WHEN SOFTWARE RULES

RULE OF LAW IN THE AGE OF ARTIFICIAL INTELLIGENCE

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Design by Davonne Flanagan. Cover photo by koya979, (from Shutterstock).

When Software Rules: Rule of Law in the Age of Artificial Intelligence.

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EXECUTIVE SUMMARY

Artificial Intelligence (AI) is changing how our society operates. AI now helps make judiciary decisions, medical diagnoses, and drives cars. The use of AI in our society also has important environmental implications. AI can help improve resource use, improve energy efficiency, predict extreme weather events, and aid in scientific research.

While AI has the potential to improve human interaction with the environment, AI can also exacerbate existing environmental issues. Some form of governance is needed to ensure that AI is deployed in a manner that is beneficial for our environment.

Currently, there is little attention given to the environmental consequences of AI. Semiformal forms of governance in the form of industry led oversight groups are just now becoming popular in the AI sector. As the AI sector begins to consider governance, environmental implications should be a central focus.

In this paper, we provide a brief history of AI and discuss current concerns with AI systems. We provide an overview of potential environmental applications to AI and discuss different possible forms of semiformal and formal governance. Lastly, we provide recommendations for how AI governance can include consideration of environmental impacts.

What the private AI sector should do:

- Develop research teams that holistically evaluate the socio-environmental impacts of their algorithm.

- Assemble multiple stakeholders from AI sectors, human rights sectors, and environmental sectors to help develop and implement guidelines for sustainable development of AI.

- Prioritize using AI for environmental benefits.

- Use the expertise of those engaging in sustainability practices by:

    - Increasing partnerships between corporations and NGOs to assess AI impacts and ensure their ethical development and use.
    - Reaching out to sustainability experts for guidance.

- Tighten communication between those involved in governance and those developing AI to improve understanding and protection of the public and the environment.

- Develop educational materials for law, business, and policy schools to create a generation of competent and informed lawyers and policymakers.

- Be aware of the shortfalls and limits of AI, particularly as related to the environment.

What programmers should do:

- Increase transparency and explainability of algorithms to avoid "black box" decisions.

- Increase commitment to use artificial intelligence to solve environmental issues such as climate change.

- Recognize and evaluate the ethical frameworks under which AI systems are designed to operate and explore alternatives.

What governments should do:

- Adopt a holistic system to assess the impact of AI. Develop guidelines for assessing the environmental impacts of AI systems.

- Dedicate funding to governance and legal research for AI.

- Establish legal guidelines to determine environmental accountability for "black boxes."

- Tighten communication between those involved in governance and those developing AI to improve understanding and protection of the public and the environment.

- Create policies that ensure that systems that use AI are powered by energy efficient or renewable resources. This will help meet the power demand of these new systems while reducing impacts on the environment.

- Create incentives for the development of AI that tackles environmental issues.

What the public should do:

- Advocate on behalf of comprehensive governmental regulations for environmentally relevant AI.

- Make responsible consumer choices by supporting AI companies that are transparent and environmentally conscious.

- Reflect on how AI systems promote specific cultural norms and values.

- Raise awareness and foster critical thinking about potential applications and impacts of AI.

THE POWER OF ALGORITHMS

The Good:

Two years ago, the artificial intelligence group DeepMind applied its machine learning expertise to reduce energy consumption at one of Google's many data centers.[1] Using information regularly gathered at the data center, the machine learning system was able to model energy efficiency performance with an accuracy of 99.6 percent. With DeepMind's AI system, Google reduced the energy use of its already-efficient data center by 15 percent. Data centers in the United States consumed 70 billion kilowatt hours (kWh) of energy in 2014 or 1.8 percent of the total estimated energy consumption in the United States.[2] Data center energy use is projected to increase to 73 billion kWh by 2020. The application of DeepMind's AI system to other data centers could result in massive reductions of the carbon footprint of the cloud computing resources used by businesses and consumers.

The Bad:

In September of 2015, the German car company Volkswagen was at the center of an international environmental scandal. Volkswagen engineers purposefully programmed emissions-regulating software to manipulate the results of emissions tests on their diesel-powered cars, advertised extensively as 'clean diesel models.' The software could recognize when cars were being tested for emissions levels and activate emissions controls of nitrogen oxide gases (NOx gases). However, once on the road, emissions controls were deactivated and NOx emissions increased by up to 40 times.[3] NOx gases are harmful because they contribute to significant health problems, including asthma and other respiratory problems.[4] Subsequent studies indicated that the additional emissions could cause over 1,200 premature deaths in Europe and result in €1.9 million (approximately $2.4 million USD) in lost productivity.[5]

1 Deep Mind, DeepMind AI Reduces Google Data Centre Cooling Bill by 40%, July, 2016, https://deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-40/ (last visited Nov. 29, 2017).
2 A. Shehabi et al., United States Data Center Energy Usage Report (2016).
3 Coral Davenport and Jack Ewing, *VW Is Said to Cheat on Diesel Emissions; U.S. to Order Big Recall,* THE NEW YORK TIMES, Sept. 18, 2015, https://nyti.ms/2jS9COF (last visited Nov. 3, 2017).
4 Environmental Protection Agency, Ozone Basics, https://www.epa.gov/ozone-pollution/ozone-basics#effects (last visited Nov. 3, 2017).
5 Guillaume P Chossière et al., Public Health Impacts Of Excess NOx Emissions From Volkswagen Diesel Passenger Vehicles In Germany, 2017, Environ. Res. Lett. 12 034014, available at http://iopscience.iop.org/article/10.1088/1748-9326/aa5987/pdf.

Once independent researchers at the International Council on Clean Transportation accidentally stumbled upon the discrepancy between test emissions and road emissions, federal and state governments swiftly responded. As of October 2017, Volkswagen will owe more than $20 billion in fines and settlements in the United States alone. Those specifically responsible, including an engineer and a project manager, were brought to court. Other firms operating in the VW supply chain, such as Bosch, were also implicated and fined.[6] In this case, the "bad" software was caught and the responsible parties were held accountable.

The scandal, popularly known as "Dieselgate," is one of the most infamous examples of using artificial intelligence (AI) software with malicious intent. However, the software at the center of the Dieselgate scandal only uses first-generation AI programming: programmers outline what an AI system is able to do and the software operates within those parameters. What happens when an AI system that can program itself starts accidentally producing negative consequences?

The Coin Toss:

Artificial intelligence is also driving the transportation revolution. Self-driving cars are a fast approaching reality that has the potential to change the structure of our society. Self-driving cars can improve traffic safety, reduce congestion, and make commutes more convenient and more productive.

