Emerging Tech LDT:

Open Source Artificial Intelligence

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Abstract

1.A. Synopsis

The Emerging Technology Final Report on Open Source Artificial Intelligence will dissect open source Artificial Intelligence (AI) and examine the advantages and disadvantages for companies to be so open by sharing their expertise and experiments. The development and adoption of AI-enabled technologies will transform how people live and work and interact. Technology companies that choose to develop open source AI want to scale and market share while seeking to build safe and beneficial tools that will maximize profits and enhance the quality of life for all. In exploring these topics, we researched the history of open source and the motivational drivers of both technology companies and the developers that contribute to the open source community. The authors of this report also developed and distributed a survey on open AI to gather insights on how experts believe AI will evolve and impact the industry, society, and the future workforce. The first half of the paper will cover the history of open source software, address why technology companies and software engineers choose to open source their code and make a case for open source AI. The second half of the paper will dive into the results of the Perceptions of Open AI survey and will explore major open-source Machine Learning software packages as well as open AI experiments.

1.B. Introduction

"*AI is one of the most important things humanity is working on. It is more profound than...electricity or fire,*" Sundar Pichai - Google[1]

Superintelligence may be the last invention humans ever need to make. - Nick Bostrom[2]

"*I have pretty strong opinions on this. I am optimistic. I think you can build things and the world gets better. But with AI especially, I am really optimistic..And I think people who are naysayers and try to drum up these doomsday scenarios — I just, I don't understand it. It's really negative and in some ways, I*

[1]Clifford, Catherine. "Google CEO: A.I. Is More Important than Fire or Electricity." *CNBC*, CNBC, 1 Feb. 2018, www.cnbc.com/2018/02/01/google-ceo-sundar-pichai-ai-is-more-important-than-fire-electricity.html.
[2] Cognitive, Emotive and Ethical Aspects of Decision Making in Humans and in Artificial Intelligence, Vol. 2, ed. I. Smit et al., Int. Institute of Advanced Studies in Systems Research and Cybernetics, 2003, pp. 12-17

actually think it is pretty irresponsible. In the next five to 10 years, AI is going to deliver so many improvements in the quality of our lives." Mark Zuckerberg, co-founder of Facebook[3]

"*I think the danger of AI is much greater than the danger of nuclear warheads by a lot and nobody would suggest that we allow anyone to build nuclear warheads if they want. That would be insane. And mark my words, AI is far more dangerous than nukes. Far. So why do we have no regulatory oversight? This is insane.*" Elon Musk[4]

"*As a technologist, I see how AI and the fourth industrial revolution will impact every aspect of people's lives*." - Fei Fei Lei, Professor of Computer Science at Stanford University and the Co-Director of Stanford University's Human-Centered AI Institute[5]

"We see that diversity improves innovation, and the technology itself..." If people from a variety of backgrounds are building AI systems, "it will better reflect society." - Tess Posner, CEO of AI4ALL[6]

No matter which AI thought leader you agree with or AI camp you sit in, all can agree that there are powerful implications of Artificial Intelligence (AI) and AI-enabled technologies on quality of life, economic mobility and disparity, and the future of work. Most Americans believe that the rise of AI will positively impact society and the economy, but have concerns about safety, data privacy, and the threat of job displacement as a result of automation.[7] This is a desire among many to have algorithmic explainability and fairness, and concerns about what is perceived to be a 'black box technology.' Is a better decision or outcome more important than understanding the mechanism used to get to that final outcome? AI developers and regulators, alike, will need to set a standard for AI explainability and fairness as neural networks get deeper and algorithms get smarter. Artificial General Intelligence (AGI) may be a few decades away, but how the government, private, and education sectors approach AI today and more broadly, data privacy, will transform thought leadership, implementation, and regulation across all sectors.

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[3]Clifford, Catherine. "Facebook CEO Mark Zuckerberg: Elon Musk's Doomsday AI Predictions Are 'Pretty Irresponsible'." *CNBC*, CNBC, 24 July 2017,
[4] Clifford, Catherine. "Elon Musk: 'Mark My Words - A.I. Is Far More Dangerous than Nukes'." *CNBC*, CNBC, 14 Mar. 2018,
www.cnbc.com/2018/03/13/elon-musk-at-sxsw-a-i-is-more-dangerous-than-nuclear-weapons.html.
[5] Hempel, Jessi. "Melinda Gates and Fei-Fei Li Want to Liberate AI from 'Guys With Hoodies.'" *Wired*, Conde Nast, 17 June 2017,
www.wired.com/2017/05/melinda-gates-and-fei-fei-li-want-to-liberate-ai-from-guys-with-hoodies/.
[6] Deirdre Bosa, Laura Batchelor. "A.I. Industry Suffers from Deep Gender Gap, World Economic Forum Says." *CNBC*, CNBC, 18 Dec. 2018,
www.cnbc.com/2018/12/17/ai-industry-suffers-from-deep-gender-gap-world-economic-forum-says.html.
[7] Gallup, Inc. "Are Americans Ready for the Artificial Intelligence Revolution?" *Gallup.com*, Gallup, 5 Mar. 2019, news.gallup.com/reports/226475/gallup-northeastern-artificial-intelligence-report.aspx.

AI did not spark the open source revolution, but it is a well-documented technology in open source project platforms such as Github. In 2018, Facebook had nearly 500 active open source projects on Github including Pytorch, it's Python-based Deep Learning Platform.[8] In addition to hosting projects, developers employed by top technology companies are contributing to open source projects on these platforms. Sarah Novotney, Head of Open Source Strategy at Google Cloud Program (GCP) was quoted in saying, "*We have more than 20 million lines of code we have contributed to open source projects on GitHub, and in 2017 Googlers contributed nearly one percent of total pull requests on GitHub*."[9] Why would a $7B company like Google open source its code and encourage employees to work on open source projects during the work day? What is the motivation of the Google employee to work on an open source project, and why would an external contributor choose to contribute to a Google-initiated project? There is an economic argument to be made, but research shows how the networked information economy is driven by non-monetary factors such as social connectedness and paying it forward.[10]

Understanding the history of open source technology as an established community may shed light on the rise of open source AI software, and allow researchers to compare growth and adoption of open source ML tools such as Google's Tensor Flow and Amazon's MXNET to other open source technologies using a common framework. Interoperability of web platforms to host open source AI software is also an interesting business decision to explore. For example, the Amazon Web Services (AWS) platform is positioned to host its own ML product, MXNet in addition to Google's Tensor Flow and Facebook's PyTorch, and finds interoperability as a method to build capacity and provide a suite of services to its customers. Finally, the Perceptions of Open AI Survey results will shed light on what educators and technologists perceive as the impact of AI on the future of work, and more broadly, quality of life. Analyzing the perceived concerns and risks of AI can also explain why many technologists agree that working in the open and setting ethical and security standards for AI is critical to addressing issues of bias and fairness universally.

[8] Marcey, Joel, et al. "Open Source: 2018 Year in Review." *Facebook Code*, 2 Jan. 2019, code.fb.com/open-source/open-source-2018/.
[9]Carey, Scott. "How Google Decides to Open Source Its Technology." *ComputerworldUK*, 3 Aug. 2018, www.computerworlduk.com/open-source/how-google-decides-open-source-its-technology-3681832/.
[10] Benkler, Yochai. The Wealth of Networks : How Social Production Transforms Markets and Freedom. New Haven [Conn.] :Yale University Press, 2006.

