

AI Today and Tomorrow

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Abstract

Artificial intelligence technology is being used in more and more applications, and it is expected to be used in more and more tasks to automate as much as possible. To prepare for this future, we must understand the capabilities and limits of the technology. Capability limitations, transparency/ethics issues, lack of sustainability, and limited availability and access are stopping AI from being applied to even more applications. In order to identify whether availability/costs is the most significant factor holding AI back from widespread adoption and whether AI as a service is the solution to these factors, qualitative research was conducted. Four AI experts at The University of Maryland Baltimore County were interviewed. The interviews shed light on capability and transparency/ethics issues, and provided insight on the drawbacks of AI as a service. The interviewees noted AI has a lack of understanding of causality, deficiencies in planning, decision making, emotion, creativity, collaboration, and the lack of the ability to carry over experience from one task to another. They also explained that AI also has a black box issue, which means the researchers themselves do not understand why the AI makes a decision, which can lead to biases. And while AI as a service will have a great impact on the adoption of AI, AI as a service still requires experts and a lot of resources to customize and apply. And for many applications, AI as a Service will not suffice and many might not want to share their data. These results indicate that AI must be further developed, the issues of ethics and transparency, sustainability, and reliability must be further researched and addressed.

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Literature Review

Everyone hears about how artificial intelligence will take over, but what does that mean and will it happen any time soon? While AI literally taking over the world to rule humans is unlikely, a world where most decisions and tasks will be carried out not by humans but rather by computers, is inevitable. The reason AI and machine learning technologies are not being used everywhere they can be at this moment is because current AI and ML technology have many drawbacks and limitations and must mature to become more available for widespread adoption.

In the world today AI is being used for countless applications. To review the different subsets of applications, applications will be broken down into robotics applications and software/data applications. First, robotics based applications will be used to indicate that the AI is used to have a physical effect in our universe whether that may be a heater, rocketship, submarine, or a car. As a personal anecdote, when I used to do VEX EDR, we had to write autonomous code and our robots were never consistent and accurate. I learned that a feedback control system like PID was crucial. For example, if a robot or machine is given the command to raise its arm, travel 5 meters, rotate 180 degrees, etc., the robot may make a mistake or not know how to do it. So control algorithms like the variants of PID are used everywhere from airplanes to thermostats and kitchen stoves. A PID algorithm tells a machine how to do what it is told to do, and makes sure that the goal is achieved autonomously; if the robot is simply told to rotate its tires a certain number of degrees, it may not go the distance the programmer/user intended, but with PID the robot will check if it has achieved the goal, which, in this case, is moving a certain distance, and make sure that the robot has actually gone the distance using sensors and by telling the robot what to do autonomously (Avery, 2009). But every task requires setup and fine tuning to its PID algorithm. While this can be done by humans, AI algorithms can use simulations and their high computational ability to swiftly and accurately tune these PID algorithms. Using different variants of AI and ML algorithms Shipman & Coetzee (2019) and Brunton (2018) tuned a PI and PID algorithm. This demonstrates that the technology can observe situations and or real life data and make logical changes simulating learning.

While Farag & Saleh(2018) were able to use PID to get a simulated car to stay between the lanes at different speeds, roads have traffic signs, pedestrians, other vehicles, multiple lanes, and so many other complicated systems that to achieve a truly autonomous vehicle you need much more intelligent software than a classic PID control algorithm.

A more complicated application of AI in the real world is autonomous vehicle control.

“Autonomous helicopter flight represents a challenging control problem, with complex, noisy, dynamics” (Ng et al., 2003, pg. 1) Because of the difficult challenge, Andrew Ng and his colleagues developed an ML model to create an autonomous helicopter. Andrew Ng and his team were successfully able to get a helicopter to both hover and complete competition maneuvers (Ng et al., 2003). In another experiment Ryan and Reid (2000) were able to make an airplane fly in a simulation. While a simulation does not mean it will work in real life, this demonstrates that AI technology, even 20 years ago, was able to complete complex tasks like flight. One source marks that “commercial flights use autopilot and self-driving cars may be mass-produced starting 2021”(Faggella, 2020, p. 11). Many commercial airplanes already use some form of autopilot, and semi self driving vehicles have become very common. AI has already been able to tackle and achieve much success in the difficult task of autonomous vehicles control and the technology is already in mass production showing that the technology is at a stage where it can be reliably used for some applications.