Driverless Cars Are Giving Engineers a Fuel Economy Headache

By **Gabrielle Coppola** and **Esha Dey**
October 11, 2017 5:00 AM EDT *Updated on* October 11, 2017 3:38 PM EDT

***Figure 1*: Driverless cars require an immense amount of power.**

While self-driving cars have the potential to be beneficial for the environment, many researchers are concerned about the potential consequences of this newly convenient mode of travel. Self-driving cars programmed to take the most efficient route and reduce idling could result in reduced fossil fuel consumption and greenhouse gas (GHG) emissions. However, increasing the efficiency of use of a resource can increases the resource's use, a phenomenon known as Jevon's Paradox. Safer and easier driving trips could result in a willingness to tolerate longer commutes and reduced use of public transit systems, bikes, and walking. The advent of self-driving cars might also slow the transition to electric vehicles. According to a recent Bloomberg report, the added weight and energy required to power the computers that run self-driving cars may make it difficult for cars to attain future fuel efficiency

6 David Shepardson and Joseph White, *VW engineer sentenced to 40-month prison term in diesel case,* REUTERS, Aug. 25, 2017, https://reut.rs/2vviwnO (last visited Nov. 3, 2017).

standards. The increased energy use and increased vehicle miles travelled could result in increased GHG emissions, despite gains in driving efficiency.[7]

A recent study from the University of California at Davis found that the environmental impact of self-driving vehicles will depend on how they are integrated into our society. The report finds that to reduce vehicle miles travelled and GHG emissions, self-driving cars must be deployed in shared ownership and ride-sharing fleets as opposed to privately owned vehicles. The report also recommends that self-driving cars should be deployed as zero-emission vehicles and should be designed to increase public transit use rather than replace it. All of these initiatives require strong policies to influence consumer and manufacturer behavior. Ride-share fleets would help to limit the number of trips taken by requiring that consumers pay full price for the ride (as opposed to the sunk cost of owning a car). Improving vehicle and road safety could increase bike ridership and walkability. Policies promoting the use of self-driving cars in combination with public transit options could help provide the "last mile of travel" and increase use of public transit. Governance will play an important role in ensuring that the use of AI-dependent technologies like self-driving cars has beneficial socio-environmental impacts.[8]

Artificial intelligence can be applied to a variety of environmental issues. For instance, algorithms can provide valuable insights into improving resource management and help support land use management decisions, and AI systems can help make agricultural systems more efficient: reducing food waste, fertilizer application, and water use. AI can also help model vulnerable ecosystems, predict weather patterns, and project climate forcing.[9] While the potential benefits of AI to the environment are limitless, there may also be unforeseen consequences. In this paper, we argue that as AI systems become more complicated and opaque in their functioning, we must begin to consider the unintended effects AI may on our environment and consider the role governance can play in mitigating these effects. In the following sections, we define the levels of algorithm complexity and highlight some of the problems algorithms are already causing in our society. We discuss the potential problems algorithms can pose to the environment and finally, provide general recommendations for preventing future "Dieselgates" as well as other unintended, yet still dangerous, consequences.

***Figure 2*: Screenshot of headline from Mongabay (2008)**

7 Gabrielle Coppola and Esha Dey, *Driverless Cars Are Giving Engineers a Fuel Economy Headache,* BLOOMBERG, October 11, 2017, https://www.bloomberg.com/news/articles/2017-10-11/driverless-cars-are-giving-engineers-a-fuel-economy-headache.

8 Circella et al., Keeping VMT And GHGs In Check In A Driverless Vehicle World, UC Davis (2017).

9 Changarno, *Applications of Artificial Intelligence in Environmental Science*, STORIFY.COM, 2014, https://storify.com/changarno/applications-of-artificial-intelligence-in-environ.

THE AI REVOLUTION FINALLY ARRIVES

Three Waves of AI

The term “artificial intelligence” was first used in a 1955 research proposal authored by researchers at Dartmouth, Harvard, IBM Corporation, and Bell Laboratories. The proposal was the foundation for a workshop held at Dartmouth in 1956 that is recognized as the “birth of the field” of artificial intelligence. While AI was “born” in the 1950s, several key advancements to computational science contributed to its foundation, including Alan Turing’s "Computing Machinery and Intelligence" research paper. From the initial workshop, AI projects proliferated over the next three decades. By the 1980s, significant advances had been made in the field of AI. However, they were not seen as applicable to the real world and a result, funding plummeted. The 1990s brought abundant available data sources through the internet and cheaper hardware. These changes fed a resurgence in AI research and have supported the exponential increases in the capabilities of AI over the past few years.[10]

A combination of big data, fast processors, better algorithms, and cash — venture capital investments in AI were almost $3.6 billion in 2016 in the US — has aided significant AI advances in the past three to four years.[11] AI developers are producing tantalizing examples of AI applications such as the medical diagnostic capabilities of IBM’s “cognitive cloud” computer Watson, the new machine learning program from Google’s Magenta project, which wrote a 90-second piano melody, and Uber’s self-driving truck that recently delivered 50,000 cans of Budweiser beer on its first test drive in Colorado.[12]

Artificial intelligence, as defined by the Defense Advanced Research Projects Agency (DARPA), is the programmed ability to process information.[13] Typical AI systems use four mechanisms to process information: perception, learning, abstraction, and reasoning. To define AI systems according to their complexity, DARPA uses a three-tiered classification system. Each tier differs based on the by the shares of each mechanism they use.

10 Peter Stone, Artificial Intelligence and Life In 2030, Stanford University https://ai100.stanford.edu/sites/default/files/ai_100_report_0831fnl.pdf (last visited November 6, 2017).

11 Axios, Venture Capital Investments in AI, https://www.axios.com/venture-capital-investment-in-artificial-intelligence-skyrockets-2446299877.html (visited November 8, 2017).

12 Dave Rejeski, Environmentalism in the Next Machine Age, https://www.eli.org/vibrant-environment-blog/environmentalism-next-machine-age (last visited Nov. 3, 2017).

13 Defense Advanced Research Projects Agency, A DARPA Perspective on Artificial Intelligence, https://www.darpa.mil/attachments/AIFull.pdf (last visited Nov. 3, 2017).

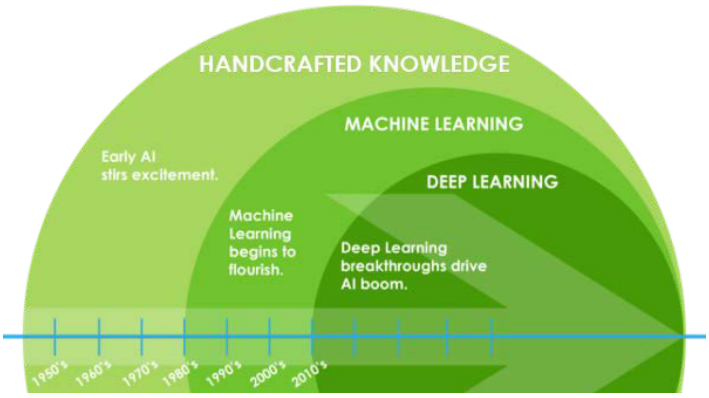


***Figure 3*: Defining Deep Learning, Machine Learning and AI, increasing levels of complexity**[1]

The first and most primitive category identified is “Handcrafted Knowledge”. This is AI at the most basic and general level. The AI system receives information from the world around it and solves problems by executing decisions based on a well-defined data set combined with a set of rules. This type of AI has no ability to learn or abstract and performs poorly when it is faced with uncertainty and in ambiguous situations.. An example of a system with “handcrafted knowledge” is an automated customer service robot that can answer customer queries based on an algorithm that is adept at perception and reasoning.

