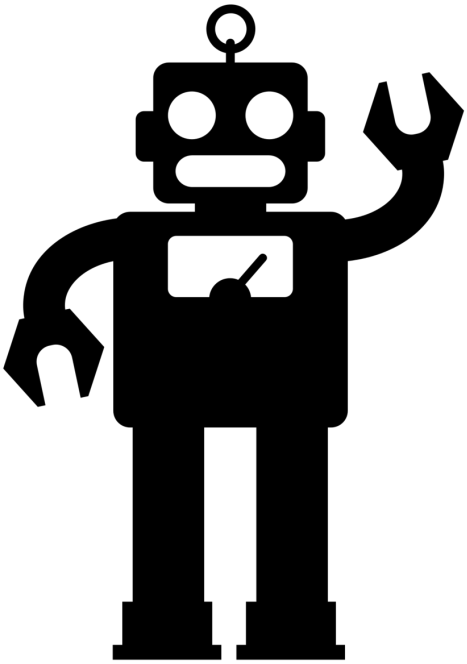
Robots: Fact and Fiction



An Exploration Into What Separates
Make-Believe Metal Men From Real Robots

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Robots Are Marvelous

From Rosie the Robot in the ABC's classic animated television show The Jetsons and Robbie from Isaac Asimov's classic short story, to C3P0 from George Lucas's Star Wars and the T100 from James Cameron's Terminator, robots have mesmerized and captivated audiences for nearly a century. Metal men and mechanical beings have been brought to life by talent authors and directors, and with advances in computational technologies, it looks as if robots are no longer be confined to the domain of fiction. Companies like iRobot and Rethink Robotics have been able to create a variety of commercial machines that autonomously perform tasks, such as vacuuming floors and sorting parts on a factory assembly line. By companies and consumers alike, these sweepers and suckers, sorters and shifters are called robots. Rethink Robotic's Baxter may not quite be as self-sufficient as James Cameron's Terminator, and iRobot's Roomba may not have a snarky personality like Rosie the Robot, but many believe that real world robots will soon be as intelligent and adaptable as their science fiction counterparts. Unfortunately for robotic enthusiasts, the future robotic humanoids working and living among humans is just as much as a dream today as it was fifty years ago. To put is plainly, Professor of Robotics Hans Moravec observed that, "in stark contrast to the largely unanticipated explosion of computers into the mainstream, the entire endeavor of robotics has filed rather completely to live up the predictions of the 1950's"[6]. As advanced as Baxter, Roomba, and every other commercial robots are, no machine contains the keystone trait that defines every classic fictional robots: self-awareness. No machine that exists today processes an intelligence that is capable of responding emotionally or able to develop a personality wholly its own. Though it may look as if rudimentary artificial intelligence exists today, Rosie the Robot is no closer to becoming a reality than she was in the 1960s. *In this essay, I explore what it means for something to be a robot, the defining differences between fictional and functional robots, and suggest where the field of robotics is actually leading.*

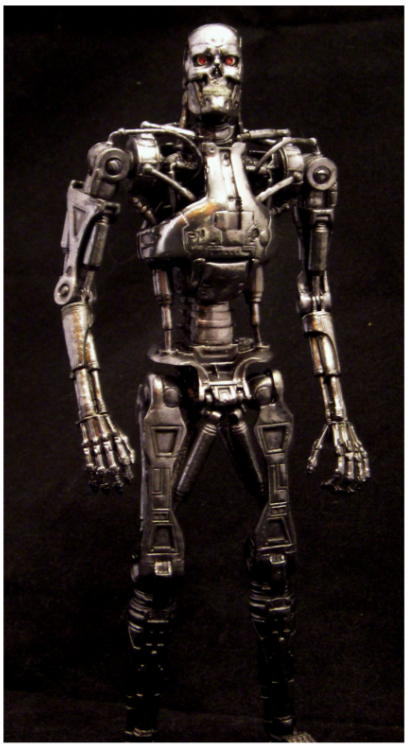

Figure 1: (Left) James Cameron's T-800 from The Terminator is a sentient machine sent back in time to assassinate the mother of a future revolutionary leader. Conversation may not be the T-800's strong point, but the machine is self-ware and capable of completing nearly any task designed for a human.

(Right) George Lucas's C3P0 from Star Wars: A New Hope is a humanoid drone designed to interact with organic beings. His experiences have led to the development of his anxiety-prone personality and his attachment to robotic companion, R2D2.