Next, I will analyze the current uses and abilities of AI and ML technology in the world of software and data. First let us review the prevalence of AI today. Examples of software/data applications that we use are prediction software for traffic, ride-sharing apps, email spam filters, email categorization, plagiarism checkers, essay graders, mobile deposits, bank account fraud prevention, credit decisions, identifying people on smartphones, face filters, social media algorithms, advertisement targeting, chatbots, search systems, recommendation systems, fraud protection, voice to text, and personal assistants (Faggella, 2020). Needless to say AI is very capable and applicable to a wide range of tasks enabling a lot of the technology used today making a big impact on our lives. Going forward AI will be used for a variety of more advanced and important software applications including medical diagnosis, investment

analysis, improve and automate businesses, manage databases, change and improve the field of cyber security and more (Ghosh, 2018). While these AI applications are not intentionally physically altering something in the real world, the data and information they provide helps us make the right decisions, like giving the right medicine to a patient or buying the right property and stock. In a personal interview with Dr. Wang, he explained that an AI should understand why it is making a decision in order to explain to us the decision it made. If we know why or how an AI makes a decision we can check its work and even learn from it.

AI is very prevalent in both robotics and software applications and allows for countless technological advancements, automations, and even discoveries. However, humans are more capable than AI and ML in many ways and many tasks cannot be automated. Some of those tasks are too complex for current models, some are so important that AI cannot be relied upon, some are at a stage where applying AI is not profitable, and some simply do not require such advanced systems.

While AI is great and enables many automations, advancements, and discoveries, AI and ML must further mature and become more available for further widespread adoption. Current AI and ML technologies have many weaknesses including capability limitations, transparency issues, lack of sustainability, and limited availability. For example, learning new things from experiences from other tasks is unsupervised/reinforcement learning and AI has a deficiency and is far behind humans (Binary District Journal, 2019).

Another limitation of AI is “The capacity to reason and find connections between seemingly disparate ideas is something humans possess to a high degree, while the ability to be completely independent and achieve emergent learning still eludes machines” (Binary District Journal, 2019). Dr. Gani and Dr. Wang both expressed that current AI have a reasoning and causality deficiency. Dr. Gani gave the example that in Florida in the summer the crime rate and ice cream sales go up. Current AI and ML systems assume that one or the other cause the other to happen. But any reasonable person will know that that is not the case. Dr. Gani did express how many researchers are working on this issue and have partially overcome it, but it is still a prevalent and widespread issue. As we can see from these sources AI

has a reasoning and explainable model deficiency. While AI is still very useful without truly understanding reasoning and causality, “Aschenbrenner lists five major areas where humans still have an advantage over machines: vision, unsupervised/reinforced learning, explainable models, reasoning and memory, and rapid learning”(Binary District Journal, 2019, p. 24). So as mentioned above humans still have a great edge over machines in complex tasks like learning, understanding, reasoning, vision, and memory.

Another crucial issue slowing the widespread adoption and further development of AI is transparency. The issue of transparency occurs in three layers. The researchers do not understand why an AI makes a decision. Next, many organizations and researchers are hesitant to share research. And, finally, the public does not understand and trust AI.

First of all, “it can be impossible to say exactly how or why a machine-learning model produces the results it does”(Heaven, 2020, p. 3). This is an ethics issue because biases can go unnoticed. AI applications are being used and will be used to decide life altering matters including how much loan a bank should give to a person, whether to hire someone, and more. So a bias in an AI can cause great damage to people's lives. For example Amazon made an AI to review job applications and make right decisions based on the employees Amazon had hired in the last 10 years. The AI developed a preference to men, and even though the researchers did not provide the AI with gender or name data, the AI used clubs, activities, sports, and more to try to guess gender and make a biased decision (Dastin, 2018). If such a system was implemented or a faulty AI was given more important duties one can see the harmful effects it could have.

Dr. Wang also explains that the only purpose of AI is not to automate tasks and give humans accurate answers; rather, AI should be able to help us research the universe and grow human knowledge and understanding. For an AI to explain and teach humans a decision or discovery it has made and to avoid and prevent ethically corrupt AIs, we must ensure that there is an order that we understand in the decision making process of an AI.

