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Pioneering the Personal Robotics Industry

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Russell is a Computer Science Major with minors in Asian Studies, Management, Mathematics and Physics. This paper is the first part of a two part report on the home robotics industry that Russell is conducting under the mentoring of Professor John Santore. Russell is anticipating to continue this report during summer 2009 by traveling to Japan and performing firsthand research. Russell also plans to present this report over the summer at various local robotics conferences, hoping to make researchers and investors aware of this upcoming industry.

T*he up and coming industry that I will be reporting about here is the personal and home robotics industry. I will show how the development cycle in the United States functions. I will then answer the question: What are the main limits that hold back this industry? The US approach to robotics will be contrasted with Japan's approach as Japan has another very well developed robotics program.*

First, the definition “home robotics” has to be established. Since robotics is an extremely broad field, one must specify what “home robotics” includes. For this paper, the definition of “home robotics” is a collection of hardware and software with general assistive use to humans that can safely be integrated into a social location such as a home or mall. While ultimately the pinnacle of home robotics would be a “Rosie” (a home robot that has multiple uses and can essentially take the place of a human servant as popularized by the Jetson’s cartoon) currently the trend is small robots with one fixed application (such as vacuuming). The reason that the current state of the home robotics industry should concern America is that it is unguided and has difficulty allocating resources to compete or join with other major robot players in the world, particularly Japan.

In recent years, a whimsical professor with a prototype came into the tech news circle of magazines, blogs and news stories. This man is Professor Sankai and his laboratory at University of Tsukuba. Sankai is quoted in a CNN article [1], “I am making these robots because I feel that, despite the fact there are many robots made here [Japan], very few of them are practical or useful. I thought I should make one that is practical and can be used usefully for human lives.” Sankai and his company Cyberdyne describe their mission on their site, “We strongly believe that technologies should be designed for the benefits of humankind. We will be focusing on strong R&D and will introduce very new products and services to the society.” [2] This progress towards robots that help individuals with problems rather than the creation of entertainment robots is a critical base for the growing robotics industry. By making “miracles” with robotics, people demand the new robot similar to the way they demand new experimental medical treatments today. The product that drives the current research and goals of Professor Sankai is the HAL which stands for Hybrid Assistive Limb. HAL is a robotic suit that helps amplify the strength of a human. Professor Sankai hopes the suit will be used

in fields like rehabilitation, construction and rescue efforts. The HAL also demonstrates the positive physical therapy uses and provides good press for robotics. This technology is also aimed at the consumer market; the planned cost of HAL is about the cost of a wheelchair.

An American company, Raytheon, has an exoskeleton that is on parallel with HAL. Raytheon has a long standing history of major defense projects. Their self description:

“Throughout its more than 80-year history, Raytheon Company has been a leader in developing defense technologies and in converting those technologies for use in commercial markets. From its early days as a maker of radio tubes, its adaptation of World War II radar technology to invent microwave cooking, and its development of the first guided missile, Raytheon has successfully built upon its pioneering tradition to become a global technology leader.” [3]

Raytheon’s ability is to convert defense projects into commercial use projects. This capability could greatly amplify the speed at which advanced household robotics enter the home. The exoskeleton has been demonstrated to the media just as successfully as HAL. However, I would argue that people interested in exoskeletons for physical therapy have more hope in the Japanese HAL. The simple reason is that Raytheon’s main goal is fulfilling military goals before converting the device to the commercial market, while the Japanese approach is inverted or simply does not include the military portion of research. [4]

Europe is jumping aboard this home robotic opportunity as well. The European Union started the “Sixth Framework Programme” [5] which funds and encourages research and work in such areas as helpful robotics. A video of one such project recently captured public interest: a live demonstration of a learning robot that could make a rudimentary breakfast by using learned movements. This demonstration was produced by the European Commissions Cogniron project using an open platform for robotics (HOAP, Humanoid for Open Architecture Platform) developed by a company in Japan. This shows Japanese researchers are actively teaming with European researchers to develop new robotic platforms.

One report titled “Robots could be nurses of the future” explains:

“The Japanese government is set to invest heavily in setting up a robotics industry, in a move that could speed up the development of futuristic devices such as robots that could nurse and entertain people, or carry out dangerous tasks.” The article then goes on, “It [Japan] believes that robotics is set to become an extremely important part of the manufacturing industry in the future, and hopes that the project -- titled “Robot Challenge in the 21st Century” -- will help to make Japan a world leader in the sector.” [6]

It is clear now that Japanese government has its sights set on developing a large robotics industry to help society and make money doing it. In the meantime it seems the focus of robotics in the United States is largely military and destructive. The United States government seems uninterested in the personal robotics market. Most American institutes are trying to independently keep up with the global robotics market.