2. History of the Open Sourcing Community

A culture of collaboration and information sharing in technology in software development has existed for decades, and given a name, Free Open Source Software (FOSS), in the 1980s.[11] Developers were freely licensed to use FOSS to use, copy, or iterate, and had full access to the software's source code, which was made available by developers of proprietary software.[12] For the purpose of this report, Open Source Software (OSS) will be defined as software is "open" to outside developers to use, modify, and distribute without a license.[13] Its origin stems from the academic community where collaboration and information sharing was the norm, and academic institutions would share research freely with corporate laboratories. STEM disciplines have historically leaned into openness, and many early innovations in AI were discovered in university labs. The book *Wealth of Networks* makes a similar argument that the networked information economy was made up not only economic structures but also technological advancements and social practices such as that enabled non-market, cooperative production.[14]

In response to the shutdown of the Massachusetts Institute of Technology's Intelligence Lab in the 1980s, an open source movement began that included the development of OSS licenses and the start of a free software community. Richard Stallman, an open source movement activist, and programmer, started the first OSS community in 1983 called the GNU project, seeking to develop an open source operating system.[15] Interestingly Stallman also referred to by his initials, 'rms,' began his career as a programmer at the Massachusetts Institute of Technology's Artificial Intelligence Lab, and described his experience sharing source code with external researchers for critique, enhancement, or even, cannibalization as being the norm.[16] Stallman insisted that the term 'free' referred to liberty, not price, and the goal was to facilitate a collaborative community that would build superior products. Many

[11] "History of the OSI." *History of the OSI | Open Source Initiative*, (last revised) Oct. 2018, opensource.org/history.
[12] "History of the OSI." *History of the OSI | Open Source Initiative*, (last revised) Oct. 2018, opensource.org/history.
[13] Duberstein, Billy. "Google Takes a Friendlier Path to Open Source Than Amazon." *The Motley Fool*, The Motley Fool, 12 Apr. 2019, www.fool.com/investing/2019/04/12/google-takes-a-friendlier-path-to-open-source-than.aspx.

[14] Benkler, Yochai. The Wealth of Networks : How Social Production Transforms Markets and Freedom. New Haven [Conn.] :Yale University Press, 2006.
[15] Stallman, Richard. "The GNU Project." *[A GNU Head]*, www.gnu.org/gnu/thegnuproject.en.html.
[16] Stallman, Richard. "The GNU Project." *[A GNU Head]*, www.gnu.org/gnu/thegnuproject.en.html.

stipulations were put in place for a given piece of software to be free and open source. Software is considered free if you, the user, has the freedom to:

1) Run the program as you wish, for any purpose.
2) Modify the program to suit your needs.
3) Access to the source code
4) Redistribute copies, either gratis or for a fee
5) Distribute modified versions of the program, so that the community can benefit from your improvements. [17]

While much of the early contribution to open source came from individual developers and academics, *The Transformation of Open Source Software*, explains how technology companies entered the open source community as a way to gain a competitive advantage in the market, bootstrap new software tools, and to create new markets and reduce costs.[18] Seeking to compete against proprietary software, technology companies began to open source their code in an effort to position their software as a standard and drive mass adoption.[19] This new type of collaboration was coined OSS 2.0. In this new model, technology firms were able to leverage a collaborative community in the development and maintenance of OSS while positioning themselves as open source brands that are transparent and pay-it-forward.[20] OSS with a reputation of being high quality and well-maintained, compete effectively against proprietary tools and attract the attention of top talent in the open source community.[21] There is no exception to this strategy in the development of AI and ML software where companies like Google, Facebook, and Amazon are capturing large market share and contributions from external developers as open source providers.[22]

[17] Singh, Vivek. "A Brief History Of Open Source." *Gitcoin's Blog*, 28 May 2019, gitcoin.co/blog/a-brief-history-of-open-source/.
[18] Fitzgerald, Brian. "The transformation of open source software." *MIS quarterly* (2006): 587-598.
[19] Fitzgerald, Brian. "The transformation of open source software." *MIS quarterly* (2006): 587-598.
[20] Fitzgerald, Brian. "The transformation of open source software." *MIS quarterly* (2006): 587-598.
[21] Fitzgerald, Brian. "The transformation of open source software." *MIS quarterly* (2006): 587-598.
[22] "Artificial Intelligence (AI) Market 2019 Size, Share, Development Strategy, Key Companies, Recent Trends, Future Scope and Potential of Industry by 2023." *Reuters*, Thomson Reuters, 6 Feb. 2019, www.reuters.com/brandfeatures/venture-capital/article?id=81301.

3. Motivation Drivers of Technology Companies and Developers to Contribute to the Open Source Community

Why Do Companies Create and Contribute to OSS?

Today, multi-billion dollar technology companies are open sourcing code and are encouraging their employees to contribute to the open source movement.[23] A few well-known AI-enabled technologies that have opened since 2015 include Amazon's Alexa, Google's TensorFlow, and Microsoft's Computation Network Tool Kit. Does open sourcing contribute to mass adoption and scale? Is there greater value in building a bigger user base and having access to more data? [24] This section will look at drivers of motivation for technology companies to participate in the open source movement around AI.

First, developing OSS expands the market, and develops an ecosystem around the technology that drives mass adoption, and increases market share for software and related services.[25] Becoming the standard in an open source environment gives the company a competitive advantage, and encourages mass adoption. While OSS in its infancy was made by developers for developers and was not very user-friendly,[26] developers of AI seek novice and expert use participation by open sourcing experiments, data sets, and analytical tools.[27] Think about the technical requirements of Google's Tensorflow vs. Quick Draw? Both capture user data and involve neural networks, but one requires knowledge of algorithms and the other requires the ability to move a computer mouse. Google knows that more users and the massification of data will strengthen AI predictions and lead to more personalization. The data collected from these experiments and open source tools are perceived to be more valuable than the software licenses in AI, which may be why we see the rapid development of new open source tools in this space.[28]

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[23] M. Andersen-Gott, G. Ghinea, and B. Bygstad, "Why do commercial companies contribute to open source software?," International Journal of Information Management, vol. 32, no. 2, pp. 106–117, 2012.
[24] Andrew, Elise. "Why Big Tech Companies Are Open-Sourcing Their AI Systems." *IFLScience*, IFLScience, 11 Mar. 2019, www.iflscience.com/technology/why-big-tech-companies-are-open-sourcing-their-ai-systems/.
[25] "Why Open Source?" *Google*, Google, opensource.google.com/docs/why/.
[26] Volpi, Mike. "How Open-Source Software Took over the World." *TechCrunch*, TechCrunch, 12 Jan. 2019, techcrunch.com/2019/01/12/how-open-source-software-took-over-the-world/.
[27] "AI Tools." *Google AI*, ai.google/tools/.
[28]Metz, Cade. "Google Is Giving Its TensorFlow AI Engine Away for Free Because Data Is Even More Valuable Than Code." *Wired*, Conde Nast, 30 June 2017, www.wired.com/2015/11/google-open-sourcing-tensorflow-shows-ais-future-is-data-not-code/.

