Devin Checa

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Professor Paul Gracia

Mobile Robots and Human Capabilities

(1) Abstract. It comes first in your report, but you write it last.

Anyone that takes a glance at modern society will have no choice but to admit that computers have integrated into all facets of human life. It is only a matter of time before computers are capable of handling tasks that humans perform. This change may happen quickly; however, it will not happen overnight. Steadily, current technologies will be part of the solution that augments mobile robot capabilities. These technologies include the Internet of Things, cloud computing, and machine learning. These capabilities will manifest as things only humans normally can do. There will be a bottleneck in the future that prevents these aforementioned technologies from progressing. That bottleneck will be computer hardware itself. Alternatives to current computer architecture will pave the way for the kind of computers necessary for this future. These computers will support mobile robots so that they are equipped with human capabilities.

(2) Summary. Gives succinct information on the purpose, methods, results, and conclusions reported.

Mobile robots will possess human capabilities as computers process data and mobile robots realize tangible action in the real world. Intuition, wisdom, and common sense will be difficult to implement for mobile robots. Before that can be attempted, an automated process for imparting dynamic know-how will be required outside of the scope of typical programming. Hardware will have to change for a mobile robot to have human capabilities. Some computer functionality will have to be compromised as well.

(3) Introduction. Include background material and discuss the scope and limitations of your project.

When taking a glance at the past hundred years, it appears that the world has changed. Gone are the days of telegrams and rotary phones. Cameras are capable of much more than black and white images. Globalization has made the world feel smaller. Computers have automated many things in the world. Part of this is due to advancements in computing capabilities. Computers can process more data now than ever before. In addition to this, computers can now actuate and alter the real world. This is a trait humans possess as well. Our ability to do this is refined because our species is refined. Computers and mobile robots continue to be refined also.

If mobile robots are to possess human capabilities in the future, computer architecture will have to change, learning will become an automatically managed process, and actions will be carried out by approximations. Mobile robots will possess human capabilities as computers process data and mobile robots realize tangible action in the real world.

Through better integration with newer technologies like the internet of things, machine learning, and data science, mobile robots will extend the functionality of a computer and mirror a human's capabilities. The question remains if mobile robots can surpass a human's abilities beyond human comprehension. This paper will not focus on this topic. The focus will revolve around how newer technologies will extend the mobile robot to come closer to a human's abilities.

(4) Discussion. The body of your report. This includes the methodology used. Be sure to fully describe any figures, tables or diagrams you include.

Computers are capable of processing data. A computer takes in data via various mechanisms that are managed by humans. Humans have automated these tasks with things like network routers and Ethernet cables to ensure computers are connected. Computers are also able to make use of peripherals in an autonomous way. Video cameras and microphones on computers can be activated remotely by a human or computer. Abstraction is layered by humans through the computer's interface. As the abstraction increases, the computer's ability to process data increases.

Mobile robots take advantage of mechanics to move and affect the world. The limits of a mobile robot are restricted by the hardware provided by humans. A mobile robot processes data under most applications depending on the task; however, the abstraction of the processing is at another level compared to computers. When a computer processes data, there is nothing noticeable. The result of the processing does not persist in the real world unless it is connected to a mobile robot.

Humans are capable of both. Like computers, humans can process data and leave the surrounding environment unaware of what results were found. An example of this is mental math. Data is presented in the form of a math problem and a human solves it without persisting anything in the real world like writing on scratch paper or picking up a calculator. As with mobile robots, humans can affect the real world and leave the surrounding environment in an altered state. Writing on scratch paper or using a calculator to solve a math problem are simple examples of this.

There are still many questions to be answered regarding how long it will take before machine learning can think about common knowledge. The processor will need to be capable of handling astronomical amounts of data and algorithms will have to be smart enough to choose what data is relevant to the task. This concept does have an analog in humans and it takes time for a human to acquire what is often referred to as "common sense." There is inherent accuracy with common sense because in trivial situations the desired outcome is obvious to humans. According to Psychology Today, humans can operate with intuition without having to consciously think. (Intuition) Intuition can be seen from this perspective as a performance enhancement for computers when a step can be skipped. Computers may require this intuition to be passed on to them in some way unless this ability is compromised for computers in the future like it is in the present day. It is also possible that computers will not need to be so capable of common sense at some future point because of how the process of instructing computers can be refined.