The next layer in the issue is a lack of transparency between researchers and organizations. AI replication is important for researchers to learn from each other and to check each other's work, and Heaven (2020) notes that “What is stopping AI replication from happening as it should is a lack of access to three things: code, data, and hardware”(Heaven, , 2020, p. 3). And “only 15% of AI studies share their code”(p. 3). Based on the MIT Technology Review, the major offenders are industry researchers rather than university researchers; “Data is often proprietary, such as the information Facebook collects on its users, or sensitive, as in the case of personal medical records. And tech giants carry out more and more research on enormous, expensive clusters of computers that few universities or smaller companies have the resources to access”(p. 3). As stated above, large companies like Facebook not only have valuable data but also access to powerful computers, which allows them to train models that little to no universities and small companies can compete with. AI research is being compared to the research of pharmaceutical companies; however, according to the MIT Technology Review researchers are working to increase the code being shared and companies like Facebook have been giving university researchers access to their computing power making efforts to give small research groups a chance to run large scale experiments. While there is improvement there is no doubt that industry researchers are doing the majority of research and development and are not all willing to share their work.

When the lack of transparency between researchers and their AI and ML models and the lack of transparency between researchers is put together, public trust in the technology is undermined and for good reason. Undermining public trust limits the adoption and development of the technology. Widely implementing systems we do not understand can lead to implementing systems with severe biases and flaws which can have devastating effects therefore it may even be good for the public to not completely trust AI and force the people developing to make sure it is safe.

The next issue holding AI back is efficiency and sustainability. While computers can calculate a lot more than humans and are not bound by time, humans are a lot more efficient in terms of energy use by a factor of many 10s of thousands (Binary District Journal, 2019). This means that computers and AI may be wasting more energy and resources than needed for a task, and even harming the environment.

“Compared to 2012, it now takes 44 times less compute/resources to train a neural network to the level of AlexNet2”(Hernandez & Brown, 2020). And yet a “simple chat bots could cost anywhere in the range of a few thousand dollars to upwards of \$10,000, depending on the complexity”(Binary District Journal, 2019). Even though our computers and algorithms are getting better, we use more and more power and data to make better and better AIs, which is driving up costs. According to Dr. Pan, current big models use tons of data and computational power which are not sustainable and require an alternative solution. Currently the amount of energy and computers used to train AIs is increasing beyond Moore's law, so instead of competing with better software the competition has become resource based. And according to Professor Song Han at MIT and the MIT Technology Review training complex AI is expensive not only because computers and data cost a lot, but also because power is necessary to train these AIs, and training one AI model can emit 5 times as much carbon than a car will in its lifetime (Youth AI Lab, 2020). So while AI can do very complex tasks and is improving at an astonishing rate, currently the technology is not very efficient when compared to humans, and a lot of development is due to resource increases and we cannot increase the resources used by AI forever. And this lack of efficiency leads to high prices and environmental damage. This does not mean AI is more expensive than hiring humans or that no AI can be economically implemented, rather the new cutting edge AIs being currently developed are not yet economical or sustainable. For these reasons many experts agree that alternatives like tiny AI are needed. For example neural networks can be trained on powerful computers then simplified to run on low power devices with minimal accuracy loss (Youth AI Lab, 2020). This is yet another example that AI needs to be and is being improved and that more resources is not the best solution to increasing the adoption of the technology.

Another factor holding back the adoption of AI and ML is availability. Machine learning and artificial intelligence technology is still too expensive for most individuals (Binary District Journal, 2019). AI technology can be very expensive and difficult to develop and implement, but that does not mean an individual or small business/organization cannot take advantage of the technology. If 1 person is using the technology they have to pay for both implementation and development costs. But if 1000 people are using

the technology, while they would each have to pay for the implementation costs, they could split the development costs. And as demand grows there will be more competition further lowering the price. Dr. Pan explained that human resources are the largest expense for most businesses; therefore, AI technology could be profitable for businesses. And Dr. Wang explained that businesses adopt technology when it becomes profitable; just like business adopted card readers and self checkout machines, they will adopt more AI technologies as they become profitable and reliable. As Dr. Pan explained, new technologies are always expensive and go down in price with time. So while some new AI technologies might be out of reach for most businesses today, there are many AI and ML technologies that businesses can and are implementing, and with time the more advanced and newer technologies will become more affordable and more available.