OSS can benefit all technology companies, regardless of size. Small businesses and emerging start-ups rely on the open source community to build capacity without having to increase research and development budgets.[29] The open source platforms enable knowledge sharing among technical experts, and open critique and maintenance lead to better products. For large technology companies, the deployment of OSS can grow the market for complementary services such as consulting, training, and certifications. Amazon Web Services, for example, has a suite of micro-credentials and certifications for ML, and trains developers and data scientists to use its products on the AWS platform.[30] Training programs and certifications positions AWS as a thought leader and will lead to more use cases and retention on the platform.

Outside of economic factors, technology companies that work in the open can foster a maker culture, which can improve product development and talent acquisition.[31] Sarah Novotney, Head of Open Source Strategy at Google Cloud Program (GCP), believes open sourcing employee-driven innovations at Google fosters creativity in its workforce while encouraging external parties to participate in less prioritized projects.[32] When more developers have access to test and refine software, the more likely it will be that the software is effective and bug-free.[33] Collaborators on an open source ML project can also expose the software to new data sets which can strengthen the algorithm without additional costs to the company.

Why do Tech Employees Create and Contribute to OSS?

Developers are participating in the open source community as individual contributors and through their employers. The 2017 GitHub Open Source Survey provides an excellent overview of why developers broadly contribute and receive help open source project platforms, how they prefer to contribute in an open environment, and the level of encouragement employed developers receive to participate in the open source community.

While the survey results were limited to GitHub members, it was interesting to see their perceptions on OSS, and how they wish to contribute to the open source community. Not only did a majority of

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[29] Fitzgerald, Brian. "The transformation of open source software." *MIS quarterly* (2006): 587-598.
[30] "AWS Certified Machine Learning - Specialty." Amazon. Amazon. https://aws.amazon.com/certification/certified-machine-learning-specialty/.
[31] Team, Insights. “The Power Of Open Source AI.” *Forbes*, Forbes Magazine, 5 June 2019, www.forbes.com/sites/insights-intelai/2019/05/22/the-power-of-open-source-ai/#735bab863000.
[32] Carey, Scott. “How Google Decides to Open Source Its Technology.” *ComputerworldUK*, 3 Aug. 2018, www.computerworlduk.com/open-source/how-google-decides-open-source-its-technology-3681832/.
[33] Carey, Scott. “How Google Decides to Open Source Its Technology.” *ComputerworldUK*, 3 Aug. 2018, www.computerworlduk.com/open-source/how-google-decides-open-source-its-technology-3681832/.

respondents prefer OSS over proprietary options, but they also believed that open source tools were more secure.[34] The most frequent engagement activities by survey participants were code contribution, filing bugs and project maintenance, and the factors they perceived to be very important in an open source community were responsive maintenance and a welcoming community.[35] A majority of participants use the public forums to ask for help, and over half get help with writing code and contributing ideas.[36] This appears to be a very dynamic community where strangers help each other at no cost to iterate and troubleshoot.

The survey results also showed that a majority of employed developers contribute to or use OSS in their formal work. 94% of employed respondents reported contributing to the open source community as part of their professional role, and 84% of employed respondents reported that their employer actively encourage their use of open source applications.[37] Other research affirms that many employees choose to engage and contribute to the open source community because of the collaborative nature of the work and field, and the long-term maintenance only made available by open sourcing.[38]

As mentioned in the previous section, many technology employers encourage their employees to contribute to open source code as part of their work. Nearly half of the survey respondents could contribute to open source code without checking in with their employer. Based on quantitative research and anecdotal evidence, it is apparent that both employers and employees see value in contributing their code to the open source community due to both intrinsic and extrinsic motivation.

4. Arguments for Open Sourcing AI

Why open source AI? The developer community is built upon a culture of collaboration and generosity. A notable example of this is GitHub, where developers around the world share their code to make it more accessible.[39] GitHub holds over 100 million repositories, which makes it the largest global open

[34] Geiger, R. Stuart. “Summary Analysis of the 2017 GitHub Open Source Survey.” 2017, doi:10.31235/osf.io/qps53.
[35] Geiger, R. Stuart. “Summary Analysis of the 2017 GitHub Open Source Survey.” 2017, doi:10.31235/osf.io/qps53.
[36] Geiger, R. Stuart. “Summary Analysis of the 2017 GitHub Open Source Survey.” 2017, doi:10.31235/osf.io/qps53.
[37] Geiger, R. Stuart. “Summary Analysis of the 2017 GitHub Open Source Survey.” 2017, doi:10.31235/osf.io/qps53.
[38] Wu, Chorng-Guang, et al. “An Empirical Analysis of Open Source Software Developers' Motivations and Continuance Intentions.” *Information & Management*, North-Holland, 30 Jan. 2007, www.sciencedirect.com/science/article/pii/S0378720607000067.
[39] “Build Software Better, Together.” *GitHub*, github.com/.

source code host.[40] Peer to peer networking aids in embedding Artificial Intelligence in the coding community. Not only does the culture of open sourcing code reinforces a culture of innovation, but it also democratizes access to code, so people do not need to reinvent the wheel, saving time, money, and resources.

1. **For the betterment of humanity and society.**
   One of the goals of open sourcing AI is to ensure that this technology benefits humanity. One of the leaders in this movement is Open AI, a company dedicated to ensuring that AI benefits humanity by building safe and beneficial Artificial General Intelligence (AGI).[18] The Partnership on AI (PAI) is a nonprofit that launched in 2016 to study and formulate best practices on AI technologies in the open and to effectively educate the public.[41] Amazon, Facebook, and Google are all members of PAI. Notable leaders in the technology ecosystem are advocating for AI to be used to benefit humanity. Silicon Valley investors such as Reid Hoffman's charitable foundation and Khosla Ventures have funded Open AI in hopes of ensuring that highly autonomous systems can contribute to the economy and society.

2. **Adoption of a standard:**
   Adopting a standard for Artificial Intelligence means that there will be more contributors to build an ecosystem around AI. This encourages others to adapt and build on top of the code, creating buy-in from other players in the ecosystem.[9] Even larger financial players are participating in Open Source. A recent Forbes article in May 2019 states, "*This year, Goldman Sachs plans to release some of the code it uses to analyze and manage risk with machine learning applications. The goal is to encourage engineers to build new applications using the code, and perhaps get the first chance to invest in promising new companies built in part on that code. By enabling other companies to participate, Goldman Sachs will reap benefits, as will other businesses that use the code to strengthen products and services."*[42] Open source code contributions result in a higher return on the investment compared to the closed source process.[7] A noteworthy example of this is Linux, an open operating system, which was released under free and open source licenses and after saw rapid adoption by consumers. In the same

[40] Johnson, Khari. "GitHub Passes 100 Million Repositories." *VentureBeat*, VentureBeat, 9 Nov. 2018, venturebeat.com/2018/11/08/github-passes-100-million-repositories/.
[41] "The Partnership on AI." *The Partnership on AI*, www.partnershiponai.org/.
[42] Team, Insights. "The Power Of Open Source AI." *Forbes*, Forbes Magazine, 5 June 2019, www.forbes.com/sites/insights-intelai/2019/05/22/the-power-of-open-source-ai/#735bab863000.

vein, with Google's TensorFlow's machine learning system, developers were able to accelerate product development to improve the machine learning framework.

