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Leveraging AI to Fight Climate Change

Artificial intelligence has become a buzzword in the past few years. Whether it is about a new AI startup that optimizes food delivery times, autonomous vehicles or the ethicality of AI, it has definitely made quite a few headlines. However, despite all of the different and extremely interesting applications of AI that are up-and-coming, we often forget some of the most important areas where the wonders of artificial intelligence can create some magic. The area that needs AI's attention right now is climate change.

Background on Climate Change and IPCC's Special Report

Earlier this year in October, the world's top experts at the Intergovernmental Panel on Climate Change (IPCC)¹ released a report, at the request of the Conference of Parties, on the impacts of climate change when global temperatures reach 1.5°C above pre-industrial levels. The IPCC is a body of the United Nations that is made up of experts from around the world to synthesize the most recent developments in climate science, adaptation, vulnerability, and mitigation every five to seven years². Instead of conducting their own research or making policy recommendations, they comprehensively synthesize research into information that is aimed to be policy-relevant for government representatives and the world's political leaders to make policy decisions to curb the effects of climate change.³

¹ <https://www.ipcc.ch/sr15/>

² <https://www.ucsusa.org/global-warming/science-and-impacts/science/ipcc-backgrounder.html#.XA73BS2ZPOQ>

³ <https://www.ipcc.ch/about/preparingreports/>

The origins of this report are quite interesting. During the Paris Agreement in 2015, 197 countries, including America at the time, came together to sign an agreement that committed them to limit global warming to below 2°C. At this convention of world leaders is when the IPCC was asked to investigate what would happen at 1.5°C. The historic special report came out in October and created more waves than climate change had done before. The report involved 91 authors from 40 countries, 133 contributing authors, over 6,000 cited references and 42,001 expert and government review comments.⁴

One of the report's key messages is that the consequences of 1°C of global warming are already being observed through more extreme weather, rising sea levels, and diminishing Arctic sea ice, among many other changes. The report emphasizes the climate change impacts that could be avoided by limiting global warming to 1.5°C compared to 2°C. It also explains that global anthropogenic carbon dioxides (CO₂) emissions would need to decrease by about 45% from 2010 levels by 2030, reaching net zero by around 2050. The bottom line of the report is that while conditions at 1.5°C are going to be precarious and cause a lot of damage, the conditions at 2°C will be outright terrifying: massive ecosystem loss, potentially irreversible melting of ice sheets triggering sea-level rise affecting millions, mass species extinction, and many other catastrophic events. Therefore, we need to think of 1.5°C as the new goal to prevent and not 2°C. The other huge takeaway and what has been and should be a wakeup call to many around the world is the narrow window of time left to take action. We have to slash carbon emissions and make huge

⁴ <http://sdg.iisd.org/news/ipcc-special-report-limiting-global-warming-to-1-5c-will-require-unprecedented-transitions/>

changes by 2030. That is less than 11 years away and the clock has not stopped ticking. The report summarizes the level of the actions needed to be taken in one specific paragraph in the report⁵:

“Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (medium confidence).”

AI is the Key to Curb Climate Change

The keyword that sticks out here is *unprecedented*. The IPCC calls on the world to make changes on a scale that is larger than ever and do this faster than ever before. The innovation of the tech world has allowed us to scale our technological advancements at an unprecedented level over the past decade that this period is now called the “Fourth Industrial Revolution”. One of the driving pieces of technology of this period of time has been artificial intelligence. Due to the advancements we are making, AI could be the key to curbing climate change. Today, AI is in use in our daily lives and has reached a historical moment because of six converging factors⁶: big data, processing power, a more connected global than ever before, open-source software and data, improved algorithms, and accelerating returns on AI applications. The convergence of these factors and the urgency of climate change makes it the perfect time for the world to leverage AI to help fight climate change. The spectrum of AI is also expanding greatly and on the positive side,

⁵ <https://www.climaterealityproject.org/blog/2030-or-bust-5-key-takeaways-ipcc-report>

⁶ http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf

there are a number of applications of AI to help with climate change already in place. Here are some of the applications of AI currently in place from the private section:

Microsoft's AI for Earth

Microsoft is one of the biggest technology companies in the world and they are also at the forefront of large corporations taking steps to ensure a better future and Earth. Microsoft's AI for Earth is their \$50 million commitment to empowering the creation and testing of new AI applications.⁷ They initially provide seed grants for projects applying AI for Earth around the world and also provide access to Microsoft's Azure and AI technology. They are also working to provide universities, NGOs and others with advanced training to put AI to its best uses. As these projects mature, they hope to identify the projects that show the most promise and make larger investments to bring them to scale. These investments are not only through monetary support but also involve multidisciplinary teams from Microsoft including AI and sustainability subject matter experts. Finally, they hope to pursue the opportunities where these AI advances can be incorporated into platform-level services so that others can use them for their own sustainability initiatives.