For the foreseeable future, it is best to relegate such precise learning to more managed forms of education like those that humans rely on. This is especially true if computer architecture adapts to better accommodate this form of learning. Programming has taken humans through more than fifty years of progress because of how humans can tell computers what to do. Although this is a great feat, the programming process is not perfect. This stems from the fact that things like functional requirements have to be communicated to a human and then the human has to translate those into instructions a computer can understand. When considering this as a learning process for computers, a human is an essential part of it; even so, humans are often discontent when a computer provides undesired results. To demand precision from a human is unreasonable because humans are not precise. If a computer manages the learning process, then precision can be attained.

A human is born without much knowledge of the outside world. Even if a child does not have parents involved with its development, a child still learns about the real world through experience. For example, the child will learn that a hot stove is hot through experience even if some parent warns it. The learning process takes years. In most cases, an adult will have made mistakes and hope the next generation does not make the same mistakes. This development throughout a human's life varies. All too often it is assumed that computers will have learning refined. This is not the case.

No learning process is perfect. Humans have not found whether public school or private school is ideal for a child's development. Some learn better with audiobooks while others prefer visual aids from a textbook. There are many problems in addition to the limitations of machine learning that have not been solved yet. To assume that a machine will refine the learning process on its own would be to assume that a machine can exceed a human's capacity. There is no evidence of that; however, this does present the possibility of better educated mobile robots.

Given the same learning process, some students are bound to excel while others are left to excel in other areas. School is not always the best way to prepare someone for the real world even though it is society's measuring stick. Humans have integrity; therefore, they do not execute and dispose of students that fail in this learning process. Opportunities are provided through comparative advantage and other economic factors. This same logic will apply to mobile robots trained with machine learning.

Humans have to manage the training process for computers to be capable of completing tasks in various settings. This can become a managed process so that learning for mobile robots can be facilitated and managed by computers. Society has an analog for this kind of process. Schools manage a process of learning for students. Even when this method of instruction does not work out, humans still undergo a managed process to learn at a young age. For computers to learn with dynamic hardware, this process will have to be managed as well. In the same way that faculty and staff in schools manage human learning, an automated form of faculty and staff will have to evolve to train computers as well. This will vary by application in the same way that schools tend to have a specialty for the subjects that are taught. A school might be renowned for the graduates that go on to excel in Mathematics while another may be famous for graduates that end up on Broadway. Training systems for computers will have specialties too. Other capabilities specific to humans like intuition, wisdom, and common sense will require another means of instruction.

Some robots will retain a better intellect than others which will create greater demand in the market for those learned mobile robots. These may be capable of tasks that require more processing than other machine-learned mobile robots. In the same way quality control is implemented with the manufacturing of things like transistors, mobile robots will have some form of quality control enforced. The free market economy will decide if it is best to dispose of less intelligent machine-learned robots or use them for other tasks. Some traits like intuition will be highly sought after.

Consider how the square root of a negative number has a real and imaginary component defined in Mathematics. This is deterministic; however, outside of applications like heat transfer and poles that stem from Complex Analysis, imaginary numbers are not relevant for daily life. Machine learning is analogous to this idea in that it only applies logic with the data it has. The relevancy is provided with the data. "Machine learning is stochastic and non-deterministic." (Stewart) It does not have common sense and it does not operate with basic assumptions integrated into its computation. Machine learning does not possess the capabilities for intuition.

The limitations of a computer processor impact the ability of machine learning to solve problems. If too much data is required to solve a problem, then computing a solution may take too long. This will not prove to be the case in the future with mobile robots because they can affect the real world. A mobile robot is capable of connecting and augmenting its abilities if need be. Cloud computing and the Internet of Things are tools mobile robots can use to augment processing capabilities. From a programming perspective, it is possible that leveraging overwhelming data in mobile robotics may be reduced to a try-catch block where the algorithm tries to compute a solution and if the computation times out then the catch block allocates more resources. If this works out, then problems will manifest in the data itself without consideration for whether it can be processed.