The second type of AI is “Statistical Learning,” also known as “Machine Learning”. The machine is trained to generate a certain output based on an initial data set fed to the machine. However, the program often fails to adequately abstract or reason outside of its programmed context. Machines with statistical learning capabilities can handle large quantities of multilayered data but are not entirely reliable in their ability to interpret it. For example, a second-wave AI system may be able to learn how to identify an object in a clear, resolute photo but may fail when the photo becomes distorted or when the object appears outside of its normal context.

The third wave of AI is called “Deep learning” and is a subset of machine learning. Deep Learning machines are more advanced in that they are able to improve their accuracy and functioning as they operate. Any data received, even after the initial “training” data set, is used to improve the AI system. This approach can eventually lead to what DARPA has termed "lifelong learning machines (L2M). These AI systems become increasingly less dependent on humans for input and instructions.[14] DARPA is looking to develop deep learning machines that have the capacity to pair their conclusions with explanations of where, when, and why viable alternatives are incorrect or correct. This type of AI may be able to identify a cat in a photo, for example, and then explain its reasoning by listing the features that a cat typically possesses and where in the photo it found these features.[15][16]

14 The objective of the L2M program is to develop a next-generation adaptive artificial intelligence (AI) system capable of continually learning and improving performance in real-world environments. The system will apply previously learned knowledge to new circumstances without pre-programming or training sets, and will update its network based on its situation for a variety of applications of interest to the Department of Defense. See the

15 John Launchbury, A DARPA Perspective on Artificial Intelligence, https://www.youtube.com/watch?v=-O01G3tSYpU (last visited Nov. 3, 2017).

Unintended Consequences

Like its human creators, artificial intelligence is imperfect. Scientists, doctors, programmers, and professionals in all fields are beginning to encounter unforeseen consequences of using AI systems in their work.

For example, COMPAS, a risk-assessment software that produces a score to predict the probability that a criminal will reoffend,[17] has been widely criticized for being racist. The software uses data sets that contain underlying assumptions about where people live, their family history and background, and personality traits.[18] Journalists from ProPublica found that the formula incorrectly labelled black people as likely to commit further crimes at twice the rate as white people, even after controlling for other factors such as age and gender.[19]

BLACK BOXES

Particle physicists working on the Large Hadron Collider (LHC) in Geneva, Switzerland, are enlisting the help of AI to manage huge quantities of data and speed up the process of discovery in using particle accelerators to understand dark matter. Statistical learning algorithms have been useful in the past to find relevant patterns in the data, but as particle collision technology becomes more advanced, machines are becoming overwhelmed by the number of data points to be collected and analyzed. Thus, physicists are relying more and more on AI to sort through data: The AI programs its own algorithm to decide which data to keep and which to throw out. This has physicists concerned about a "black box," as the machine is making decisions to throw out data based only on the task at hand, and may be discarding data that could be relevant to other future experiments yet to be developed. Physicists are also concerned about the "black box" because they want to be able to read the algorithms to be sure they are following the basic principles of physics that constrain results. Developments in deep learning AI may further increase reliance on algorithms in the discovery of dark matter and decrease transparency.

Algorithms have also been criticized for being opaque in their decision-making processes. AI system users and even AI programmers often find it difficult to understand the logic of "deep learning" AI systems that have the capacity to program their own algorithms. An example of an indecipherable AI system is the deep learning program Deep Patient. Deep Patient is a disease-predicting software that uses health data to uncover patterns and accurately diagnose patients at early stages of their diseases. Without a built-in explanatory mechanism, the algorithms that analyze information become a "black box." While Deep Patient can accurately diagnose patients, its "black box" inhibits medical professionals' ability to learn how it arrived at a diagnosis.[20]

16 DARPA website's description at https://www.darpa.mil/news-events/lifelong-learning-machines-proposers-day (last visited Nov. 3, 2017).

17 Matthias Spielkamp, *Inspecting Algorithms for Bias*, MIT TECHNOLOGY REVIEW, June 12, 2017, https://www.technologyreview.com/s/607955/inspecting-algorithms-for-bias/ (last visited Nov. 3, 2017).

18 ProPublica, COMPAS Risk Assessment, https://www.documentcloud.org/documents/2702103-Sample-Risk-Assessment-COMPAS-CORE.html (last visited Nov. 3, 2017).

19 Julia Angwin et al., *Machine Bias,* PROPUBLICA, May 23, 2016, https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing/ (last visited Nov. 3, 2017).

20 Will Knight, *The Dark Secret at the Heart of AI*, MIT TECHNOLOGY REVIEW, April 11, 2017, https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/ (last visited Nov. 3, 2017).

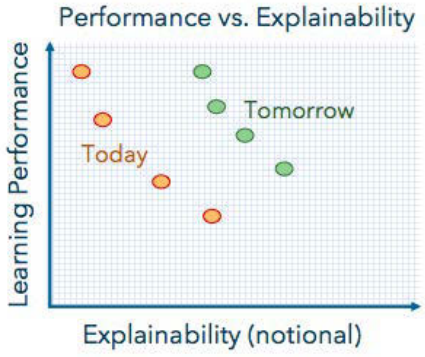


***Figure 4*: Performance vs. Explainability of AI systems**

The issue of the "black box" has led AI developers like DARPA to pursue initiatives in creating "explainable AI", or artificial intelligence systems that can explain the rationale behind their decisions. The goal is to create high-performing AI systems that can then show the user the rationale behind a produced output. DARPA believes that this will improve the accountability of AI systems and increase user confidence in the capacities and limitations of AI systems.[21]

THE IMPORTANCE OF EXTREMES:

Machine Learning algorithms take data and use it to create sets of parameters that produce a likely output. However, considering the unlikely is important in an environmental context. Already we have observed the negative effects of what happens when scientists ignore unlikely or deviant data. In 1978, The United States Congress directed NASA to study the upper atmosphere and in particular the "health" of the ozone layer. NASA developed two new sensors to assess ozone levels in the atmosphere. However, it wasn't until 1985 that British scientists found the hole in the ozone over Antarctica using a different tool. NASA's sensors had been programmed to capture only a weak signal of ozone depletion when in fact ozone was being depleted at a much higher rate than expected. The sensors set aside any data that deviated greatly from the expectation. As a result, NASA scientists missed data that would have indicated a problem for 7 years. As ecosystems and climate systems become more variable and extreme with the unpredictability of climate change, considering data and conclusions that are outside what is "likely" will become imperative to scientific analysis.

Other Sources of Concern in AI

Bias and lack of transparency are two concerns raised by researchers in the AI field. Researchers at the Oxford Internet Institute and Alan Turing Institute summarize the six categories of concerns surrounding algorithms found in a review of the literature:[22]

1. Inscrutable evidence can lead to unjustified actions.
2. Inscrutable evidence can lead to opacity.
3. Misguided evidence fed to algorithms can lead to bias, and unfair outcomes from algorithms can lead to discrimination.
4. Algorithms can cause transformative effects that lead to challenges to individual autonomy.
5. Algorithms are transforming our notions of privacy, and are leading to a lack of privacy.