Land Cover Mapping

One of the major projects that have come out of the AI for Earth initiative is the land cover mapping project which is aiming to use real-time data mapping to enable higher precision in conservation efforts.⁸ Microsoft is using the Geo AI Data Science Virtual Machine⁹ which is an Azure VM type specially tailored to data scientists and analysts that manage geospatial data. Along

⁷ <https://blogs.microsoft.com/on-the-issues/2017/12/11/ai-for-earth-can-be-a-game-changer-for-our-planet/>

⁸ <https://www.microsoft.com/en-us/ai-for-earth/land-cover-mapping>

⁹ <https://docs.microsoft.com/en-us/azure/machine-learning/data-science-virtual-machine/geo-ai-dsvm-overview>

with the VM they are using Microsoft's Cognitive Toolkit to train a deep neural network-based semantic segmentation model to assign land cover labels from aerial imagery. By reducing costs and speeding up land cover map constructions, they can help organizations like the Chesapeake Conservancy to track processes like deforestation and urbanization with higher accuracy.¹⁰ This will allow the conservancy and other local agencies to better understand the impacts of climate change in the area and help them plan for natural disasters. This understanding can also help these agencies come up with more effective and targeted solutions to problems in the area.

FarmBeats

Another project that came out of the AI for Earth initiative is called FarmBeats.¹¹ The idea of this project is to bring AI and IoT (Internet of Things) to enable farmers to sustainably lower costs and improve yields. Microsoft researches and engineers are bringing different kinds of sensors and devices to local farms to gather all kinds of data. Soil sensors gather moisture, soil chemistry, and temperature data. Tye balloons, which are low-cost Tethered Eye helium balloons, help gather all kinds of imagery and video of the farm. Microsoft deploys machine learning algorithms to create a detailed heat map of the farm which the farmer can then use to increase efficiency and conserve resources.¹² This is a simple and effective way for farmers to employ a low-cost solution to better understand their farming practices and increase yield. While the FarmBeats project does not necessarily directly help combat climate change, resource conservation will play a huge role in controlling conditions by 2030.

¹⁰ <https://blogs.technet.microsoft.com/machinelearning/2018/03/12/pixel-level-land-cover-classification-using-the-geo-ai-data-science-virtual-machine-and-batch-ai/>

¹¹ <https://www.microsoft.com/en-us/ai-for-earth/farmbeats>

¹² <https://www.microsoft.com/en-us/research/project/farmbeats-iot-agriculture/>

Smart Grid

Outside of their AI for Earth initiative, Microsoft is partnering with Adger Energi and Power AS in Norway to help create and deploy a Smart Grid. “Think of the Smart Grid as the internet brought to our electric system,” says the U.S Department of Energy.¹³ The grid typically refers to the electric grid, a network of transmission lines, substations, transformers, and more that deliver electricity from the power plant to a home or business. A Smart Grid will bring the digital transformation that the Internet has brought to the outdated grid system.¹⁴ This will allow for many benefits including more efficient transmission of electricity, quicker restoration of electricity after power disturbances, and will even allow for better integration with the adaptation of renewable energy systems into the grid.

IBM’s Green Horizon Project

The Green Horizon Project from IBM is another great example of an industry leader taking an initiative to invest advanced technologies like artificial intelligence, big data processing, and Internet of Things to help the environment. They aim to analyze environmental data from thousands of sources to create accurate and self-configuring weather and pollution forecasts.¹⁵

Air Quality Management

Working with the Beijing Environmental Protection Bureau, which is grappling with reducing air pollution in the broader Beijing-Tianjin-Hebei region (one of the world’s most populous, industrialized and polluted regions), IBM has helped develop a better air quality

¹³ <https://www.nasdaq.com/article/how-microsoft-is-using-artificial-intelligence-to-fight-climate-change-cm944514>

¹⁴ https://www.smartgrid.gov/the_smart_grid/smart_grid.html

¹⁵ <https://www.research.ibm.com/green-horizons/interactive/>

management system.¹⁶ PM2.5 is a measure of particulate emissions including carbon, nitrogen, sulfur, and heavy metals. A clear blue sky has a level of 0 and busy cities have scores between 40 to 60 and anything around 200 is hazardous to public health. Areas in this densely populated and polluted area have even exceeded 600. IBM has worked to develop a system capable of generating predictive models to show where the pollution is coming from, where it will likely go, and what its potential effect could be. On top of this, they have come up with a scenario modeling system to create hypothetical “what if” scenarios – enabling city officials to try out the effectiveness of different action plans to achieve a balance between environmental and economic concerns. The system is able to generate highly accurate pollution forecasts, down to the nearest kilometer, 72 hours ahead of time, as well as pollution trend forecasts up to 10 days into the future. Armed with this information, city officials in Beijing can employ the most targeted, effective and sustainable responses.

