Arctic 2.0: How Artificial Intelligence Can Help Develop a Frontier

*Patrick Lin and Fritz Allhoff**

Artificial intelligence (AI) is set to revolutionize all manner of things, from smart toys to smart cities, from developed nations to developing ones. But what has been overlooked is how AI and other technologies can play a role in developing new frontiers, such as the Arctic. This is a strange gap, since technology—tools and knowledge systems—is often our only competitive advantage in this world. And it is a crucial gap, since frontiers hold intrinsic potential for great conflict as well as great benefits, either of which could be accelerated by technology.

Thanks to climate change, a new Arctic is emerging from under the melting ice, and it promises to be geopolitically vital.[1] Yet in regional military exercises, Arctic rivals largely ignore the role of cyberattacks, drones, and other irregular forces and tactics that are now part of the playbook for modern "hybrid warfare." That is to say, even in domains where technology is a driving force, little attention has been paid to these unconventional technological aspects in the Arctic context. So how might these technologies play a role in developing the Arctic, and what new challenges to ethics, law, and policy would they generate?[2]

This essay will offer some initial answers, with a focus not on war but on how AI can be employed for *humanitarian* purposes. This is a reasonable possibility, as the Arctic has been a relatively peaceful territory thus far.[3] But the conditions that have enabled peace are quickly changing, and a productive path forward needs to

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be identified if international cooperation is to unseat the all-too-often default mode of competition and conflict.[4] More broadly, the lessons here can inform the responsible development of other frontiers, such as outer space—another peaceful global commons that is also about to become more crowded. Even developed nations have frontiers of sorts within their borders, as urban landscapes are being reimagined as a canvas for AI-powered "smart cities."[5]

The Arctic Context

First, we need to recognize the pressures—the political fears and economic temptations—that may drive us toward conflict in the Arctic, even if the region has been generally insulated from conflict so far.[6] The Arctic has great strategic importance given its proximity to the Global North, the main theater for the two world wars of the last century.[7] Yet global rivals have spent little effort safeguarding their regional interests from hostile actions because the geography is so unforgiving. As one military general said about the possibility of a ground attack: "If someone were to invade the Canadian Arctic, my first task would be to rescue them."[8] But the remote geography is opening up as a result of climate change: sea ice is melting, glaciers are retreating, and permafrost is thawing. As new passages reveal themselves in once-impenetrable frozen seas, ships would no longer be forced to go through only the Suez and Panama canals, saving about *half* the distance and costs between key shipping ports.[9] Depending on the ports, this could translate into a savings of 4,000 nautical miles,[10] two weeks of time,[11] and $300,000 in fuel and operating costs per one-way trip.[12]

A more hospitable Arctic would also mean new access to vast energy and mineral reserves. Offshore, the continental shelves are estimated to hold 13 percent of the world's oil supply and 30 percent of its natural gas,[13] translating into volumes approaching ninety billion barrels of oil, almost 1,700 trillion cubic feet of natural gas, and forty-four billion barrels of liquefied natural gas.[14] Onshore, hundreds of new oil and natural gas fields have been discovered, estimated to hold 10 percent of the world's known conventional petroleum resources.[15] Besides hydrocarbons, significant deposits of zinc, lead, gold, and coal are attracting new mining operations in the Arctic.[16]

Less appealing are the environmental disruptions related to climate change and resource extraction. These include air and water contamination, increased ultraviolet radiation from ozone depletion, and habitat alteration and pollution, as well

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as increasing pressure on land and resources (such as from overfishing) related to a growing human population in the Arctic.[17] Besides harm to the ecosystem, local and indigenous communities are facing greater food insecurity, flooding, and other risks.[18]