21 Defense Advanced Research Projects Agency, A DARPA Perspective on Artificial Intelligence, https://www.darpa.mil/attachments/AIFull.pdf (last visited Nov. 3, 2017).
22 Brent Daniel Mittelstadt et al., The Ethics Of Algorithms: Mapping The Debate, Big Data & Society, (2016).

6. A lack of traceability in algorithm processing leads to questionable moral responsibility when algorithms make mistakes.

1. *Inscrutable evidence can lead to unjustified actions.*
   Many algorithms function on the basis of correlation without necessarily proving causality. For example, credit risk calculation algorithms may correlate using a credit card to pay for anything from marriage counseling to tire repairs with increased risk. This correlation does not demonstrate causality thus any risk ascribed by the algorithm is therefore unjustified. [23]

2. *Inscrutable Evidence leads to opacity.*
   Algorithms that use correlations to lead to a determined outcome or action often do not provide explanation or justification for the outcome. The process of determining the outcome is often opaque and unknown. This can reduce transparency and inhibit oversight of algorithms. The algorithms used by Deep Patient are often inscrutable, thus leading to opacity.[24]

3. *Misguided evidence leads to bias, and unfair outcomes lead to discrimination.*
   Algorithms trained on biased data will produce biased results. The COMPAS judicial decision support system is one such example of biased data producing unfair outcomes.[25]

4. *Transformative effects lead to challenges to autonomy.*
   Transformative effects result in a reorganization of how we view the world. Algorithms that filter information and personalize search outputs can nudge the behavior and perceptions of a user by favoring certain pieces of information. This removes the autonomy of the user to use their own values to sort and filter information. This erosion of our personal autonomy by technology is the central critique in Franklin Foer's recent book *World Without Mind*, and has helped give rise to new organizations such as The Center for Humane Technology, a group of former employees of firms like Google and Facebook who are concerned about the personal and social impacts of technologies created by their former companies. [26] In a critique of the increased use of AI technology to improve the functioning of cities, urban researchers argue that creating "Smart Cities" could further contribute to privatization of social services because of the need to contract out the development of AI software solutions to external developers (see box on page 15).[27]

5. *Transformative effects lead to a lack of privacy.*
   Most algorithms related to advertising and filtering rely on sorting users into certain groups based on data about the user. The increased use of data mining by big data companies and

23 Danielle Keats Citron and Frank A. Pasquale III, The Scored Society: Due Process for Automated Predictions, Washington Law Review (2014).
24 Will Knight, *The Dark Secret at the Heart of AI*, MIT TECHNOLOGY REVIEW, April 11, 2017, https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/ (last visited Nov. 3, 2017).
25 Julia Angwin et al., *Machie Bias,* PROPUBLICA, May 23, 2016, https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing/ (last visited Nov. 3, 2017).
26 Foer, F. 2017. *World Without Mind: The Existential Threat of Big Tech*, NY: Random House. Bowles, Nellie 2018. "Early Facebook and Google Employees Form Coalition to Fight What They Built," *New York Times*, Feb. 4.
27 Rob Kitchin, Reframing, Reimagining Rethinking Smart Cities, Maynooth University, (2016).

advertisers has transformed our views on individual privacy as user profiles are increasingly shared, often without our knowledge or consent.

6. *A lack of traceability leads to questionable moral responsibility.*
   When machines develop learning capacity and the ability to make decisions not written into code by a programmer, it becomes more difficult to define the responsible party when things go wrong.

LIABILITY

Much of U.S. law relies on intent to determine liability. For example, involuntary manslaughter is evaluated under the law less harshly than is intentional murder, and thus a lighter sentence is delivered. With statistical learning AI, however, it is difficult to discern intent when there are many potentially responsible parties that contributed to its creation and the AI fails to reveal the source of its decision because of a "black box." Potentially responsible parties may include the owner of the artificial intelligence, the user, the designer, the manufacturer, the programmer, and the algorithm itself.

When things go wrong, who should be held accountable?

Researcher, Ryan Calo at the University of Washington School of Law argues that emergent behavior in second-wave artificial intelligence is not autonomy, and thus, current AI systems do not act with intent.

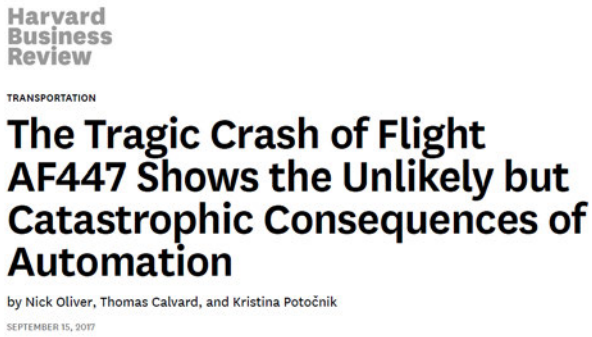
This report is based on Calo's premise that AI systems cannot exhibit intent and therefore as a product of human design, the system itself should not be held liable for harm caused. Further research on who should be held accountable as artificial intelligence systems progress is needed but will not be discussed in this report.

Other sources of concern found in the literature reference an overreliance on automation and a lack of consideration for anomalies and the extreme. Cummings writes that reliance on algorithms can create moral distance — for example, decision support systems in the military diminish users' feelings of agency and responsibility.[28] Reliance on automation has also been shown to decrease situational awareness and reduce skills.[29] While automation has increased safety in the AI industry, AI can be linked to several catastrophic accidents that were a result in pilots' inability to manage the transition from autopilot to manual control.[30] Similar concerns have been raised for self-driving cars. If passengers with little driving experience are suddenly asked to take control of a machine in an "extreme situation," the outcome could be catastrophic.

28 Mary Cummings, Automation and Accountability in Decision Support System Interface Design, Journal of Technology Studies, (n.d.).

29 Mary Cummings, Automation and Accountability in Decision Support System Interface Design, Journal of Technology Studies, (n.d.).

30 Nick Oliver, Thomas Calvard, and Kristina Potočnik, *The Tragic Crash of Flight AF447 Shows the Unlikely but Catastrophic Consequences of Automation*, Harvard Business Review, Sept. 25, 2017, https://hbr.org/2017/09/the-tragic-crash-of-flight-af447-shows-the-unlikely-but-catastrophic-consequences-of-automation.