Renewable Energy Forecasting

Apart from air quality management, IBM’s Green Horizons initiative is also working on developing a renewable energy forecasting system that combines climate modeling, IoT and AI with computing power to help utility companies predict how much available energy they will have ahead of time. This project is a great example of an initiative aimed to directly help reduce CO2 which is one of the biggest causes of climate change. Solar farms are fitted with sky-facing cameras to monitor cloud movement and calculate their potential blocking impact on solar radiation. Wind turbines in wind farms are fitted with sensors 80 meters above ground to monitor wind speed, moisture, and other factors. All of this data combined with weather forecasting data (IBM partners

¹⁶ <http://www.research.ibm.com/green-horizons/#fbid=g1UcJof4EKi>

with The Weather Company)¹⁷, are used by IBM's system to predict the performance of wind and solar energy farms with 90% accuracy several days ahead. This helps save thousands of megawatts of energy that would otherwise be lost. IBM is currently working with Zhangbei Demonstration Project, China's largest renewable energy initiative on this project.

Other Initiatives and Energy Optimizations

Large corporations are not the only ones taking action when it comes to applying AI to climate change. A number of different applications are currently in place especially in the area of energy production optimization and renewable energy. This is an area where the applications of AI can be the most impactful. The intermittency of renewable energy like solar and wind make a world where we are only using renewable energy at current operations unrealistic. Working to manage these issues and create a smarter energy grid will help make renewable energy a more realistic alternative in the near future.

The Department of Energy's SLAC National Accelerator Laboratory operated by Stanford University will use machine learning and AI to identify vulnerabilities in the electric grid¹⁸ similar to Microsoft's work in Norway. This initiative aims to strengthen the grid in advance of failures and restore power more quickly when failures do happen. They are starting out by analyzing data from renewable power sources in California and the goal is to develop a grid that can automatically manage renewable energy without interruption and recover from system failures with little human involvement.

¹⁷ <https://www.ibm.com/blogs/research/2018/03/ibm-climate-change/>

¹⁸ <https://www6.slac.stanford.edu/news/2017-09-14-slac-led-project-will-use-artificial-intelligence-prevent-or-minimize-electric-grid>

Other examples of innovation with AI in the energy space include wind energy companies incorporating AI into their operations to get each turbine's propeller to produce more electricity per rotation by incorporating real-time weather data.¹⁹ AI will enable each individual propeller to determine the wind speed and direction coming from other propellers and adjust accordingly. This will help combat the wake created by the front row of wind turbines in a wind farm that decreases the efficiency of those behind them. Researchers at the Department of Energy and National Oceanic and Atmospheric Administration (NOAA) are using AI to better understand atmospheric conditions in order to more accurately project energy output of wind farms.²⁰

These are just a handful of applications of AI in energy optimization and renewable energy space. Deep learning algorithms and further applications of AI to this space will help revolutionize the demand and supply sides of the energy economy. Franklin Wolfe, a researcher and grad student at Harvard University discusses a number of other potential applications of AI.²¹ He believes that large regional grids will be replaced by specialized microgrids that manage local energy needs with a finer resolution which can be paired with advanced batteries which will allow power to continually flow to and between local communities even when severe weather or other outages afflict the broader power system (renewable or not). Smarter meters for consumers and businesses will allow utility companies to better monitor demand and supply. These meters and sensors that are measuring energy in the grid real-time can allow operators to actively manage and avoid disruptions in energy flow. In the age of big data, data centers can also use AI optimize

¹⁹ <https://www.bloomberg.com/news/articles/2018-05-09/smarter-wind-turbines-try-to-squeeze-more-power-on-each-rotation>

²⁰ <https://research.noaa.gov/article/ArtMID/587/ArticleID/2396/New-research-improves-wind-forecasts-for-the-renewable-energy-industry>

²¹ <http://sitn.hms.harvard.edu/flash/2017/artificial-intelligence-will-revolutionize-energy-industry/>

to reduce their power consumption. Microsoft and Google reported investing in this area and cutting their energy costs by millions of dollars.²² Similar kinds of optimizations can be scaled up and down to different needs and cut costs as well.

Recommendations and Future Applications of AI

In January of this year, the World Economic Forum partnered with PwC and Stanford Woods Institute for the Environment to release a report titled: *Harnessing Artificial Intelligence for the Earth*. It was released as a part of their series on the Fourth Industrial Revolution and enumerates a number of different target areas for AI to develop to improve the state of the planet in many different verticals.²³ They identify 6 different priority action areas for addressing Earth's challenges which includes climate change. Within climate change, they break down 6 different areas that can be worked on: clean power, smart cities and homes, sustainable land-use, sustainable production and consumption, and smart transport systems. Within clean energy, they mention optimized energy system forecasting and smart grids for electricity use as discussed earlier. Other applications within clean energy include decentralized & peer-to-peer renewable energy systems and optimized virtual power plants. Smart traffic light and systems for urban mobility management, energy-efficient building management systems, and smart and integrated recycling systems and waste management are just a few of the numerous ways outlined in this report.