3. **Accelerates Improvement of Quality of Life:**
   Open sourcing AI has massive implications for improving the quality of life, especially in healthcare. Dr. Eric Topol, a cardiologist and author, forecasted about how AI can see things that humans cannot due to machines training from deep learning. Notable examples of this are determining the potassium in your blood from a watch, analyzing the retina to determine gender, and machine vision to pick up polyps that are missed by physicians.[43] Not only can AI improve lives, but it can also save lives. In 2018, two Australian teenagers were struggling to swim against the heavy turfs in the ocean. Lifeguards sent a drone which spotted the swimmers and then dropped an inflatable rescue pod. With this, the boys were able to use a flotation device and made it to shore.[44] Recently, in June 2019, an open source AI prosthetic leg was revealed at Amazon's Re: MARS Conference. The goal of open sourcing the leg is to democratize the design and programming in order for researchers, programmers, and patients to improve the leg. [45]

4. **Machine learning drives innovation:**
   Companies such as Google, Amazon, Facebook, and Microsoft open source their AI software because they want to help other people innovate. As AI learns and adapts, new opportunities will be brought up and can be capitalized on.[46] As there are new ideas, this information will be democratized allowing new contributors into the space. Argo AI, a Ford backed motor company, has open sourced some of the information from its development of autonomous vehicles.[47] One

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[43] Chen, Angela. "A Doctor Explains How Artificial Intelligence Could Improve the Patient-Doctor Bond." *The Verge*, The Verge, 12 Mar. 2019, www.theverge.com/2019/3/12/18261718/eric-topol-deep-medicine-artificial-intelligence-algorithms-health-science-interview.
[44] "Drone Saves Two Australian Swimmers in World First." *BBC News*, BBC, 18 Jan. 2018, www.bbc.com/news/world-australia-42731112.
[45] Frost, Natasha. "An AI Bionic Leg Could Change the Future of Prosthetics." *Quartz*, Quartz, 5 June 2019, qz.com/1636413/an-open-source-ai-bionic-leg-is-the-future-of-prosthetics/.
[46] Andrew, Elise. "Why Big Tech Companies Are Open-Sourcing Their AI Systems." *IFLScience*, IFLScience, 11 Mar. 2019, www.iflscience.com/technology/why-big-tech-companies-are-open-sourcing-their-ai-systems/.
[47] Korosec, Kirsten. "Self-driving car startup Argo AI is giving researchers free access to its HD maps." 17 June 2019, https://techcrunch.com/2019/06/19/self-driving-car-startup-argo-ai-is-giving-researchers-free-access-to-its-hd-maps,

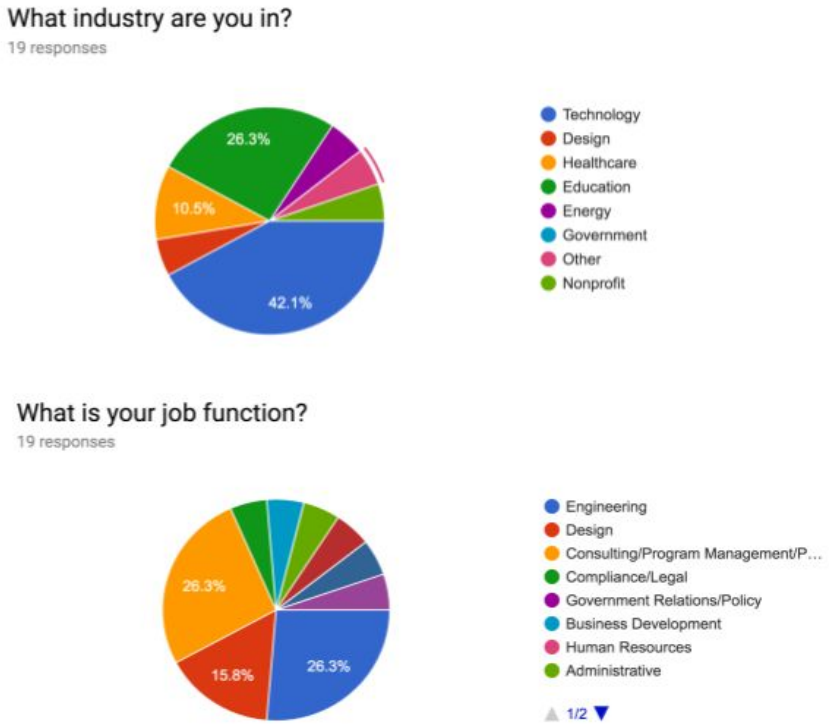
of the reasons for this was to give researchers the ability to study the impact of maps on perception and forecasting. The goal of open sourcing their Argoverse is to support more research and breakthroughs in self-driving cars.

5. Perceptions of AI Survey Results from Professionals

Survey Overview

The co-authors of this report developed and disseminated a brief survey to education and technology professionals across sectors to understand their perceptions on AI's value to society, and identifying AI's contributions, risks, and its impact on the future of work. The survey was shared with technology professionals, master's students studying learning, design, and technology, and select legal and policy professionals working on issues of AI research and data policy. Participants were also asked about the emerging AI trends in their respective industries. Below are the open multiple choice and open-ended questions that were asked:

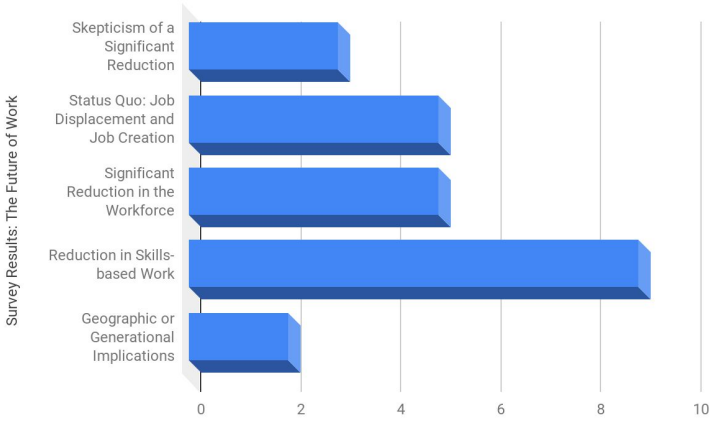
1. What industry are you in?
2. What is your job function?
3. Does your company open source its code?
4. If your company open sources its code, how is it able to profit from contributions to open source?
5. How do you think that automation, as a result of AI-enabled technologies, will lead to job displacement and workforce reduction in the next 20 years?
6. What do you see as risks or areas of concern for the rise of AI?
7. How do you expect the AI community to contribute to society?
8. What are emerging AI trends in your industry?



Qualitative Responses

Future of Work

How do you think that automation, as a result of AI-enabled technologies, will lead to job displacement and workforce reduction in the next 20 years?