Harvard Business Review

TRANSPORTATION

The Tragic Crash of Flight AF447 Shows the Unlikely but Catastrophic Consequences of Automation

by Nick Oliver, Thomas Calvard, and Kristina Potočnik

SEPTEMBER 15, 2017

Figure 5: **Harvard Business Review**

While planes and cars present high-risk scenarios for automation, the Harvard Business Review argues that "everyone has their equivalent of autopilot" and that the safety and perceived reliability of automated AI systems may make it difficult for humans to act in situations that are extreme or outside of the norm.[31] For example, if a decision support system algorithm designates an individual applying for welfare as not eligible for the receipt of social assistance, a social services worker may find it too difficult to make an effort to override the system in special cases.[32]


ANDY GREENBERG SECURITY 07.21.15 06:00 AM

HACKERS REMOTELY KILL A JEEP ON THE HIGHWAY—WITH ME IN IT

Figure 6**: Already researchers have demonstrated the ability to hack into and control a car from miles away.**

Lastly, an increased reliance on machines and algorithms increases the likelihood of systems hacking. For example, the adoption of interconnected smart grids in cities renders energy systems, transportation systems, and any interconnected systems vulnerable to hacking.[33] In the Amazon Forest in Brazil, programmers hacked into the electronic permit system to give out logging permits to logging companies.[34] As algorithms become more integrated into our livelihoods the consequences of hacking become more severe. Already researchers have demonstrated their ability to take control of a car

31 Nick Oliver, Thomas Calvard, and Kristina Potočnik, *The Tragic Crash of Flight AF447 Shows the Unlikely but Catastrophic Consequences of Automation*, Harvard Business Review, Sept. 25, 2017, https://hbr.org/2017/09/the-tragic-crash-of-flight-af447-shows-the-unlikely-but-catastrophic-consequences-of-automation.

32 Amitai Etzioni and Oren Etzioni, AI Assisted Ethics, Ethics and Information Technology (2016).

33 Cerrudo Cesar, An Emerging Us (and World) Threat: Cities Wide Open to Cyber Attacks, https://ioactive.com/pdfs/IOActive_HackingCitiesPaper_CesarCerrudo.pdf. (2015)

34 Rhett A. Butler, *Computer Hackers are Helping Illegal Loggers Destroy the Amazon Rainforest*, MONGABAY, 2008, https://news.mongabay.com/2008/12/computer-hackers-are-helping-illegal-loggers-destroy-the-amazon-rainforest/.

through the computerized parts of an engine (See figure 6).[35] Self-driving cars that are fully computerized offer more potential routes for hacking.

FORMS OF GOVERNANCE: THE SOCIAL CONTRACT AND AI

When socio-political issues such as data privacy, safety, and environmental health enter the public sphere, often, the rule of law is not immediately applied. Before a socio-political issue is formally regulated, it passes through several stages of the social contract. The path to formalized regulation begins when citizens, research institutions, and the media raise concerns and awareness about a new issue. This stage of the social contract is the "Frontier Expectations" stage where the public establishes a moral code around a certain issue. As norms are established around a certain issue, institutions adopt these norms to appeal to stakeholders and investors.

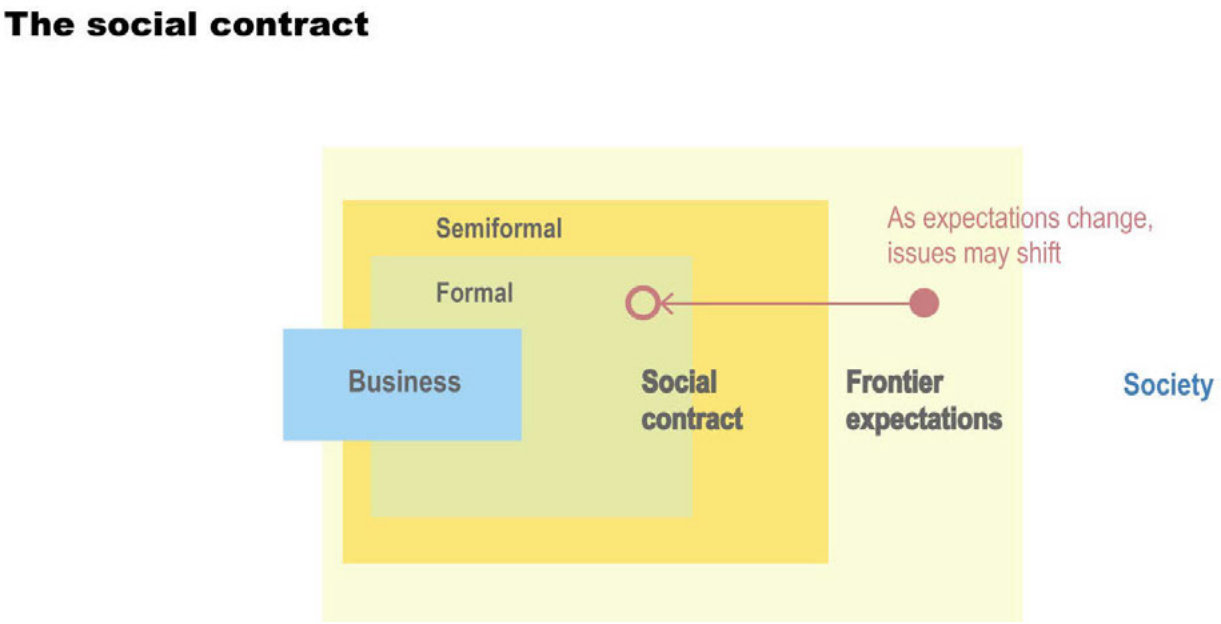


***Figure 7*: The Social Contract (McKinsey Quarterly, 2006)**

Formal contract

- Explicit expectations, usually laws
- Regulation
- Tax policy
- Private contracts
- Intellectual property
- Shareholder rights
- Product Liability

Semiformal Contract

- Implicit Expectations
- Adhere to global labor, environmental standards
- Follow industry norms, codes of conduct
- Fulfill brand promises
- Violations result in swift action by stakeholders eg NGOs, local and global communications

Frontier Expectations

- Issues that could over time become expectations of business (e.g. health implications of obesity create expectations for food and beverage companies)

35 Andy Greenberg, *Hackers Remotely Kill A Jeep On The Highway—With Me In It*, WIRED, July 21, 2015, https://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/ (last visited Nov. 3, 2017).

This is known as the semiformal contract stage. Lastly, in the formal contract stage, the government codifies expectations for engaging with the issue.[36] Issues of sustainability and environment are already flushed out in the semiformal and formal stages. Institutions from universities to corporations have clear policies asserting their commitment to environmental sustainability. Laws such as the Clean Air Act, Clean Water Act, and the National Environmental Policy Act (NEPA) all provide formalized enforcement of environmental protection. However, the social contract for AI systems is only just transitioning from the "frontier expectation" stage to the "semiformal" stage of governance.

AI and Individual Semiformal Contracts: Voluntary Codes

Forward-thinking minds such as Stephen Hawking and Elon Musk have signed onto voluntary codes outlining engagement with artificial intelligence research.[37] The principles promote development of AI that is reflective of human values, is transparent, respects personal privacy, and promotes the benefit of all human beings.[38] The Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems (IEEE) outlines three principles for guiding ethics in artificial intelligence in a lengthy report: Artificial Intelligence should embody the highest of human ideals, maximize benefit for humans and the natural environment, and should mitigate any negative impacts associated with future AI. The White House's "Preparing for the Future of Artificial Intelligence" report provides 40 recommendations for governmental engagement with AI. The majority of these codes and guidelines concern issues of equity, economics, and socio-cultural organization. While these issues require immediate attention, addressing how algorithms will impact our environment is equally important. Exclusion of environmental impacts from our frameworks of values and concerns could exacerbate problems such as climate change and air pollution that are already affecting our society.