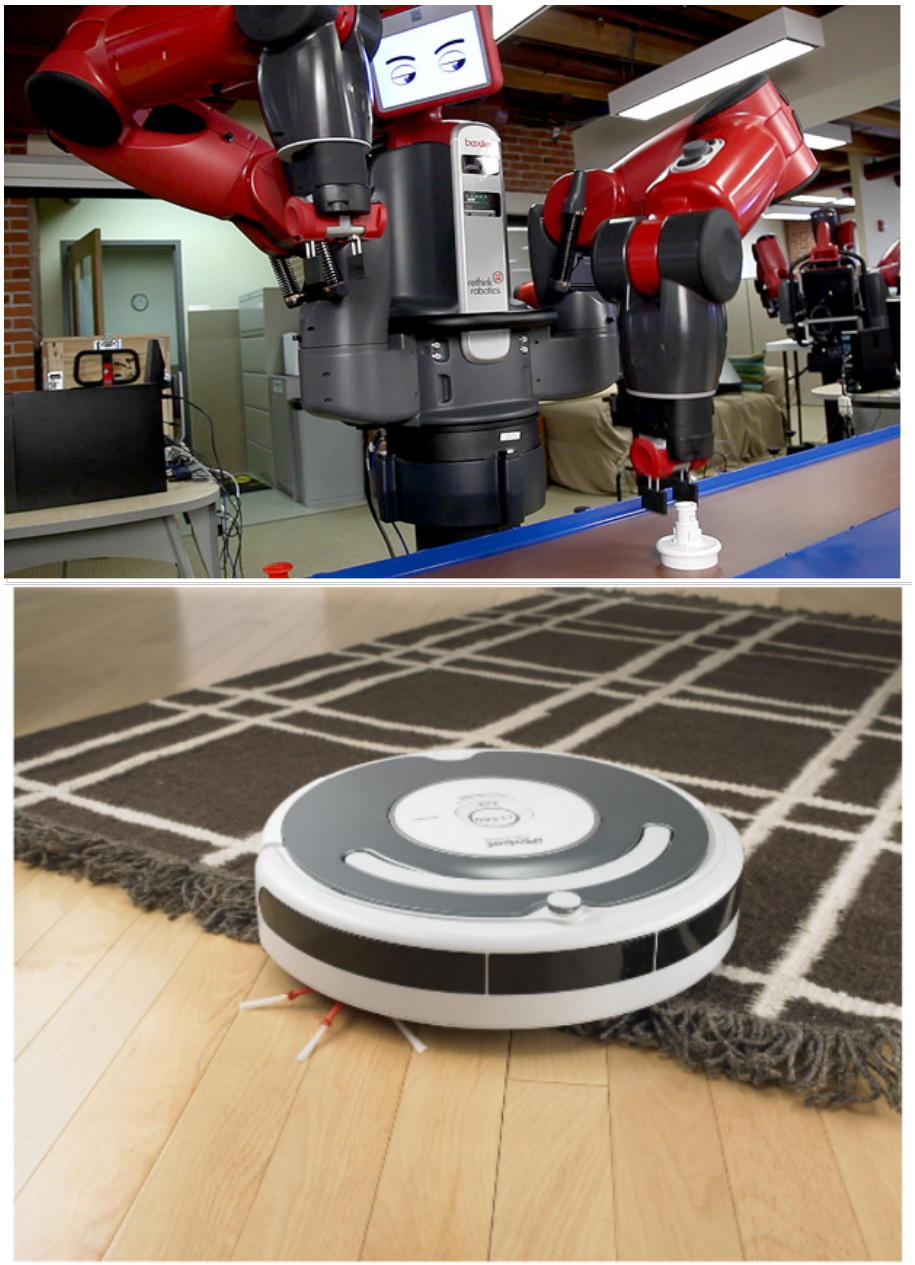

Figure 2: (Top) Rethink Robotic's Baxtor factory robot is an order of magnitude less expensive than existing single purpose manufacturing robots, can be used with no technical training, and is currently designed to sort and place parts on an assembly line.

(Bottom) iRobot's Roomba is an autonomous vacuum cleaner and is one of the most successful household robotic systems currently being sold.

What is a Robot?