The field of Statistics is limited to the data that is provided. The logic can be sound; however, if the data provided is nonsense then the conclusions derived from it will mean nothing. Predictions can be made with little value and if the system itself is the means of provisioning data, then this sort of error may go unchecked. It is common knowledge within the realm of statistics that correlation does not imply causation. Computers do not have this kind of intuition. Computers inflate this problem because machine learning "encodes correlation, not causation." - Peter Voss (Stewart) In the future, humans will face this challenge. The intuition humans refer to as "common sense" will have to be passed on to computers somehow. This phenomenon varies in a significant way from how causation is not implied by correlation.

If something causes something else to transpire, nearly any sample of observed data can be used to establish this connection. In the present, humans provision this data and provide the computer with a means of interpreting. This intermediary step will vanish as computers develop better senses. Hardware already does a great job replicating some human senses. To bridge the entire gap, humans will have to show computers that intuition is data-driven.

Humans learn from their mistakes. Confucius says “I hear and I forget. I see and I remember. I do and I understand.” This quote puts a spotlight on how humans learn. Computers will need facilities to make mistakes like humans on their own to train and learn in a data-centric way. This may relegate the job of a programmer to a profession more like a computer trainer. Although the way this happens may change, it will not alter much of the development process. Consider how much testing goes into any software product. This testing is a means of training a computer that uses the programmer as a translator to tell the computer what it should do instead for the next test run. Programmers develop experience and intuition through this process which adds value only in how it eases the development process. This wisdom eases the training process. Sometimes wisdom is enough for a human to understand if something did not work in the past. This concept of wisdom is also data-driven, and yet it differs from human intuition. Humans do not need to consider some things because of intuition. Humans impart wisdom over time from generation to generation. Over time, computers will acquire the data necessary to do this like humans.

The learning process for a human is a delicate process that involves investing time to reap benefits later on. This initial investment of time can vary from person to person where some humans may pick up a concept quicker than others. In the present day, computers do not need this sort of upfront investment. They are built with the tools they need and are put in an environment where they need to perform. This provides instant gratification and a "what you see is what you get" (WYSIWYG) phenomenon at the consumer level. This works well for consumer-level computers that primarily operate on software interfacing with data made available on the internet. Imagine a typical session for a computer with a human. There is a boot process that fires off a launcher. This loads an interface for the user to login and conduct business like running applications and interfacing with data over the internet. Now try to envision a typical operation for a mobile robot in some industrial setting. Perhaps the end effector on a robot arm needs to screw a piece off from one place and screw the piece into another. This process involves quite a bit of computation and data processing. If a programmed algorithm is used to process the peripheral data for the configuration space, then the processing can become a computationally taxing operation. If machine learning is used, then data points have to be processed for regression purposes which also imposes a computational load on the system. Loading a consumer-level computer with proper hardware work in practice. Computers for mobile robots will operate fine with the proper hardware. If the hardware of the computing system is put together differently, then a mobile robot will be capable of handling this operation more efficiently.

Graphcore, a company building an alternative to modern computer hardware, is an example of hardware technology learning what to do for its application within its environment.

Computers learning to use their hardware is key. This shift in a computer's thinking is essential for augmenting a computer's capabilities to that of a human. (Carr)

Computer architecture now is questioned because of the inefficiencies that the current model presents. Power consumption, inefficient data processing, and pursuing unnecessarily complex, computational endeavors are some reasons why the current computing model will have to change in the future. The current computer model now faces the Law of Diminishing Returns due to how much data needs to be processed to solve today's problems. In Software Engineering, the concept of loose coupling and tight cohesion does manifest in robust systems; however, at a computer's lower level, it appears that this goal was never realized. This problem is something humans have dealt with since the dawn of computers. Newer models for computer architecture attempt to fix the current system by providing a computing architecture that relies on components working with each other to learn about the state of the hardware and how it can be used to solve the problem. This is a sharp contrast from the model computers use today which keeps the processor, memory, and storage separated. When these pieces are having to depend on each other so much and traverse the same paths on a circuit board to communicate, this causes redundancy during intense calculations which create heat. This heat gets in the way of computers extending their capabilities. Moore's Law is now being questioned because of other issues with transistors like not enough space between them within a processor. All of this to ensure precision.

