtitle of the chapter on forensic architecture in Eyal Weizman, *The Least of All Possible Evils: Humanitarian Violence from Arendt to Gaza* (London: Verso, 2012).

63 Goldfarb, "SEC is hiring more experts."

64 Ibid.

65 Its precarious and vulnerable state in informational capitalism might to some extent be conditioned by insufficient coalitions against the global investor/shareholder hegemony—a crucial counterbalance in order to curtail power regimes, which, for instance, trade unions exerted in industrial capitalism.

66 In the light of automated algorithmic practices in which the future is exploited by the generation of microsecond arbitrage opportunities, the future forum will be a counter-future forum where agency is recuperated from the capitalist enclosure of a future-at-present—among many other things by making use of (instead of being used by) algorithmic processes.