Despite the fact that the term 'robot' has become a modern buzzword, used excessively by marketers with products to sell and futurists with agendas to peddle, the word has its roots in science fiction, and the genre does not use the term so haphazardly. The word robot, derived from the Czech word robota meaning forced labor, was first coined in K. Čapek's play R.U.R. 'Rossum's Universal Robots' (1920)[4] . The roboti, or robots, in Čapek's play were artificial people, constructed from synthetic matter and lacking "nothing but a soul". Demand for the willing working robots was insatiable, but in the final act, the robots rebel and nearly drive the human race to extinction. The rebellion is halted when the robots realize that humans hold the key to their reproduction, and by destroying the human race, they would be effectively destroying their own kind as well. British mathematician I. J. Good, describes the achievement of creating an artificial intelligence at the "technological singularity", and he warns that the creation of such intelligence would mark the beginning of the decline of mankind. To this day, the term robot carries with this both the exciting desire to create advanced machines as more capable than human beings and the bleak fear of what such a creation could do.

Over the decades following 'Rossum's Universal Robots', the term robot evolved through works of authors around the globe, shifting from referring to a synthetic human to more of a mechanical being. In "Helen O'Loy" by Lester del Rey (1938)[8] , robots look and act like humans, but are internally comprised of coils and wire. Isaac Asimov's "Robbie" (1950)[2] presents the reader with the mute RB series mechanical robot. In 1962, the first episode of ABC's original animated series, The Jestons, airs "Rosie the Robot"[3], introducing the nation to the first iconic televised robot character . Rosie is particularly noteworthy, for she has not only contributed to the definition of the term 'robot', but she is the epitome of what a household robot is projected to be. To the Jetsons, Rosie is first and foremost a machine, an appliance, bought and paid for like any other piece of equipment. From cooking and

cleaning to caring for the children, Rosie does every task her owners do not want to do, and she performs her work with a level of strength and precision that no human could ever match. However, what makes Rosie a remarkable robot is not her ability to cook tasty meals from food scraps: it's the fact behind her electronic eyes, there's something more than computer. Rosie is snarky and saucy, she sticks her tongue out at people to insult them (seemingly the only use for her tongue), and she even once defended the honor of her owners by dumping a cake on a discourteous guest's head. She has a distinct personality and is not limited to list of preprogramed responses. After the cake incidence, Rosie even states, "the opinions expressed are my own and do not necessarily reflect those of my employers", emphasizing the fact she is in command of her own actions. Rosie's is a mastery of conversational nuances and body language, often making puns, using metaphors, and conveying nonverbal undertones with her gestures and expressions. Her face, though seemingly nothing more than a metal tube, is incredibly expressive. Slight shifts in her eyes and ears/antenna evoke an emotional response, allowing her to communicate with the same level of complexity and subtlety as a human. These features combine to make her an ideal generalize robot, an achievement that has been sought after by scientists and engineers for more than half a century and yet continues to be on the proverbial horizon.

The Attempt to Build a Robot

One spring morning in 1961, with nearly no announcement, the Unimate was placed on the assembly line of General Motor's Ewing Township plant. Unimate was an electromechanical arm that resembled a toppled refrigerator with a modified turret gun mounted to its side. Designed to manipulate and weld together various die-cast car parts, Unimate was able to complete a notoriously dangerous task and reduce the factory workers' exposure to hazardous environment. The arm followed commands stored in a large drum memory system, a mechanical magnetic data storage device commonly used in computer systems at the time. General Motors did not publicize their new addition to the assembly line, as it was an experimental technology and there was a justified fear that it would not work. Much their relief, Unimate caused no catastrophic failures, never injured a human, and was an overall success. Workers saw Unimate as tool that aided in their ability to do their job, not as any competition for the job itself. Factory assembly lines were often updated in order to increase efficiency, and to the layman, Unimate was part of a natural progression. Today, Unimate is widely considered the first industrial robot, and its success gave much hope to the dream of creating a generalize robot capable of doing anything a human could do.