Computers have staked their success in the world through impeccable accuracy. Most humans are not capable of this consistent accuracy. For decades, this has been a computer's value proposition. If computers are to possess greater capabilities in the future, this value proposition will have to be extended in another way. If computers will no longer handle computations in the same way via discrete precise structures, then some actions for a computer will have to be carried out in an approximated fashion. This may lead to a sophisticated thought process like common sense for computers; however, in the foreseeable future, this will lead to computers taking advantage of approximations wherever possible. If an operation can still succeed by using an approximation, then this indicates an avenue a computer can take to attain a successful outcome with less processing. From a technical perspective, this appears to be a mere implementation detail. The concept of a computer having to trust their gut may become a real form of error handling in the future for mobile robots.

From an economic perspective, this is a detrimental hurdle that will have to be compromised in some way depending on the application. This would depend on how much error an application can bear before another solution is sought out. Consumers will not want to trust a computer that operates on approximations especially if the action a computer is taking involves the safety or wellbeing of a human. For example, self-driving cars have already revealed this concern from an ethical perspective. More cases like that are bound to make themselves known as computers embed themselves deeper into the world.

(5) Results.

Intuition, wisdom, and common sense appear to be the most difficult things for mobile robots to accomplish. There is plenty of progress to be made on other fronts where this functionality for a mobile robot can be compromised. The free market economy is likely to embrace the easier to attain goals of mobile robotics over time as water goes down the path of least resistance. Machine learning algorithms have their limits which will become more apparent as they are applied to more problems in the future. Hardware is limited in capability as well which will put pressure on companies like Graphcore to innovate.

(6) Conclusions.

Economics will regulate priorities concerning which technologies are pursued within the free market. No matter the order in which advancements in mobile robotics occur, the bottleneck that impedes progress will manifest at the mobile robot's analog to the human brain. This analog may be something hardware related like the processor making too many calls to memory, or a software-related problem like an inefficient regression algorithm processing too much data. The solution to this bottleneck is likely to be found in a fundamental change to hardware since changing software involves nothing more than a hardware abstraction.

Lastly, humans have limits too and it is still questionable to say whether or not something like a mobile robot will be able to exist like a human. However, a mobile robot is surely capable of performing any single isolated human task. For this reason, mobile robots will have human capabilities.

(7) Recommendations, especially for future work and unsolved problems.

Some recommendations for future work will involve integrating a better comprehension of existential philosophy to prove, with logic, whether or not humans can realize something beyond comprehension. "What is being?" is a question posed by philosophers for ages and now some of the implications of this question might become extremely relevant.

The great chain of being would be questioned. The hierarchy starts with inanimate objects (rocks, dead tree branches), followed by lifeforms that are not sentient (plants, algae), sentient lifeforms, and humans. Higher power does follow at the top of the hierarchy; however, if computers surpass comprehension, then the question could be more precisely formulated as "Can computers surpass what lies ahead of humans in the great chain of being?" To paraphrase, if humans assume something exists that is greater than humans like the laws of physics or existence, can something like mobile robots surpass that? (Wildberg)

(8) References (must always be included), annotated if possible.

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1. Carr, Austin. "In Fierce AI Race, Everybody Wants This New Human-Like Chip." *Bloomberg.com*, Bloomberg, 4 June 2019, 9:01 PM PDT, www.bloomberg.com/news/articles/2019-06-05/graphcore-s-ai-chips-could-kickstart-the-next-wave-of-computing.
2. "Intuition." *Psychology Today*, Sussex Publishers, www.psychologytoday.com/us/basics/intuition.
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4. Wildberg, Christian. "Neoplatonism." *Stanford Encyclopedia of Philosophy*, Stanford University, 11 Jan. 2016, plato.stanford.edu/entries/neoplatonism/.

(9) Appendices, including supporting material as needed.