Data Collection and Methods

In order to identify whether availability is the most significant factor holding AI back from widespread adoption and whether AI as a service is the solution to these factors, qualitative research was conducted through interviews to learn about the opinions of experts. Interviews were conducted with AI experts and Ph.D. students. Questions were asked about how current AI technologies are being utilized, the weaknesses and strengths of AI, why the technology is not being used more, and how people can make sure this technology is used in more applications.

Interviewee**Date/Method of Interview**

Lujie Karen Chen, PhD	Dec 4, 3:30 PM, ZOOM
Md Osman Gani, PhD	Dec 8, 3 PM, ZOOM
Shimei Pan, PhD	Dec 1, 1:30 PM, ZOOM
Jianwu Wang, PhD	Dec 6, 1 PM, ZOOM

Results and Analysis**Figure 1**

	Dr. Pan	Dr. Chen	Dr. Gani	Dr. Wang
How widespread is the use of AI and ML today?	-AI use is widespread -Impacts everyone on a daily basis (online websites)	-30% utilization of AI in Education -50% AI Utilization in Healthcare -Online education and healthcare tech allow for more data collection which can increase AI use.	-Computing power and new methods increase use. -A lot of tasks to automate left.	-Everyone tries to use AI for their application. -AI at an early stage. Long way to go

Figure 1 demonstrates that all of the people interviewed agree that AI is being utilized in many ways. But 3 of the 4 interviewees indicated that there is room for improvement and development and the other simply stated that AI does not solve all problems. These results show that there is more to AI than costs and availability.

Figure 2

	Dr. Pan	Dr. Chen	Dr. Gani	Dr. Wang
AI Strengths	-Data analytics	-perception including vision and voice recognition -		-Big data/finding relationships
AI Weaknesses	-AI is weak	-planning, decision making, emotion, creativity, collaboration -AI does not carry over experience from task to task	-Ethics, biases, black box, causation, transparency.	- reasoning and data quality. - Black box - AI can not explain or teach its findings to humans.

Figure 2 demonstrates that all interviewees indicated that current AI is good at analyzing data and finding relationships and one interviewee indicated that this allows for computer perception. All interviewees indicated that current AI has many weaknesses. Two interviewees indicated that there is a black box issue and a lack of understanding of causality in AI. One interviewee indicated that these weaknesses hold AI back from successful planning, decision making, emotion, creativity, collaboration, and carrying over experience.

Figure 3

	Dr. Pan	Dr. Chen	Dr. Gani	Dr. Wang
Effects of widespread Adoption	-Widespread adoption inevitable -Large impact on jobs. -will assist professionals	-People will seek more and new entertainment. -Human machine collaboration	-Many jobs like truck driving will be lost. -Jobs will change, doctors can use AI to interpret x-ray.	
What is stopping Widespread Adoption?	-Current AI does not solve every problem	-Maturity of technology, costs of implementation, and social impact.	-Lack of trust in AI, black box.	-More time and development needed.

Figure 3 demonstrates that all interviewees believe AI will be widely adopted and peoples lives will change as AI either takes jobs or assists professionals with their jobs. 3 of the 4 interviewees believe that current AI cannot solve all problems and more time is needed for the technology to mature. And 2 interviewees indicated that there is a black box issue with AI limiting trust, and that the social impact of implementing this technology must be extensively considered.

Figure 4

	Dr. Pan	Dr. Chen	Dr. Gani	Dr. Wang
Can small businesses afford AI?	-AI models with big models and big data are very expensive and not sustainable. - There are cheaper options. And HR is the largest expense of small businesses. - Depends greatly on needs and circumstances.		-Off the shelf options are making it possible.	-Technology is used more now in business than before. Investments are necessary and when the return is profitable businesses will take the leap. -The technology has to and will mature and lower in cost.
How are costs and availability changing and why?	-Technology is getting cheaper -New models are both more expensive and super powerful. -Worrisome trend appearing	- If the technology is adopted more and more the price will go down. -Software development costs will go up.	-Hard to access technologies are now affordable and accessible through APIs. - And as competition increases the prices go lower.	

Figure 4 indicates that all interviewees believe that some sort of AI is accessible to small businesses and individuals however they believe that costs are still high and AI cannot do everything right now. All interviewees indicate that the technology is becoming cheaper and as it is adopted more and more it will continue to become cheaper. 2 interviewees do note that further investment into new technologies will

increase prices of new technology, and 1 interviewee is worried about this trend and believes that it is not sustainable.