The majority of respondents believe that jobs, especially skills-based professions, are at risk of automation with the rise of AI. Many respondents believe that new jobs would be created as a result of new technologies, but these new opportunities would require new skill sets. There was a call to develop workforce development initiatives to support reskilling and upskilling for the current workforce. 50% of professionals working in the technology sector believe that new jobs would replace old jobs as experienced during the Industrial Revolution.

Select Quotes:

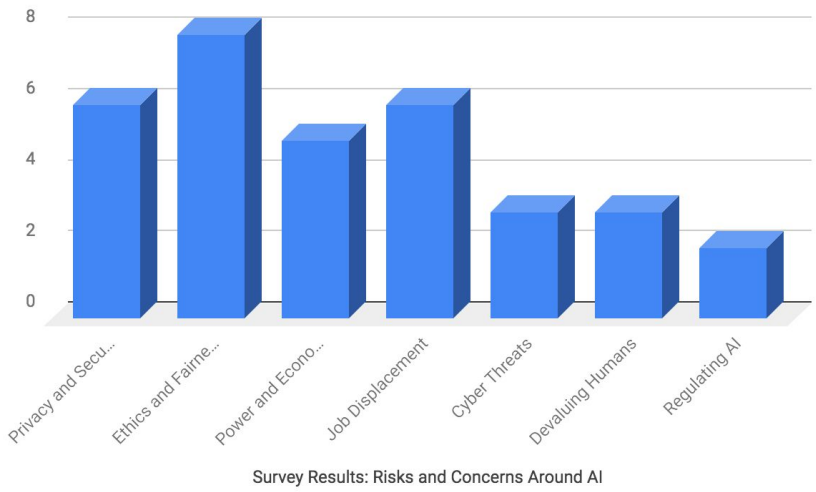
"Technology advancement is nothing new - cars have replaced horses, and robots are a key part of every factory assembly line already. They've always resulted in more productivity and less reason for fear and outrage than the public initially thought."

"Although it will remove some jobs, it will also create new ones in the industry. Programs that allow for training in this space will help to mitigate displacement."

"Blue collar or gig-economy jobs are the occupations most "at risk" by automation and AI enabled technologies. studies show that 30-40% of current jobs in the USA will be automated by the year 2030."

Risks and Areas of Concern

What do you see as risks or areas of concern for the rise of AI?



Survey Results: Risks and Concerns Around AI

The most cited risks and concerns from the rise of AI are data privacy and security, fairness and bias in the algorithm and deployment of technology, and the threat of job displacement with the need for considerable workforce development in the form of training and upskilling programs. Issues of increased economic disparity and geopolitical power dynamics were also mentioned as critical concerns as global powers seek to achieve AGI or possibly create autonomous weapons. Another interesting perspective was the concern that AI will devalue human contribution to society and the importance of human-centered design in the development and deployment of AI.

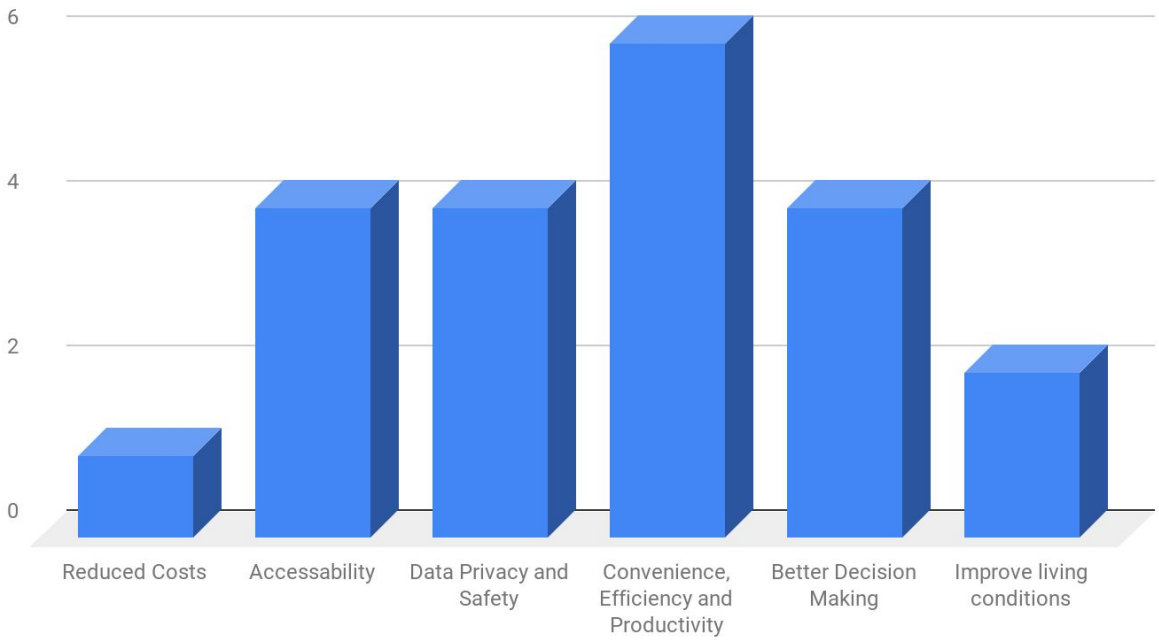
Select Quotes:

"Those that deploy AI in healthcare are unable to explain or understand algorithmic architecture; the AI is conditioned for outcomes that sacrifice actual care, such as maximization of profit or distribution of certain treatments; Consumers chase AI as a cure-all and end up with poorly delivered AI that is not secure, ethical, or validated under both federal and state regulatory structures"

"How do we help education keep up with innovation? Specifically, how can we make sure "at risk" populations are educated sufficiently to qualify for and obtain jobs in a world of increasing AI?"

AI's Impact on Society

How do you expect the AI community to contribute to society?



Survey: AI's Community's Impact on Society

Participants believe that the AI community will positively impact society in many areas from convenience, efficiency, and productivity to better decision making, data privacy and safety, and accessibility. AI support in making better decisions came up frequently in the responses.

Select Quotes:

"AI can assist in taking smart decisions which cannot be done by a human. With a vast amount of data generated by devices, a single person cannot skim through those in detail. Rather an AI model can understand the nuances of data and help in making an informed decision."

"First, AI would bring productivity in many industries. It also benefits to everyone enjoying personalized products/services. The most interesting part for AI is its self-learning ability, which would change and improve our quality of life by reducing our energy in doing mundane and repeated work, in order to make innovation for things rather than keep alive."

Emerging Trends

What are emerging AI trends in your industry?

A wider range of tools and technologies were mentioned from automated cars and buildings to adaptive learning software and AI-enabled tutoring systems in the education sector.