Warming permafrost, which could be entirely thawed by 2100, is starting to release once-dormant pathogens, greenhouse gases, and toxic substances for which we are not prepared. In 2016, for example, Siberia suffered a large outbreak of anthrax, with about one hundred victims hospitalized and at least one fatality, after a heat wave released the disease from reindeer carcasses that had been frozen in the permafrost for decades.[19] Such a new pandemic could become a global threat.[20] Thawing permafrost in Alaska alone emitted 220 million gallons of CO_2 into the atmosphere between 2012 and 2014, which is equivalent to the total annual commercial emissions of the United States.[21] Currently, the frozen Arctic permafrost holds 32 million gallons of mercury and other toxins, which is twice as much as is present in the rest of the world.[22]

Taken together, these trends and temptations build into a perfect storm for international competition and conflict. Since 2006, all eight Arctic nations—Canada, Denmark (Greenland), Finland, Iceland, Norway, Russia, Sweden, and the United States, by virtue of having sovereign territory in the Arctic circle—have announced either new or retooled "comprehensive Arctic strategies," with sovereignty, security, development, and sustainability as dominant policy themes.[23] Meanwhile, non-Arctic states such as China, France, Germany, Japan, South Korea, and the United Kingdom are looking for footholds in the region as well, viewing the Arctic as a global resource.[24]

AI for the Global Good

That the Arctic has been mostly peaceful thus far gives us reason to be hopeful that international cooperation can prevail. To help continue that cooperative spirit, it would be useful to have a target to aim for; that is, to recognize the collective benefits at stake and how to get there. Because technology has an outsized impact on the modern world, it could also be used to develop the Arctic as a common good, instead of slipping into an uncoordinated tragedy of the commons. AI, in particular, holds much promise as a foundational technology that is driving advances in robotics, cyber operations, healthcare, biotechnology, operational efficiency, and many other areas.

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What exactly is AI? There is no consensus on a definition, which should come as no surprise since even "intelligence" is a contentious and multifaceted concept. For instance, it can refer to analytical skills, emotional intelligence, musical intelligence, spatial visualization abilities, and more. For the purposes of this essay, we stipulate a working definition as follows: AI is a computational system designed to *automate* decisions, with the appearance of intelligence (whatever that is).[25] Depending on their sophistication, robots therefore may be *embodied* AI, translating automated decision-making into physical tasks.

In this essay we will not elaborate on how AI might change the future battlefield, as that has already been competently done elsewhere.[26] Those forecasts can be extended to the Arctic with some adaptations; for instance, we might see a role for autonomous icebreaker ships, in addition to the unmanned surface and underwater vehicles that exist today. Rather, we will focus on two critical areas where AI can provide significant help: (1) human security as a basic need and (2) the infrastructure needed to promote that security.

Human Security

The three human security elements we will discuss here are related to food, emergency services, and crime—all challenges to the two most basic layers of Maslow's hierarchy of needs. Only with those needs met does it make sense to envision what a broader "good life" or human flourishing might look like in the Arctic. Military dominance alone cannot meet those needs, so any serious discussion of Arctic development will need to consider these elements.

Apart from disappearing food sources in the native environment, food is also very much a transportation problem in the Arctic, since much of it needs to be imported. As we will discuss more in the next section, little infrastructure is in place to support efficient and broad distribution, whether it is to replace a broken machine part or to restock grocery shelves. Delivery can take weeks and adds greatly to the expense. Given these inefficiencies, food prices in the Arctic—especially the rural Arctic—can be astronomical, a problem compounded by dismal average wages. For instance, in northern Canada it can cost US$14 for a bottle of ketchup, US$10 for a head of broccoli, and US$29 for a jug of orange-flavored drink.[27] In an isolated country like Iceland, as much as half of the food may be imported, creating a risk of food security; anything from geopolitics to a volcano eruption could compromise supply chains.[28]

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But AI and other technologies can help with this food insecurity. In recent years online retailer Amazon has been instrumental in shipping more food and supplies to remote locations than previously possible, given how the company has optimized supply chains so dramatically.[29] Leveraging AI further, Amazon is also working on unmanned aerial vehicles for deliveries,[30] as is Google/Alphabet and other companies.[31] Even if these drones, as currently conceived, solve only the "last mile" of the distribution chain, that can be as important as the first mile. If emergency medicine, for instance, cannot get to where it is needed and is stuck at a waypoint, it might as well not have shipped in the first place.