Few of the guidelines and codes mentioned above address environmental sustainability and those that do, mention it only in passing or are not widely recognized. For example, The Biosphere Code[39] outlines guidelines for creating environmentally friendly algorithms. However, the code does not seem to be well-recognized within the sphere of AI developers. Although the IEEE report mentions the environment in its principles, the report does not explore issues of potential environmental impacts. The White House's "Preparing for the Future of Artificial Intelligence" report mentions the various benefits AI in environmental assessments but does not explore areas where algorithms could be detrimental to the environment.[40]

As AI moves from societal expectations to semiformal social contracts in the social political sphere, these environmental impacts merit exploration.

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36 Mckinsey & Company, When Social Issues Become Strategic, The McKinsey Quarterly, (2006).

37 Future of Life Institute, Asilomar AI Principles, https://futureoflife.org/ai-principles/ (last visited Nov. 3, 2017).

38 Association for Computing Machinery, Statement on Algorithmic Transparency and Accountability (2017), available at https://www.acm.org/binaries/content/assets/public-policy/2017_usacm_statement_algorithms.pdf.

39 Victor Galaz et al., The Biosphere Code Manifesto, http://thebiospherecode.com/index.php/manifesto (last visited Nov. 3, 2017).

40 Executive Office of The President National Science and Technology Council Committee on Technology, Preparing for the Future of AI (2016), available at https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf.

SMART CITIES

The "Smart City" is a popular concept in urban planning. "Smart Cities" represent efficiency, control, and planning in the chaos of a rapidly urbanizing society. Smart Cities use data to improve efficiency in areas such as policing, traffic control, disaster management, and energy use. While improved efficiency is attractive, some argue that broader implications of these changes on urban societies are not considered. Rob Kitchin an urban researcher at Maynooth University in Ireland is concerned that "Smart Cities" could result in top-down decisions that fail to take local stakeholder input. Cities are dynamic and diverse places, treating the city as a single entity could result in increased economic disparity and further marginalization of already disadvantaged communities. The use of smart technology may result in the corporatization of public spaces and livelihoods. Cities may become dependent on certain technologies or corporations, creating a "technological lock-in." Moreover, private companies who administer these new technologies may be more concerned with private revenue than public good. A recent study on the use of "Smart City" technology in the UK found that most technologies did not result in improved environmental quality. Smart city technologies often do not prioritize the environment, because programmers are not incentivized to do so.

Marshall Brown, an architect at the University of Illinois, expresses his concern for pervasive use of technologies in cities: "A city is not a problem to be solved. A city is a cultural construct... A city is not science alone."

AI and Semiformal Contracts: Institutions Self-govern

Organizations are already engaging in "self-governance" by looking to create "ethical" artificial intelligence systems that adhere to moral codes. DARPA recently launched a funding program in explainable AI to close the gap between the performance of AI systems and their ability to explain their behavior to humans, though program director David Gunning commented that this may be a difficult gap to close given rapid advances in machine learning.[41] However, transparency in AI systems decision-making can help create accountability.

DARPA is not the only group concerned with AI systems. Between 2014 and 2017, funding for "AI Safety" has increased from $1.75 million in 2014 to $9.09 million in 2017. Concern across sectors has also increased. In 2014, only nonprofit organizations funded AI Safety research. In 2017, nonprofit organizations, academic institutions, and industry funded AI Safety research. [42]

AI research groups like Open AI and DeepMind have started thinking about how to develop AI systems that act in alignment with human society. Google's artificial intelligence research group, DeepMind, recently assembled a research group on AI, ethics, and society. The goal is to use a holistic approach to

41 Gunning, David, Explainable Artificial Intelligence (XAI), DARPA, Personal communication, October 2017.

42 Seb Fahuqar, Changes in funding in the AI Safety field, AI Impact, February 20, 2017, https://aiimpacts.org/changes-in-funding-in-the-ai-safety-field/ (last visited Nov. 6, 2017).

assess the impacts of artificial intelligence systems on society. Encouragingly, members and advisors of the group include AI experts as well as philosophers and climate change experts.[43]

Voluntary conglomerates of corporations can also play a role in self-governance. Already, other industry groups exist to address areas of societal concern. For example, the World Business Council for Sustainable Development (WBCSD) is made up of 200 major corporations dedicated to sustainable practices. However, the WBCSD consists of mostly non-digital companies; IT and telecom companies make up only 4 percent of the more than 200 members of the WBCSD. The Partnership on AI to Benefit People and Society is specifically geared towards addressing issues of AI in society. Founded in 2016 by tech industry giants like Amazon, Apple, Facebook, Google, IBM, and Microsoft, the Partnership works together to bring experts to work on issues such as climate change, food access, and inequality.[44] As the AI sector progresses, self-governance organizations like these can play an important role in facilitating semiformal contracts.

Other actors such as nongovernmental organizations (NGOs) can play an important role in semiformal governance as well. Corporations already partner with NGOs to ensure that they are engaging in sustainable business practices. For example, Walmart and the Environmental Defense Fund have been partners in working to make Walmart a more "environmentally friendly" corporation since 2006.[45] NGOs could play a similar role in the artificial intelligence sector, offering guidance on algorithmic development and proving third-party validation of performance objectives.

NGOs can also play a role in convening stakeholders to address issues of AI and the environment. The Environmental Law Institute and the Center for Law, Energy and Environment at Berkeley School of Law recently held a conference to convene, researchers, lawyers, engineers and computer scientists to "create a community of interest" around AI and the environment. Gatherings like these can help foster understanding across the tech industry and lawmakers and can help develop standards of practice that benefit all stakeholders.

43 DeepMind Ethics & Society, Key Ethical Challenges, https://deepmind.com/applied/deepmind-ethics-society/research/ (last visited Nov. 3, 2017).

44 The Partnership for the Benefit of People and Society https://www.partnershiponai.org/#s-our-work.

45 Even Walmart has started using AI driven machines: Walmart Uses Self-Driving Technology for Floor Cleaners. Potential areas of environmental governance include monitoring dispensary of chemicals used for cleaning that could affect environmental health.

***Figure 8*: Source: Microsoft Blog, July 12, 2017**

AI and Formal Contracts: Legislation and Governmental Oversight

Researchers, lawyers, and journalists have already discussed the need for algorithmic accountability to protect consumers. The areas of judicial decision-making, targeted internet advertising and credit score ranking have received attention due to possible discriminatory effects.

At the federal level, little regulation exists to protect consumers from faulty algorithms. However, there are laws that apply to processes in which algorithms are used. The Federal Data Mining Act requires any federal organization or organization working for the federal government to report any data mining activities conducted and assess potential impacts on individual privacy.[46] The E-Government Act similarly requires a Privacy Impact Statement for federal agencies using any technology that includes the "collection, maintenance, or dissemination" of information.[47] Commercial regulation of data privacy

WHOSE VALUES?