Five years after Unimate's debut, Shakey the Robot wobbled through the corridors of Stanford University. Unlike Unimate, Shakey did not follow a predefined script of commands; given a desired goal, Shakey would decide its own intermediate behavior. Using a television camera and sonar range finders, Shakey was able to perceive and model its environment, allowing it to navigate and move through its surroundings. Though painfully slow to watch, Shakey thought for itself and later referred to in LIFE Magazine as the "first electronic person". Even though putting Shakey's intelligence on par with that of a

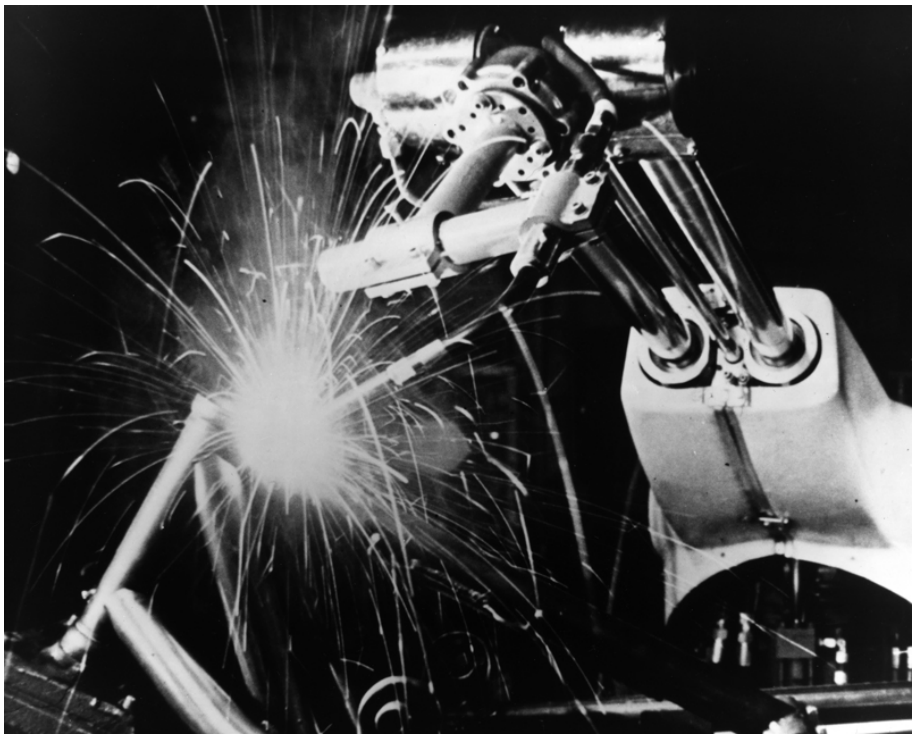

Figure 3: Unimate was the first industrial programmable machine, designed to handle and weld die castings for auto bodies. Unimate was such a success that it was even invited as a guest on the Tonight Show with Johnny Carson. On the show, Unimate poured a glass of beer for another guest and performed a few other tricks. Unimate's inventor George Devol, and his partner Joseph Engelberger founded the first robot company, Unimation.

human is an exaggeration of biblical proportions, Shakey was certainly a first.

In the roughly fifty years since Shakey's creation, one would image that breakthroughs of a similar proportion would have been made in the field of robotics. To the dismay of many, no such breakthroughs have been made, and to appreciate why, the complexity of these machines must be understood. Every existing machine can be placed on a spectrum of complexity, ranging from simple devices like levers and pulleys, and tremendously complex machines akin to the self-aware synthetic beings found in science fiction. In this paradigm, all existing machines can fall into four categories of increasing complexity: simple, reactive, feedback controlled, and predictive. Most existing robots fall into the third category of feedback controlled machines,

whereas their fictional counterparts supersede all four categories. Simple machines do their job by merely existing. A spring is a simple machine that stores potential energy; a hammer is a simple machine that transfers kinetic energy. A reactive machine incorporates many simple machines in order to accomplish a more complex task. For example, both a light bulb and a switch can be thought of as simple machines, and a lamp is a reactive machine: the lamp uses the switch to determine whether or not to supply power to the light bulb. The resulting action of the lamp is more complex, and arguably more useful, than the action either the light bulb or the switch could take on its own. Most common gadgets and gizmos, toys and tools, can be considered reactive machines, blindly reading distinct inputs and performing specific actions based on these inputs.

Feedback controlled devices can generally be thought as reactive machines, but better. A common example of a feedback controller is the household thermostat. Without a thermostat, heaters and air-conditioning units would have to be controlled manually, being turned on for brief amounts of time to adjust for heat transfer out of or into specific rooms. Thermostats accomplish this job automatically, measuring the temperature of rooms and commanding the heater and air-conditioning units when to turn on and off. The thermostat is able to react to changes in its environment, such as a window being left open, and sensing the change in the systems output and adjusting its commands accordingly. Feedback controlled systems give devices a rudimentary and scripted sense of judgment, and often creates the illusion of primitive intelligence. Feedback control allows for cars to drive with cruise control, airliners to hold a constant altitude, and insulin pumps to regulate the blood glucose levels of diabetics.