In addition to better transportation, the Arctic could also look to grow more of its own food.[32] Geothermal energy is already powering greenhouses, such as those in Iceland,[33] and Microsoft and others are developing greenhouses staffed by AI and robots.[34] Lab-grown meat is starting to catch on,[35] as well as 3-D printed foods, which are really just a different kind of processed food.[36] That is, we already eat food made up of ingredients that are ground up or even liquefied and then molded into shapes; 3-D printed food is essentially the same process but with better control, building up a shape one thin layer at a time. Already 3-D printers are creating on-demand replacement machine parts and other goods, avoiding the cruder efforts of forging, casting, milling, molding, and other traditional (centuries-old) processes.

AI can also help provide emergency services that are desperately needed in Arctic regions.[37] Currently, search-and-rescue operations are hindered by a number of factors, including infrequent satellite imaging, possible GPS errors, and polar darkness, as well as a lack of ports, airstrips, medical centers, and personnel.[38] This may partly explain why nations have been cooperative in the region: everyone needs to band together and help one another on the frontier. To assist with emergency services, AI and other technologies can provide sensing and communications capabilities, as well as help to staff medical outposts, as discussed in the following section on infrastructure. Robot patrols in the air and water could more quickly alert emergency responders to victims in need, and AI doctors can fill the skills gap by providing diagnoses and treatments, such as IBM Watson Health and da Vinci's robotic surgeons are already doing elsewhere. Autonomous icebreaker ships and airlifts can carve a path to a rescue location.[39]

The ability to provide timely emergency response is becoming ever more important as the Arctic receives more people through tourism, resource extraction, and other activities. As it stands, there are approximately four million

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permanent residents of the Arctic and, while this might sound like a high number, keep in mind that this is across a tremendous land mass, the effect of which is very low population densities. For example, over half of Alaska's 700,000 residents live in and around Anchorage, and another quarter in Fairbanks and Juneau. That leaves some 175,000 people scattered over a land mass two-thirds the size of the contiguous United States.[40] An influx of people to these regions will thus require new strategies. (Some Arctic regions, such as Norway, are already more developed, but that development has, in substantial part, been engineered to create a geopolitical buffer against Russia.)

The aforementioned increases in tourism and resource extraction mean that the odds of another *Titanic*-style crash or *Deepwater Horizon*–like disaster may approach a statistical inevitability over time. Environmental cleanup from such accidents is a related but separate concern of its own, which too can be assisted by robotics[41] and bio/nanotechnology[42]—advances in which can be promoted by AI.

The third area of concern is crime. Any growing population will inevitably suffer from the problems of crime and terrorism, including ecoterrorism, and these represent another type of emergency that needs to be addressed in the Arctic. At the level of transnational crime, a shortcut through the Northwest Passage or Northern Sea Route could be used for human trafficking and drug running, among other types of illicit shipments, just as well as for food and other legitimate goods. If Arctic borders are not currently a major concern because of the inaccessible terrain, nations may soon discover they have thousands of miles of newly opened borders to defend against such crime as the climate becomes more hospitable.

At a more local level, more humans in these regions also means more deaths, some of which may be the result of homicides that imply the need for more extensive investigative and enforcement capabilities than exist in the region today; and this logic applies to less serious crimes as well. Here again, as with emergencies, autonomous patrols and sensors can help with security, which brings us back to future-warfare technologies. This is perhaps unsurprising and unavoidable given that many civilian technologies, such as computers, the Internet, microwaves, and automobiles, all have their origins in military research.[43] We will return to dual-use technologies and their related ethical concerns in the last section of this essay.