Figure 5

	Dr. Pan	Dr. Chen	Dr. Gani	Dr. Wang
Effect of AI as a Service?	<ul style="list-style-type: none"> -Will be widely used -Can not solve all problems -Some people would rather develop their own. 	<ul style="list-style-type: none"> -Will have a large impact on the adoption of AI - Can not solve all problems. - Experts needed to customize and apply the AI. 	<ul style="list-style-type: none"> - For general purposes the tech will be used, but for specific tasks it is not great. -May be trust issues. 	<ul style="list-style-type: none"> -Most companies will likely use AI as a service. - Every company has different needs so the implementation is not that straight forward. -Development from scratch is not wise.
What applications require custom solutions?	<ul style="list-style-type: none"> -Security applications -Sharing proprietary data with competitors -Applications off the shelf solutions can not solve. 	<ul style="list-style-type: none"> -Depends greatly on the needs of the business. 	<ul style="list-style-type: none"> -Off the shelf solutions may not suffice. -Customization and training may be necessary 	

Figure 5 indicates that all the Interviewees believe AI as a Service will have a large impact on the adoption of AI, and most people and companies will use one form of AI as a service. And all interviewees indicated that the needs of businesses and individuals may not be provided by AI as a service, and even if they are they will need a lot of customization and implementation. One interviewee indicated that one reason people may not use AI as a service may be due to security reasons as a company may not want to share their data with others. For that reason many larger companies will either assemble their own AI groups or invest in/acquire private groups researching and developing AI. **Another solution to**

availability are application source interfaces which allows different apps and programs to communicate with each other and open source code. Dr. Chen said that people can use open source software and modularize parts of the technology. Tasks like object recognition can be modularized but someone has to put the parts together, train the system, and tweak it for the applications. Dr. Gani suggested that sensing APIs can be used and Dr. Wang said robotics technologies can be implemented with assistants like google assistant or alexa. Essentially developers and researchers can use existing technologies to build their own technology. As Dr. Wang put it, developing everything yourself is not wise.

Discussion/Conclusion

The research partially supported the hypothesis. As seen in figure 4, while cost and availability are major factors holding back the adoption of AI and AI as a service will have a great impact on the adoption of AI (Figure 5) as my hypothesis stated, AI as a service still requires experts and a lot of resources. And for many applications AI as a Service will not suffice and many might not want to share their data. Beyond availability and cost there are many limitations of AI. As seen in figure 2, AI has a transparency issue, a transparency/ethics/bias issue, a lack of understanding of causality, deficiencies in planning, decision making, emotion, creativity, collaboration, and the lack of the ability to carry over experience from one task to another. Similarly, as shown in figure 3 some of the leading factors holding AI back are that current AI cannot solve all problems, there is a lack of trust, and there is a lack of maturity requiring more time and development. The literature review pointed to the issue of transparency, lack of efficiency, lack of availability but not the limited capability like the lack of understanding of causality and the ability to carry over experience, which are massive roadblocks in the future of AI.

This study was only conducted on four AI experts all who work at the University of Maryland Baltimore County. Researchers at other institutions may have different opinions. This study and research can be redone with a greater and more diverse audience. The issues of transparency, the black box issue, public trust in AI, bias in AI, AI understanding of causality, AI transferring experience from one task to

another, and measuring efficiency, and making AI more available and easier and cheaper for individuals and small organizations are all topics that can and should be further investigated.

Appendix A

1. How widespread is the use of AI and ML today? What are its strengths and weaknesses?
2. How do you believe the widespread adoption of AI will change the world and the lives of people?
3. In my research, I have seen that while AI is being applied to many areas, there are still areas where it isn't. What is stopping the widespread adoption of AI from taking place?
4. One of the biggest things holding small businesses back from using AI would be the upfront cost to implement it. According to your opinion, why would it or would it not be worth it for small businesses to make such an investment?
5. How are the costs of implementing AI changing? What can this change be attributed to?
6. What role do you believe AI as a service will take place in the democratization(widespread adoption) of AI?
7. What applications do you believe justify developing a custom AI rather than using AI as a service?
8. For robotics applications, what is your opinion on how we can streamline AI and ML implementation?

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