The difference between reactive and feedback controlled systems can be seen when comparing GE's Unimate and Stanford's Shakey the Robot. Unimate was reactive, following a prewritten script of commands and executing them in a linear fashion. Unimate's actions were predictable and prescribed, unable to sense any change in its surroundings. Shakey on the other hand, was driven by feedback controllers, using multiple sensors to develop a perception of its environment and planning algorithms to determine how to react. No human told Shakey exactly how to act, but instead Shakey followed rules and functions preset by its programmers. Though Shakey's A* path planning control loop may be more complex than that of a commercial thermostat, the systems share the same fundamental structure.

For most intents and purposes, the iRobot Roomba is nothing more than a smaller, faster, and more efficient version of Shakey, utilizing modern

processing power and designed to complete the practical chore of vacuuming a room. Both machines are controlled by a finite-state machine: given condition A, execute action X; given condition B, execute action Y; so on and so forth. This method is effective for many simple tasks, but it is far from human intelligence. iRobot CEO Colin Angle explains how this level of intelligence can make robots seem smarter than they are.

> "You know, I think that we attribute so much intelligence to simple processes that – that's a very difficult question. I think that human intelligence is a mixture of very predictable, learned, stimulus-response with some probably thinner-than-we-imagine actual cognition and planning on top of that. The robots that we're building today are largely rule-based. Under certain circumstances, they will follow a prescribed set of actions, and yet people ascribe huge amounts of human-level intelligence to even our simplest robots, but bottom line, our robots are nowhere as sophisticated in their intelligence as a person. We're decades away from that. But from the perspective of people perceiving the robots as being intelligent, I think many people think the gap is smaller than it really is."[1]

Modern robots may seem intelligent, but only because they have anthropomorphized. The personification of a machine can be useful when explaining how the machine behaves, but the language can often be misleading when compared to sentient robots from science fiction. Scientists and authors work from opposite directions when creating a robot: a scientist begins with a handful of transistors and must figure out how to put them together in a way that accurately recreates the human brain, whereas the author can begin with a relatable, human character and decide what aspects to turn them into a robot. The complete inner workings of the human brain is puzzle that is only beginning to be put together, so even if tools to create an artificial intelligence were to exists, scientists would be building in the dark and without blueprints.