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Infrastructure

For technology to work its magic in the above scenarios, infrastructure is essential. Consider what it takes to bring food to people in our *developed* world, which is often invisible to us because it is so omnipresent: in addition to building the food stores themselves, we also need supply chains, roads, trucks, ports, and many other elements in order to support an economy of scale. In the Arctic, we could perhaps avoid the infrastructure needed for ground-based distribution by employing aerial drones that can make deliveries to remote locations; but even they rely on places to launch and to land, as well as the ports and airstrips that allow for goods to be shipped to the region in the first place.

As a foundation for such technological services, including emergency services, it is essential to create information and telecommunications infrastructure. Although fiber-optic Internet cables are making their way into the Arctic, communication remains difficult, as satellite, microwave, and other Internet services are expensive, slow, and unreliable with huge gaps in coverage.[44] AI can enable innovative ways to close these gaps and bring affordable connectivity to local Arctic populations. For instance, "smart" AI buoys could create a wireless network in the ocean, navigating the currents to relocate themselves where needed. Similar devices on the ground—mobile and self-positioning—could be deployed for pop-up networks on land. These and other sensing devices can also track movement and other conditions in the water or on ground, such as to help locate lost travelers.

In the air, Google's Project Loon is prototyping a network of smart balloons that beam down Internet connectivity from the stratosphere.[45] Much higher up in low Earth orbit, swarms of small satellites could also provide a similar network in the sky.[46] Global navigation satellite systems such as GPS are critical for ships and airplanes to orient themselves, but this situational awareness can be degraded by environmental disturbances from icy antennas to solar flares, and by low satellite visibility at high latitudes of the polar regions.[47] Aerial drones, autonomously loitering in the air, as well as smaller satellites in lower orbits, could help boost these signals.

Ground stations not only for communications but also for hospitals, ports, and runways (among other things) will be a crucial part of the emerging Arctic's infrastructure.[48] Just as China has built up artificial islands in the South China Sea,[49] similar outposts could be created in the far north—not so much to establish territorial claims but to provide vital services where there are none today. AI and robotics could not only help with the construction of such outposts but also provide significant staffing for their operations, such as with robotic dockworkers,

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doctors, and other labor, both skilled and unskilled.[50] These outposts could be mobile as well, in the form of autonomous floating platforms driven by AI.

A key challenge to building out Arctic infrastructure will be energy. It is one thing for an autonomous ship to contain its own fuel, but smaller devices that might otherwise run on solar power, such as Project Loon's balloons, may need to find alternative sources in order to recharge when the sky is dark or in twilight for half the year. Research on wave, wind, and geothermal energy is advancing, as is the idea of floating nuclear reactors.[51]

At the same time, responsible development also means protecting existing ecosystems as much as possible, especially from preventable industrial accidents and pollution. This may weigh against building such things as mobile nuclear power plants and instead argue for making serious investments in carbon-neutral—or even energy positive[52]—development and environmental remediation. Environmental impact, as discussed earlier, is already a top concern that can be helped with AI and other technologies—from more efficient and safer drilling/mining operations[53] to new propulsion systems to minimize the disturbances that are today caused by propeller thrusters in the water.[54]

While AI could also help devise and control some geoengineering plans to refreeze the Arctic, we will not spend time on that issue here, as it is difficult to foresee which Arctic nation would even have an incentive to make such a massive investment or effort given the economic benefits of a warmer Arctic (even if such benefits are shortsighted). The ethical questions raised by geoengineering alone are enough to merit a focused study of their own.