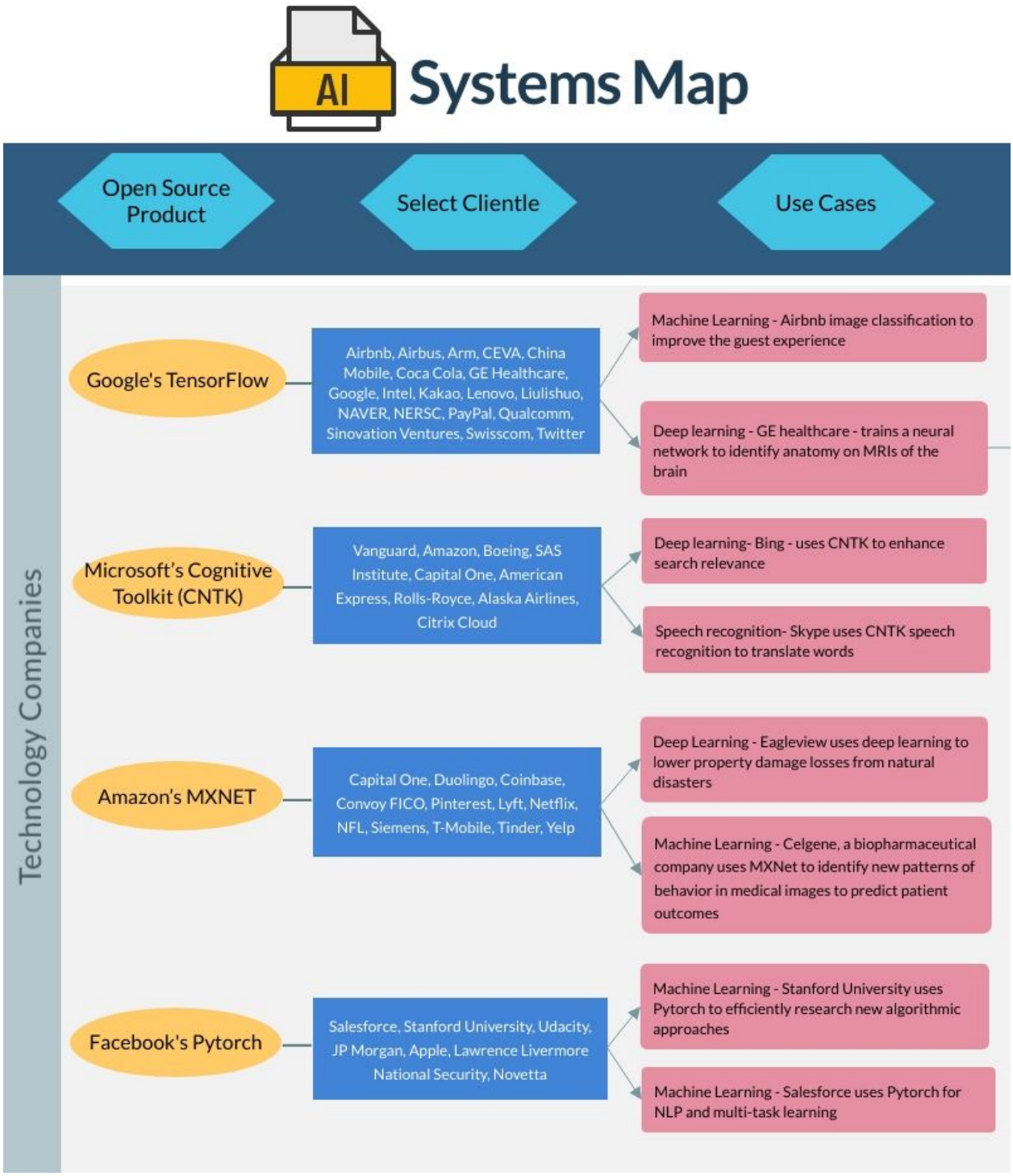
6. Systems Map of AI

By creating a systems map of the key technology players in open sourcing AI, our goal was to map out common use cases of how open AI software is used to benefit society. There are three ways to use this ecosystem map listed below:

1. **Major Technology Players who contribute to Open Source AI and their Products**
    a. Google's TensorFlow
    b. Microsoft's Cognitive Toolkit (CNTK)
    c. Amaxon's MXNET
    d. Facebook's Pytorch

2. **Select Cliente who use Open Source AI**
    a. Technology
    b. Healthcare
    c. Higher Education
    d. Security
    e. Financial
    f. Aerospace
    g. Cryptocurrency
    h. Food and Beverage
    i. Telecommunications

3. **Use Cases**
    a. Machine Learning
    b. Deep Learning
    c. Speech Recognition


AI Systems Map
Open Source Product
Select Clientle
Use Cases
Technology Companies
Google's TensorFlow
Airbnb, Airbus, Arm, CEVA, China Mobile, Coca Cola, GE Healthcare, Google, Intel, Kakao, Lenovo, Liulishuo, NAVER, NERSC, PayPal, Qualcomm, Sinovation Ventures, Swisscom, Twitter
Machine Learning - Airbnb image classification to improve the guest experience
Deep learning - GE healthcare - trains a neural network to identify anatomy on MRIs of the brain
Microsoft's Cognitive Toolkit (CNTK)
Vanguard, Amazon, Boeing, SAS Institute, Capital One, American Express, Rolls-Royce, Alaska Airlines, Citrix Cloud
Deep learning- Bing - uses CNTK to enhance search relevance
Speech recognition- Skype uses CNTK speech recognition to translate words
Amazon's MXNET
Capital One, Duolingo, Coinbase, Convoy FICO, Pinterest, Lyft, Netflix, NFL, Siemens, T-Mobile, Tinder, Yelp
Deep Learning - Eagleview uses deep learning to lower property damage losses from natural disasters
Machine Learning - Celgene, a biopharmaceutical company uses MXNet to identify new patterns of behavior in medical images to predict patient outcomes
Facebook's Pytorch
Salesforce, Stanford University, Udacity, JP Morgan, Apple, Lawrence Livermore National Security, Novetta
Machine Learning - Stanford University uses Pytorch to efficiently research new algorithmic approaches
Machine Learning - Salesforce uses Pytorch for NLP and multi-task learning

7. Overview of Open Source AI Tools

To understand how neural networks work, there are key terms defined by Korkrid Kyle Akepanidtaworn, a Microsoft technical specialist[48]:

a. "**Epoch** — an arbitrary cutoff, generally defined as "one pass over the entire dataset", used to separate training into distinct phases, which is useful for logging and periodic evaluation. In layman's term, a number of epochs mean how many times you go through your training set.
b. **Learning Rate** — "a scalar used to train a model via gradient descent. During each iteration, the gradient descent algorithm multiplies the learning rate by the gradient. The resulting product is called the gradient step. Learning rate is a key hyperparameter." Specifying the learning rate is equivalent to determining how fast weights change for each iteration. In Tensorflow playground, the learning rate ranges from 0.00001 to 10.
c. **Activation Function** — the output of that node, or "neuron," given an input or set of inputs. This output is then used as input for the next node and so on until a desired solution to the original problem is found. Available activation functions in Tensorflow playground are ReLU, Tanh, Sigmoid, and Linear.
d. **Regularization** — a hyperparameter to prevent overfitting. Available values are L1 and L2. L1 computes the sum of the weights, whereas L2 takes the sum of the square of the weights.
e. **Regularization Rate** — a scalar used to specify the rate at which the model applies the regularization, ranging from 0 to 10.
f. **Problem Type** — classification (categorical output) vs. regression (numerical output)
g. **Ratio of the Training and Testing Set**s — the proportion of a subset to train a model and a subset to test a model. I usually set it to 80/20
h. **Noise** — a distortion in data that is construed to be extraneous to the original data.
i. **Batch Size** — "a small, randomly selected subset of the entire batch of examples run together in a single iteration of training or inference. The batch size of a mini-batch is usually between 10 and 1,000."
j. **Features** — represents an input layer to feed in.
k. **Hidden Layer** — a layer in between input layers and output layers, where artificial neurons take in a set of weighted inputs and produce an output through an activation function. In this context, you can specify as many as you want but bear in mind that the more hidden layer you add, the more complex the model becomes.
l. **Output** — an output layer in the neural network, often involving the loss evaluation. Loss function (or a cost function) is a method of evaluating how well the neural network

[48] Akepanidtaworn, Korkid Kyle. "Best Place to Learn Neural Network: Interactive Tensorflow Playground." *Medium*, Medium, 12 Apr. 2019, medium.com/@kyleake/technical-demo-visualize-neural-network-with-tensorflow-playground-9f6a1d8eb57a.

performs in the given data. If predictions deviates too much from actual results, loss function will be high. We often evaluate the losses both on training and testing sets."