While AI systems are perceived to be unbiased, they inevitably are programmed with the values of the programmer. The capacity for AI systems to include different value systems has important social equity implications across all potential applications of AI. However, this is especially important in environmental decision-making processes. Due to the connectivity of ecosystems, environmental decisions have much broader impacts that span a variety of cultures. Using a single value framework in an AI system that is perceived to provide unbiased results, can result in environmental consequences that have unfair impacts on cultures that may not subscribe to those values. We should continuously ask the question: Whose values are being applied in AI decision making systems?

A basic example: An environmental justice ethic might prioritize avoiding negative impacts on already vulnerable populations while a preservation ethic might promote decisions that maintain pristine natural spaces.

46 42 U.S.C. § 2000ee–3 (2007).
47 44 U.S.C. § 101 (2002)

with FCC regulations prohibiting telecommunications companies from selling data without explicit individual permission were signed into law in 2016. However, these regulations were rolled back before their implementation in March of 2017.

The Fair Credit Reporting Act and Equal Credit Opportunity Act regulate credit scoring and, by extension, the algorithms that generate credit scores.[48] The Fair Credit Reporting Act requires that creditors maintain accurate information on the potential borrowers, thus requiring algorithms to use accurate data. The Equal Credit Opportunity Act requires that creditors not discriminate based on age (of adults), race, religion, gender, marital status, country of origin, or on whether the borrower receives public assistance. Creditors must also provide an explanation for an "adverse action" taken against a borrower. This aspect of the ECOA was adopted by the Federal Reserve Board as Regulation B. Regulation B requires credit score algorithms to list up to four factors that influenced a credit score. While not at all comprehensive, Regulation B does require some level of algorithmic transparency.[49]

The health care field has also taken steps toward regulating medical devices that use algorithms in high-risk situations. The 21st Century Cures Act[50] promulgates guidelines for the regulation of machine learning Clinical Decision Systems (CDS) that help diagnose diseases. The act requires regulation for high-risk machine learning CDS that are not transparent in their decision-making process. To facilitate

EIS FOR AI?

Under the National Environmental Policy Act of 1969 (NEPA), any major federal action must undergo an assessment of environmental impact. These actions may include any private actions that require federal approval (such as a transportation project etc.) To satisfy NEPA, decision makers must prepare an Environmental Impact Statement (EIS), a report that details adverse environmental effects and irreversible use of resources as well as an exploration of alternative actions. NEPA is an important tool for ensuring environmental accountability across all sectors.

As the scale and reach of AI applications expand, NEPA could offer a potential tool for ensuring environmental compliance and avoiding harm. For example, requiring an EIS for self-driving cars could require an assessment of all potential end uses. An EIS would ensure that all negative environmental impacts, such as endangered species threats and air pollution, are evaluated. EIS could incentivize the production of AI systems that produce minimal environmental impacts, while also holding AI programmers accountable to environmental regulations.

Given the "black box of AI" assessing and predicting outcomes may prove to be difficult. Further legal research into the potential applicability of NEPA to AI systems is warranted as the field progresses.

48 Andrew D. Selbst and Solon Barocas, Regulating Inscrutable Systems (n.d.), available at http://www.werobot2017.com/wp-content/uploads/2017/03/Selbst-and-Barocas-Regulating-Inscrutable-Systems-1.pdf.

49 ANDREW D. SELBST AND SOLON BAROCAS, REGULATING INSCRUTABLE SYSTEMS (n.d.), available at http://www.werobot2017.com/wp-content/uploads/2017/03/Selbst-and-Barocas-Regulating-Inscrutable-Systems-1.pdf.

50 21st Century Cures Act 114th Congress, House Bill 6

the regulation of digital advancements in the health field, the FDA is assembling a Digital Health Unit whose responsibilities will include developing oversight for machine learning CDS.[51] So far, the FDA has published user fee application guidelines for these regulated medical devices but guidelines for the devices themselves and the algorithms they use have not yet been put forth.[52]

Outside of the United States, the European Union has taken measures to regulate how algorithms engage with citizens' data. The General Data Protection Regulation (GDPR), which goes into effect in 2018, gives citizens more authority over their own data. The GDPR requires that citizens know the data that data controllers have and how they use the data. Citizens also have the right to know about any automated decision made using their data as well as "meaningful information" about the logic behind any automated decision-making processes (as in the case of profiling).[53] Some argue that this aspect of the GDPR will require that all algorithms be able to explain their logic in producing a certain output. This could potentially usher in new transparency in algorithms in the EU.

In the US, the environmental laws of the 1970s could play a role in avoiding harmful environmental impacts. However, no regulations address the potential environmental concerns that can and already have arisen with the use of AI systems.

Programming Ethical AI systems

Researchers have promoted different methods for avoiding negative impacts of AI systems. Christian Sandvig suggests the equivalent of a "Consumer Reports" for algorithms. These algorithms would be audited by a trusted third party using an "audit study," a method in which false data is used to test the algorithm.[54] Researchers at Open AI and DeepMind suggest that AI systems can be trained on a set of data and then corrected by human computer scientists to achieve the desired unbiased output.[55]

Many researchers, from the military to journalists, have called for increased algorithmic transparency. Increased algorithmic transparency allows users to determine whether the parameters used by an AI system are in line with their moral codes. Nicholas Diakopolous, a journalist who has focused on the use of algorithms in media, promotes transparency in understanding the actors using and directing algorithms, what data is being used, the inferences made by an algorithm, and simply when an algorithm is being used.[56]

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51 Jeremy Hsu, *FDA Assembles Team to Oversee AI Revolution in Health*, IEEE SPECTRUM, May 29, 2017, https://spectrum.ieee.org/the-human-os/biomedical/devices/fda-assembles-team-to-oversee-ai-revolution-in-health (last visited Nov. 3, 2017).

52 John Graham, *Artificial Intelligence, Machine Learning, And The FDA*, FORBES, Aug. 19, 2016, https://www.forbes.com/sites/theapothecary/2016/08/19/artificial-intelligence-machine-learning-and-the-fda/#64644be41aa1 (last visited Nov. 3, 2017).

53 ANDREW D. SELBST AND SOLON BAROCAS, REGULATING INSCRUTABLE SYSTEMS (n.d.), available at http://www.werobot2017.com/wp-content/uploads/2017/03/Selbst-and-Barocas-Regulating-Inscrutable-Systems-1.pdf

54 CHRISTIAN SANDVIG, WHEN THE ALGORITHM ITSELF IS RACIST (2016) http://ijoc.org/index.php/ijoc/article/download/6182/1807.

55 Shane Legg et al., Learning Through Human Feedback, DeepMind Blog, June 12, 2017, https://deepmind.com/blog/learning-through-human-feedback/

56 NICHOLAS DIAKOPOULOS, ALGORITHMIC ACCOUNTABILITY IN DECISION MAKING, 2016, https://pdfs.semanticscholar.org/e749/658ed9354d66d4d9b3588270ea0ad2ef0687.pdf.