Open Questions

While climate change as well as the impact and needs of a growing population have created new problems in the Arctic, other problems may be created by the solutions themselves, whether technological or otherwise. As an analogous example, ride-hailing services such as Uber and Lyft might provide cheaper, and more plentiful and convenient, transportation options, but they can also cause more traffic congestion and pollution, diverting people from mass transportation.[55] So it is with the development of the Arctic. For instance, artificial islands raise questions about territorial claims, as they are doing now in the Asia Pacific.[56] An analysis of this scenario, therefore, must examine the artificial islands and military bases installed by China to extend its territorial waters and exclusive

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economic zones in the South China Sea, which other nations still regard as international waters under the United Nations Convention of the Law of the Sea (UNCLOS).[57] This is complicated by the fact that the United States has never ratified UNCLOS, so the analysis must go beyond existing law and appeal to more foundational principles in ethics.

This scenario also motivates further questions not explicitly contemplated by UNCLOS, such as: Should island building really be enough to stake a new foothold in a territory, and what exactly counts as an island?[58] Could islands be mobile, such as those envisioned in seasteading—the movement to create floating structures in the open sea—and exist beyond the claim of any terrestrial state? As massive airships become viable and can loiter indefinitely above the ocean, could they support a claim to new territory or deny access to competitors? Again, these mobile islands (marine or aerial) could operate autonomously with an AI pilot.

As another example, ethical and policy questions arise from the reliance on private services, such as Amazon Prime today and drone deliveries in the future, to fill the supply chain gap in the Arctic. Though such services are in many ways changing lives for the better, a major risk is that the resilience and survival of some of the involved communities are becoming increasingly tied to the whims and economics of a sole company (and, in the Amazon case, a company that is already under fire for unethical conduct).[59] Similarly, other AI applications raise new challenges for ethics, law, and policy. Autonomous rescue vehicles, including icebreaker ships, could be weaponized and fuel new conflicts: how should this dual purpose be managed, and might they suffer from similar types of ethical concern that afflict self-driving cars? Any increase of human activity is bound to disturb an ecosystem for the worse; even robotic and AI activity would need to draw power and release heat and perhaps emissions. Further, smart sensors for rescues may also raise privacy concerns, as such technology may lead us down the path toward a surveillance state. These worries can be added to the usual list of ethical concerns surrounding AI, such as discrimination and ethical decision-making, as discussed in great length elsewhere.[60]

Final Thoughts

There are other technologies relevant to the Arctic's development, and these should be considered as well. For instance, hydrophobic nanocoating can prevent water from sticking to vehicles, structures, and equipment in such ways as

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reducing ice buildup on communication antennas, which can interfere with signals.[61] As more ships navigate through the Arctic, tracking their pollution will be more urgent, and new solutions such as biotagging fuel and ballast water can help identify offenders.

Much more work is needed to guide the development of the new Arctic, and having a good outcome as a target is always helpful. The familiar narratives of military competition and dystopia can slip into wish fulfillment and path dependency if more alluring and productive scenarios are not offered. Thus, as the next steps in this area of study, there is a role not only for science fiction writers to imagine these things but also for technologists to keep these visions grounded in reality. It will also require the voices of indigenous and local people among the most important stakeholders, as well as experts in international law, economics, development, history, ecology, ethics, and many other areas. The first step, however, is to raise awareness of this emerging Arctic and to understand its challenges and possibilities. Just as technology alone does not win wars, it also will not create a utopia by itself; but with the right planning, it can make a vital difference. Human history is a story of taming the world and its frontiers with our technologies, and AI is poised to be one of the most powerful—as well as one of the most ethically challenging—we have ever conceived.

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Abstract: Technology has an outsized impact on the modern world; it is how we have tamed our frontiers. But that role is largely ignored when it comes to the Arctic frontier. Emerging technologies, especially AI, can enable desperately needed services and infrastructure—but they can also challenge ethics, law, and policy, as they usually do. For instance, autonomous icebreaker ships pose a dual-use dilemma since they can be used for both humanitarian and military purposes. As a lesson for other frontiers, this article will broadly introduce the potential role of AI in the changing Arctic and some of the ethical concerns that deserve attention before that future arrives.

Keywords: Arctic, frontier, artificial intelligence, ethics, human security, infrastructure, development, conflict