The World Economic Forum (WEF) also went in-depth to discuss a number of AI game changers that could impact the Earth due to their key characteristics of making transformational impact, being highly adaptable, and their need for AI to become possible.

²² <https://deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-40/>

²³ http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf

Autonomous and Connected Electric Vehicles

Autonomous vehicles are a domain that has been one of the first adaptations of AI has garnered a lot of support for being a futuristic vision that is slowly becoming reality but also for being an environmentally friendly reality. AI is vital to make the transition to autonomous connected electric vehicles, a vision that we have made a good amount of progress towards. Uber and Lyft have transformed transportation and autonomous vehicles combined with electrical vehicles will truly take transportation to the next level. With the increasing demand for transportation, a smart transport system enabled by AI can lower emissions and improve overall efficiency. This will also encourage car sharing and reduce car ownership. Many millennials and Gen Z's already live their lives without a car thanks to ride sharing and on-demand services. Rapid innovation in this field will also make huge strides in cutting down greenhouse gas emissions and the role of AI is central in making this a reality.

Distributed Energy Grids

Smart grids and energy optimizations are also on the top of the list in the WEF's recommendations. They strongly believe that the use of AI to make distributed energy possible at scale is critical to decarbonizing the power grid, expanding the use of renewables and increasing energy efficiency. Earlier we discussed that AI applied to the energy domain will help on both the supply and demand sides of renewable energy. AI can also play a role in dynamic pricing and trading to create market incentives. Distributed energy grids can also be extended to incorporate new sources such as solar spray or paint-coated infrastructure of vehicles, and to allow AI-enabled "solar roads" to expand, connect and optimize the grid further. Smart grids can also capitalize on

other Fourth Industrial Revolution technologies such as blockchain and IoT create a more efficient system.

AI-designed intelligent, connected and livable cities

Beyond just autonomous vehicles and smart solar roads, AI can be applied to truly transform urban planning as we know it to build resilient, human-centric cities with minimal air pollutions and environmental impact. Initiatives like the Green Horizon Project from IBM show us how AI could be used to tackle and monitor air pollution quite successfully. AI could also be used to simulate and automate the generation of zoning laws, building ordinances and floodplains which are time-intensive and inefficient processes with high margins of negative impacts and errors. Combined with other technologies like AR and VR, AI-generated data could be used by city planners and other officials to aid with disaster preparedness and, when needed, reconstruction. Weather disasters in 2018 have exceeded \$1.5 trillion in damages in the US alone. AI applications here could aid reconstructions here to build smarter and more resilient communities for the future.²⁴

Solutions Exist, Taking Action is the Next Step

The applications of AI highlighted in this paper so far and the recommendations from the WEF are just a few ways AI could be applied to help the Earth fight climate change. On the bright side, many of these applications are already in the works and many others are becoming more and more realistic and feasible as technology advances. What stands in the way for these initiatives to become reality are policy-based roadblocks and resources. The more we invest in AI, whether that is assembling better data sets, training more algorithms, or increasing funding into AI research, the

²⁴ <https://www.ncdc.noaa.gov/billions/>

better AI gets. The WEF puts it well, “Leveraging AI technologies, not only for business and short-term growth prospects but also for sustainable and resilient growth, requires decisive action.”

Public agencies and private organizations need to come together to develop solutions, maintain good governances, and overcome financial barriers.

Collaborating for interdisciplinary solutions and directing finances for innovation are overarching areas that are important for all stakeholders to make this vision a reality.

Technologists, policy-makers, domain experts and many others need to come together to design and deploy AI applications for the Earth. This collaboration is needed both a high-level system view and also for individual applications. A multidisciplinary approach is key here. Just like any other vision of innovation, funding is necessary to bring it alive. Compared to short-term gain applications of AI, “Earth-friendly” AI applications will require more funding as these solutions aim for long-term impact and sustainability. Funding in R&D in both technology and environmental sciences, impact investing in technology solutions, and government financial instructions that will help spark private sector innovation are all needed.

These are solutions that will fundamentally shift current processes and are large-scale in nature. There are a number of roadblocks that these recommendations will face as it is difficult to get society to buy into long-term vision that does not have immediate returns. However, when the fate of the planet is at stake, unprecedented levels of change are not needed but required. Artificial intelligence is the key to solving climate change and society has to realize that now, before it is too late.