1. Teachable Machine by Google Creative Lab

i. **Overview**- "*Teachable Machine is an experiment that makes it easier for anyone to start exploring how machine learning works. It lets you teach a machine using your camera – live in the browser, no coding required. It's built with a library called tensorflow.js, which makes it easier for any web developer to get into machine learning, by training and running neural nets right in the browser.*"

ii. **Code**- Teachable machine was built with Javascript and deep learning.

iii. **Personal experience-** Teachable Machine is an easy to use software that teaches how machine learning works seamlessly. When a user initially clicks on the link, the voice gives an overview of the experiment and guides you to the steps. There is a camera where you will be seeing your "input." We fed the machine inputs so and did hand motions to train it to populate a GIF for each motion.

iv. **Classroom implications** - This has the potential to be used in K-12 education to pique a child's interest in STEM. It is an interactive and engaging experience and a great way to teach the basics of machine learning. Children curious to learn more about it in a studio session could explore and add to the code on GitHub. Since it is open source code, they can try to recreate a similar program to it.

b. Visualizing High Dimensional Space

i. Overview: Data scientist worked together to find a way visualize machine learning around the concept of high dimensional space. As an example, the scientists compare unique identifiers of a set of people and how they could be collected, charted, and clustered based on associations. In the experiment, the scientists fed a system thousands of words, and the AI clustered them and assigned them meaning based on their use in hundreds, if not thousands of sentences.

ii. Examples:

1. When you type in 'school,' it shows that the word was used in over 4800 sentences. The computers identifies types of school such as college or university, words related to school such as students or teachers, and verbs related to a school such as 'taught' or 'graduated.'[49]
2. It's important to note that the computer is only grouping or clustering terms based on association. It is not able to determine why these terms are interrelational or to make meaning from them.

[49] Smilkov, Daniel, et al. "Embedding Projector - Visualization of High-Dimensional Data." *Embedding Projector - Visualization of High-Dimensional Data*, projector.tensorflow.org/.

3. The computer is only as good as it's data. When I tried typing in more colloquial terms, there were no findings because those words weren't in the initial dataset.

2. **What Neural Networks See**

i. **Overview:** Data scientist worked together to find a way visualize machine learning around the concept of high dimensional space. As an example, the scientists compare unique identifiers of a set of people and how they could be collected, charted, and clustered based on associations. In the experiment, the scientists fed a system thousands of words, and the AI clustered them and assigned them meaning based on their use in hundreds, if not thousands of sentences.[50]

Ii. A convolutional neural network is a deep neural network or deep learning algorithm consisting of many layers that can be used to analyze visual imagery, audio sounds, and has been applied to many emerging technologies from self-driving cars to speech to technology systems. In machine learning, neural networks are able to accurately describe and recognize images based on specific patterns or features. Moving through each layer of the neural network from multi-pixel patterns to more complex activated layers from stacked layers, the researcher will acquire higher level features from edges to houses.

Iii. **Experiment -** user can position objects in front of the camera and see how the deep NN is effective in identifying the image. The user has twenty seconds to draw the image while the software continuously suggests what it is.

3. TensorFlow

m. **Overview**- TensorFlow is an open source, end to end AI platform that is used to build and deploy Machine Learning models with the user's choice of coding language and platform.[51] Google's TensorFlow is the most popular open-source AI software.[52]
n. **Code**- Google built its TensorFlow software with C++ programming language.[53]
o. **Demo**- TensorFlow has a feature called "A neural Network Playground" which is a digital sandbox where the user can tinker with a neural network in their browser. To understand neural networks," it is a function that learns the expected output for a given

[50] "Quick, Draw!" Google. Google. 15 June 2019<https://quickdraw.withgoogle.com.
[51]"Why Tensor Flow." *TensorFlow*, www.tensorflow.org/about.
[52] Novet, Jordan. "Microsoft Allies with Facebook on A.I. Software." *CNBC*, CNBC, 15 Nov. 2018, www.cnbc.com/2018/11/15/microsoft-allies-with-facebook-on-pytorch-onnx-ai-software.html.
[53] Metz, Cade. "Google Just Open Sourced the Artificial Intelligence Engine at the Heart of Its Online Empire." *Wired*, Conde Nast, 6 Mar. 2018, www.wired.com/2015/11/google-open-sources-its-artificial-intelligence-engine/.

input from training datasets."[54] It's another way of building a program that learns from data. Artificial neurons are inspired from biological neurons in the human brain.

p. **Demo** - The user picks a pre-populated dataset, adds the properties they want to feed it in, puts in the neurons, and then sees the output populate. Additionally, the user can personalize this experiment by changing the learning rate, activation, regularization, and regularization rate.

q. **Classroom implications** - Tensorflow has several highlighted case studies used by ubiquitous companies such as Airbnb, Coca Cola, GE, Twitter, Intel, Lenovo, and more. In a case study for Liulishuo, a language learning app, the Liulishuo algorithm team applied Tensor Flow to machine learning projects which helped build an application to teach English. Similar applications of this could be applied in the use cases of language learning in K-12 or higher education. Teachers could use language applications in addition to their curriculum to prime their students.

5. **Microsoft Cognitive Toolkit**[55] -

a. **Overview**: The Microsoft Cognitive Toolkit (CNTK) is an open source toolkit for distributed deep learning. CNTK lets users realize and combine model types across multiple GPUs and servers. Additionally, "CNTK is also one of the first deep-learning toolkits to support the Open Neural Network Exchange ONNX format, an open-source shared model representation for framework interoperability and shared optimization." Microsoft's CNTK's strength is particularly suited to building speech recognition systems.

b. **Code**: One of the major adoption barriers for CNTK in the past was the primary coding language of C++ for enterprise AI. Xeudong Huang, Microsoft's speech scientist, said, "*Using C++ for enterprise AI; that's not a problem, people are familiar with C++. But for the open source community, we needed Python and this beta offers native Python support. It's the language they're familiar with; Python is easier to understand, easier to evaluate, it's an interpretive language. Often they already have existing code using Python and when they add deep learning, they just want to augment what they have instead of switching from Python to C++. For the first time, we are bringing performance and ease of use in a more balanced way, because it can be integrated into other environments more efficiently.*"[56]

c. **Demo**: There are several examples of CNTK that Microsoft has listed on GitHub.[57]

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[54] Sato, Kaz. "Understanding Neural Networks with TensorFlow Playground | Google Cloud Blog." *Google*, Google, 26 July 2016, cloud.google.com/blog/products/gcp/understanding-neural-networks-with-tensorflow-playground.