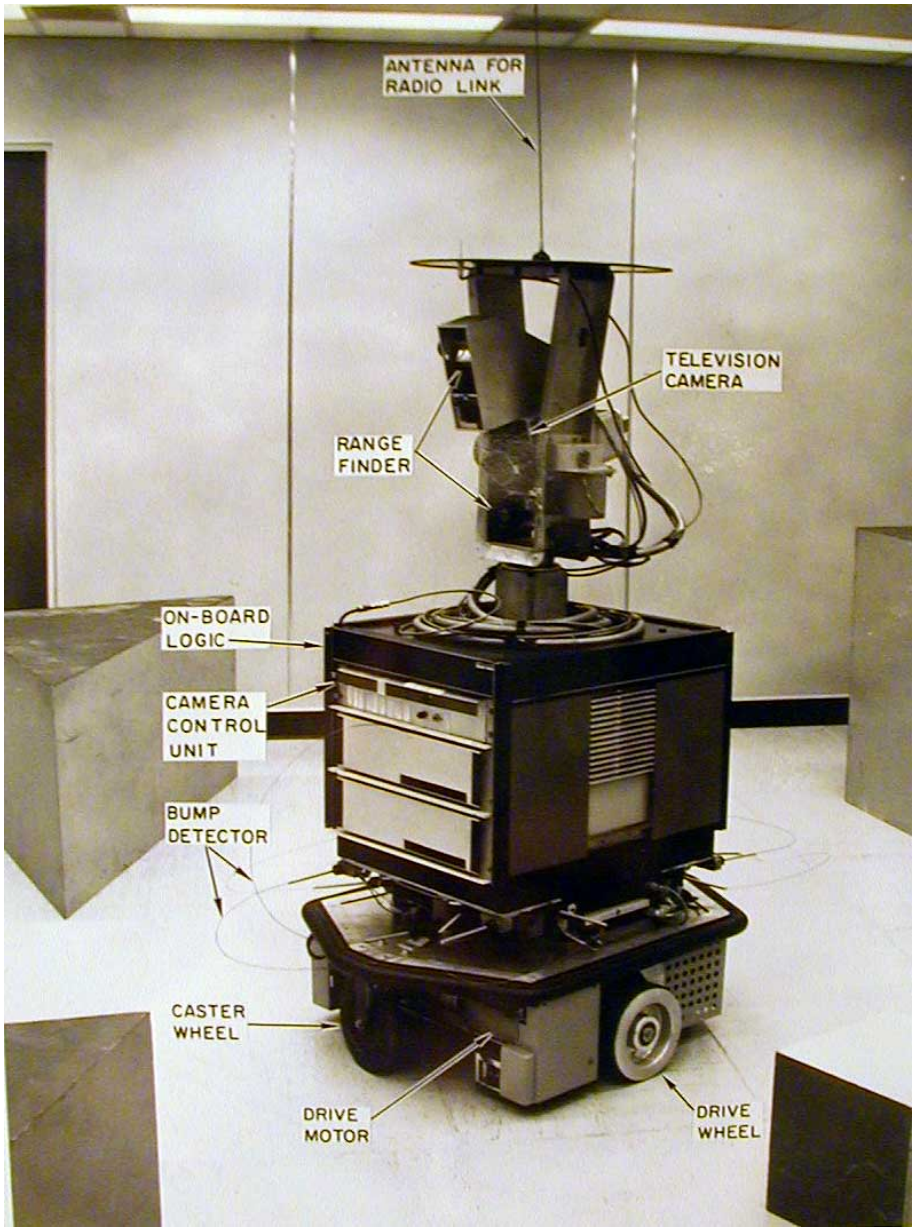

Figure 4: Shakey the Robot was the robot designed for general use and not for any specific task. Shakey could be told to go to a particular location, and it would use its sensors to determine the how to navigate through its environment. Shakey move so slowly that changing shadows caused by the moving sun would cause Shakey to constantly change its motion, contributing to wobble that gave the robot its name.

The Future of Roomba Is Not Rosie the Robot

The field of robotics is now heading into the fourth category of technology, predictive machines, and this is a departure from the path to artificial intelligence. Predictive machines feed on data, on raw information, and from the data patterns are recognized. Predictive behavior is logical increment in capability from feedback controlled machines. For example, iRobot's Roomba has to be told when to operate. Cleaning times are often set for when it is likely that rooms will be empty, such as during the day when people are at work or school. A predictive machine would not need to be told when to operate. By monitoring activity in particular rooms or by tracking the position of every habitant's cellphone, Roomba could theoretically determine the optimal time to operate given enough information. Maybe on Fridays, children come home from school earlier and thus vacuuming should be done earlier. Maybe when it snows, no one leaves the home, and regular vacuuming should be put on hold. There could be hundreds of small influences that effect when the optimal time for Roomba to vacuum is, the majority of which would be impractical to identify manually. IBM's Watson computer system, a project focused on natural language interpretation and reproduction , recently demonstrated its ability to analyze tens of thousands of online articles related in order to synthesize a well-supported argument. If technologies like Watson were applied to existing automated systems, entirely new behaviors will emerge. An autonomous vehicle could react not only to its adjacent vehicles but to the historical flow of traffic throughout an entire city. Supported forecasting of this magnitude is something that humans cannot easily do on their own, and it opens the possibly for robotic system to behave in ways no human could plan.

As intelligent and powerful as Watson and other comparable systems are, their ability to acquire and apply knowledge is still defined by the system's human

creators. Humans still define the rules, humans still provide the information, and humans still provide the mechanism through which meaning is derived from analysis. Watson is a mirror, reflecting back the voices and opinions of thousands of humans whose words he has read; his statements are not his own. The dream of an artificial intelligence will remain but a dream as long as the fundamental components of our technology remain the same. *Until then, I encourage you, the reader, to bask yourself in the thrill of science fiction, soak in the words of Isaac Asimov and Arthur C. Clarke, surrender to the androids of George Lucas and James Cameron, and do not fear that your new robotic vacuum oven will one day become sentient killing machine.*

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