Ryan Calo at the University of Washington School of Law and Kate Crawford at Microsoft promote a social systems method for assessing the impact of algorithms. They argue that although the focus of algorithms is narrow, their impact is broad. Assessing the scope of their impact across society would provide a holistic view of how our society is changing as we interact with algorithms. This method could include the impacts on our environment.

Recommendations

Advances in AI technology are progressing at such a rapid rate that societal norms and laws simply cannot keep up. As the AI social contract advances from the informal to the semiformal and formal stages, environmental issues must remain at the forefront, prompting our concerns, shaping our questions, and framing our solutions. This paper proposes the following recommendations for future AI governance:

What the private AI sector should do:

- **Develop research teams that holistically evaluate the socio-environmental impacts of their algorithm**. The AI group DeepMind recently assembled a team of expert dedicated to understanding AI impacts**.** The Partnership on AI to Benefit People and Society is a group of tech industry companies dedicated to evaluating issues around AI. Groups like these can help provide the "ethics" side of algorithm development. These groups are recent additions to the tech sector and have yet to make meaningful contributions to governance. However, their presence suggests that AI companies are moving in the right direction.

- **Assemble multiple stakeholders from AI sectors, human rights sectors, and environmental sectors to help develop and implement guidelines for sustainable development of AI.** Conferences such as the UC Berkeley Law School's "Exploring the Impacts of Artificial Intelligence on Energy & the Environment" are useful for promoting progress and sharing knowledge on the intersection of AI and the environment.

- **Prioritize using AI for environmental benefits**. Microsoft's new AI for Earth program funds projects that use AI for environmental projects including tracking diseases through mosquitoes and mapping pollution sources on the Chesapeake.[57] DeepMind's model to increase energy efficiency at Google data centers also prioritizes environmental benefits. Efforts should be made to use AI to tackle socio-environmental issues.

- **Use the expertise of those engaging in sustainability practices by:**

    - I**ncreasing partnerships between corporations and NGOs to assess AI impacts and ensure their ethical development and use**. Partnerships like these exist with brick and mortar corporations like Walmart. This model could be useful for guiding and improving sustainability initiatives at AI corporations.

57 Microsoft, AI for Earth, https://www.microsoft.com/en-us/aiforearth (last visited Nov. 6, 2017).

    - **Reaching out to sustainability experts for guidance.** The Partnership on AI to Benefit People and Society plans on including expert advice in addressing social issues.

- **Tighten communication between those involved in governance and those developing AI to improve understanding and protection of consumers.**

- **Develop educational materials for law, business, and policy schools to create a generation of competent and informed lawyers and policymakers.**

- **Be aware of the shortfalls and limits of AI, particularly as related to the environment, and find creative ways to patch shortfalls:** For example: AI system users should be trained in the case that AI systems fail.

What programmers should do:

- **Increase transparency and explainability of algorithms to avoid "black box" decisions.** To maintain control on AI decision-making, we need to understand how these systems function. Programmers recently developed "Auto-AI," or AI systems that can program AI systems. At this level of complexity, our ability to understand and explain AI systems decisions is already being outpaced by AI capabilities.[58] Explainability is important to understanding how harmful environmental impacts are produced so that they can be avoided in the future.

- **Increase commitment to use artificial intelligence to solve environmental issues such as climate change and resource use.** A recent study by the Environmental Industries Commission finds that the incorporation of "smart technology" into city systems does not always increase citywide sustainability. The report finds that often "smart technology" does not prioritize environmental benefits so efforts need to be made to ensure that environmental considerations are integrated into the technology development criteria.[59]

- **Recognize and evaluate the ethical frameworks under which algorithms are designed to operate and explore alternatives**. Ask "whose values are being programmed into AI systems?" Many argue that the tech industry is inherently biased based on the social context and values of the programmer.[60] Understanding these biases and value frameworks used in programming can help avoid AI systems that have unintended impacts.

What governments should do:

- **Adopt a holistic system to assess the impact of artificial intelligence. Guidelines for assessing the environmental impacts of AI systems should be developed.** This system should include social, cultural, and environmental impacts both within and outside of the scope of the artificial

58 Cade Metz, Building A.I. That Can Build A.I., (2017) https://nyti.ms/2j6kPgE (last visited Nov. 29, 2017).

59 The Environmental Industries Commission. Getting the Green Light: Will Smart Technology Clean Up City Environments?, 2015, http://img.thupdi.com/news/2015/08/1440491623478512.pdf.

60 Kate Crawford, *Artificial Intelligence's White Guy Problem,* THE NEW YORK TIMES, June 25, 2016, https://www.nytimes.com/2016/06/26/opinion/sunday/artificial-intelligences-white-guy-problem.html.

intelligence system's task. Holistic assessment mitigates potential risks that may exist beyond the scope of the system's functions.

- **Dedicate funding to governance and legal research for AI.**

- **Establish legal guidelines to determine accountability for "black boxes."** The European Union's forthcoming General Data Protection Regulation may provide an example for future regulation in the United States. This is already occurring for some AI system applications such as AI in medical devices.[61]

- **Tighten communication between those involved in governance and those developing AI. Better communication will improve lawmaker understanding and protection of consumers and their environment.** Researcher Marshall Brown noted that the public sector tends to "surrender" to the pace and complexity of technological advancement. Better communication between AI developers and educated lawmakers can help the government maintain their role as a protector of consumers.

- **Ensure that AI systems are powered by renewable energy to meet the power demand of these new systems while reducing impacts on climate change.**

- **Create incentives for the development of AI that tackle environmental issues.** The government should encourage the development of AI systems that address environmental issues and foster a culture of innovation around the environment.

What the public should do:

- **Advocate on behalf of comprehensive governmental regulations for sustainable AI.**

- **Make responsible consumer choices by supporting AI companies that are transparent and environmentally conscious.**

- **Reflect on how AI systems promote specific cultural norms and values.**

- **Raise awareness and foster critical thinking about potential applications and impacts of AI**. Media outlets like ProPublica, Wired, The New York Times, and Medium have played an important role in discussing issues surrounding AI.

The Dieselgate scandal has long since faded from headlines, but the time to act on environmental governance of AI has not passed. Every day, new types of unimaginably complex AI systems are being developed and our systems of governance must keep pace. Without some form of governance, be it

61 Jeremy Hsu, *FDA Assembles Team to Oversee AI Revolution in Health*, IEEE SPECTRUM, May 29, 2017, https://spectrum.ieee.org/the-human-os/biomedical/devices/fda-assembles-team-to-oversee-ai-revolution-in-health (last visited Nov. 3, 2017).

semiformal or formal, algorithms will become increasingly opaque in their functioning and increasingly difficult to understand and limit. Without knowledge of how or why the AI operates, it is impossible to assess future impacts on the environment and ensure compliance with existing environmental regulations.

As AI governance becomes a societal expectation and is later bound by semiformal or formal contracts, the environment must be a central focus in AI discourse and subsequent laws and policy. Governments must develop the mechanisms to prevent future Dieselgates, and companies must be disincentivized to produce them. We recommend a collaborative and holistic approach to AI governance that encourages multilateral participation, oversight, and transparency. Through increased accountability and cooperation among sectors, AI can be harnessed to work for the environment, not against it.

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