[55] Chrisbasoglu. "The Microsoft Cognitive Toolkit - Cognitive Toolkit - CNTK." *Cognitive Toolkit - CNTK | Microsoft Docs*, 21 Jan. 2017, docs.microsoft.com/en-us/cognitive-toolkit/.

[56] Branscombe, Mary. "Microsoft Solidifies CNTK Deep Learning Toolkit for Industrial-Grade AI." *The New Stack*, 3 Nov. 2016, thenewstack.io/microsoft-adds-python-support-cntk-deep-learning-toolkit/.

[57] Chrisbasoglu. "CNTK Examples - Cognitive Toolkit - CNTK." *Cognitive Toolkit - CNTK | Microsoft Docs*, 30 July 2017, docs.microsoft.com/en-us/cognitive-toolkit/examples.

d. **Classroom implications**: This could be used in higher education for engineering students to solve various case studies. An example of this would be using CNTK to use image classification approaches. The student would generate an annotated image dataset and train an image classifier using a pre-trained deep neural network. After training the neural network, the student could collaborate with other classmates to improve on the accuracy of the model. Since the code is open source, students could reference the code on GitHub. Students who improve on the model could also update and upload their code on GitHub. CNTK is renowned for having one of the best speech recognition systems. Their AI error rate in understanding speech is 5.9% which exceeds human performance. [58] Using CNTK in classrooms for students with hearing disabilities could ensure accessibility to learning.

7. Conclusion

Moving Open and Fast

Advancements in AI are moving forward rapidly. Massachusetts Institute of Technology (MIT) announced on June 28, 2019, a new probabilistic programming system, which will allow users to create AI models and algorithms without high-level code, making it more accessible to newcomers. MIT is positioning itself to provide accessibility to data science, and it will be interesting to see how other academic and technology players contribute to open source and the democratization of AI. Open source code is not enough to level the playing field and to ensure that AI technologies are human-centered. To counter algorithmic bias, Google is providing open source representative datasets recognizing that the algorithm is only as good as the data being fed into it.[59] The new Human AI (HAI) Center at Stanford University is working to take a multidisciplinary approach to the study of AI, and are studying issues of gender and ethnic bias, AI-enabled tutors for education, and AI-enabled therapy for Autism.[60] AI4ALL is an education nonprofit seeking to empower and employ underrepresented populations in AI fields through open source learning platforms. Working in the open and building off the collaboration and contribution of the open source community is where AI research, development, and deployment belongs. The goal for further research in open sourcing Artificial Intelligence should be ensuring that the AI community is more inclusive and accessible so humanity can benefit from these new advancements.

[58] Forrest, Conner. "Microsoft Hits New Record for AI Speech Recognition." *TechRepublic*, 21 Aug. 2017, www.techrepublic.com/article/microsoft-hits-new-record-for-ai-speech-recognition/.
[59] "Datasets." *Google AI*, ai.google/tools/datasets/.
[60] "Welcome to the Stanford Institute for Human-Centered Artificial Intelligence." *Stanford Institute for Human-Centered Artificial Intelligence*, 26 Mar. 2019, hai.stanford.edu/about/welcome.

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Appendix 1: Survey Responses (Technology)

Results:

Questions	**Technology**
Responses	8
What is your job function?	1) Engineering 2) Engineering 3) Sales 4) Engineering 5) Engineering 6) Non-profit?? 7) Engineering 8) Business Development
Does your company open source its code?	1) No 2) No 3) I don’t know 4) No 5) No 6) No 7) I don’t know 8) No
If your company open sources its code, how is it able to profit from contributions to open source?	1) We use several code libraries that are open source, including some for accessing databases, charting, and processing timestamps. 2) N/A 3) AI will reduce a lot of the entry level coding jobs 4) We don't open source our code. 5) By contribution of the public. 6) N/A 7) In general, it may bring information systems designing in bridging technology and real-world business. At least, our business model is based on data-driven analysis. They would

	be a really useful and good example for company to perform business with the support of quantitative resources. 8) N/A
How do you think that automation, as a result of AI-enabled technologies, will lead to job displacement and workforce reduction in the next 20 years?	1) Technology advancement is nothing new - cars have replaced horses, and robots are a key part of every factory assembly line already. They've always resulted in more productivity and less reason for fear and outrage than the public initially thought. 2) a lot 3) Even with AI's sophistication, human analysis is still needed 4) I don't think a massive job displacement or workforce reduction is expected. I believe in the power of collaboration of AI with people, because AI by itself is not at the level of replacing human workforce. It can be useful in assisting works that are deemed hazardous or monotonous. 5) I think in 20 years, the development of AI technologies would definitely induce a workforce reduction. Especially in some labor intensive industries. 6) It will lead to a fair amount of displacement but also new innovations. 7) I never worried about the job displacement since there will be new jobs in the new era, like people in the Industrial Revolution. 8) Although it will remove some jobs, it will also create new ones in the industry. Programs that allow for training in this space will help to mitigate displacement.
What do you see as risks or areas of concern for the rise of AI?	1) Privacy, the lack of which results in over-surveillance 2) the rich will get richer 3) AI is going to shift job roles 4) Any model can be easily biased. We have seen a lot of issues with recruitment in tech firms recently. 5) Used for the wrong purpose. 6) I think privacy is a big concern. 7) Risks of displacing jobs, autonomous weapons, fairness and transparency 8) Of course people better to be vigilant but also open-minded to invite AI into our daily life, especially in biology, legal liability, and personal privacy aspects. 9) Displacing drivers (for Uber & Lyft) as automated cars are quickly ramping up.

How do you expect the AI community to contribute to society?	1) Many routine tasks will be made easier and more convenient, without the user even noticing. 2) better decisions 3) AI can assist in taking smart decisions which cannot be done by a human. 4) With a vast amount of data generated by devices, a single person cannot skim through those in detail. Rather an AI model can understand the nuances of data and help in making an informed decision. 5) People would have better focus on specific area. 6) By giving back! And building ethics into their products. 7) First, AI would bring productivity in many industries. It also benefits to everyone enjoying personalized products/services. The most interesting part for AI is its self-learning ability, which would change and improve our life quality by reducing our energy in doing mundane and repeated work, in order to make innovation for things rather than keep alive. 8) Creating safer and more consistent communities through automation.
What are emerging AI trends in your industry?	1) In one word, democratization. Tools are becoming easier to us, enabling more people and organizations to get started using them. 2) Diagnostics 3) AI and media monitoring 4) Computer Vision. 5) Technologies could serve people and also keep their privacy. 6) In the nonprofit industry it's rarely used. 7) I think currently we are devoted in creating AI tools being more accessible and usable by other industries, not merely a computerized tool. In other words, we are trying to make AI become Artificial general intelligence, which is the intelligence of a machine that could successfully perform any intellectual task that a human being can. 8) Self driving cars