A 1990 report titled “Approaches to Robotics in the United States and Japan Report of a Bilateral Exchange” [7] greatly helps one to better understand Japan-U.S. relations in the area of robots. It reveals interesting positions on the past decades’ handling of the robotics market. The report references a “third generation” of robots coming in the future which comprise intelligent, highly adaptable machines. Even in the early 1990’s the United States ignored the market, the report exposes. “Although the United States played a leadership role in the development of robotics technology, U.S. manufacturers by and large failed to capitalize on this advanced form of automation. Unable to interest domestic manufacturers in their robots, pioneering firms such as Unimation licensed their technology to Japanese companies.” As I read this document further, the pieces began to fall into place: “U.S. manufacturers have lagged, and continue to lag, behind their Japanese counterparts in the adoption of robotics, in part because of their investment criteria.”[7] The United States desired a large profitability return (15%) while the Japanese settled with much less profit (3%) and relied on that to build long term relationships with companies. The Japanese industry drove research and development for robotics in larger company applications and the government contributes greatly to these endeavors. The Japanese research is often overseen closely by their government so funds are not wasted. The report compares the American development of robotics by the National Science Foundation as “loose” compared to the Japanese research and development and describes the task sharing ideas as “disarrayed”. There are many cooks in the kitchen, the National Science Foundation, the National Institute of Standards and Technology, the U.S. Department of Defense, U.S. Department of Energy, U.S. Department of Health and Human Services and more. All of

these organizations operate independently and aren't evaluated by any larger committee. Shockingly, the report mentions an unmanned excavation project by Carnegie Mellon University (known for its excellent achievements in robotics) was not even funded! The NSF didn't have enough funds to support the project. This is a common gripe about the NSF and its supported agencies. This example shows there wasn't much interest in cultivating robotics in America by itself or with international partners. The report ends encouraging Japan and U.S. to work together and help each other grow to develop robotics to help society and industry. The report even suggests finding similar projects and combining them into one unified project with both countries working together.

Fast forward to the year 2005 and we find this a quote from the U.S. Federal Bureau of Industry and Security: "The United States leadership position in AI is eroding as the governments and companies in Japan, and as well as in Western European, working together, have gained ground. In select areas of AI, Japan and Western Europe now surpass the U.S." [8] What happened? Why is it fifteen years after such broad plans were made between the U.S. and Japan, nothing seems to be accomplished? Sure the cooperation between the U.S. and Japan in robotics still exists but occasional and unfocused. JETRO (Japan External Trade Organization) exist on the Japanese side to extend its hand for any international collaboration. The U.S. can easily be said to meet JETRO halfway with the efforts of the U.S. Department of Commerce. But currently there are no compelling, stand-out projects that link U.S. and Japanese minds in the area of robotics. There are, however, plenty of ways for individuals and small teams with varying resources to communicate. One such society is the IEEE (Institute of Electrical and Electronics Engineers) which brings together fellow roboticists (among others). Their site boasts

"With about 40 percent of its members living and working outside the United States, the CS (computer society/portion of the IEEE) fosters international communication, cooperation, and information exchange. It monitors and evaluates curriculum accreditation guidelines through its ties with the US Computing Sciences Accreditation Board and the Accreditation Board for Engineering and Technology." [9]

A regulated system followed by groups of international engineers has laid foundation for progress in the industry. The IEEE is non-profit and has more members than any professional organization of its kind. IEEE supports Robotics and Automation in an individual, separate society as well. I witnessed this first hand attending the Trinity Home Fire Fighting Robot Competition with the Bridgewater State College

Computer Science Club. This robotics competition has global entrants including China and Israel. The Connecticut Section IEEE gave out awards for achievements to the winners and also pushed entrants to keep getting better." [9]

The argument that competition works better than teamwork is something that the United States government needs to confront. Surely, competition is beneficial as evidenced by the standard example of the space race of the 1960s. The downside of competition is that someone will be on the losing side. For an industry that has been anticipated since the creation of science fiction, this could be a painful loss. It would be best to join a team of developers and scientists rather than wait for an eventual success story. While many groups exist through the Internet, there doesn't appear to be any exchange programs supported by the government to share ideas with countries or collaborate on a home robotics project. The underlying reason this teamwork isn't developing is the fact that American government sees robotics first as government assets and military secrets and much later (if at all) as helpful commercially available assistants.

American mainstream-media and half-serious niche media often take the stance that America is "afraid" of robotics. Movies depict robots as killing machines and many advanced military projects such as Big Dog by Boston Dynamics [10] have turned these speculations into reality. USA Today featured an article discussing the Japanese view of robotics. The media stance is apparent again: "Robots have long been portrayed as friendly helpers in Japanese popular culture, a far cry from the often rebellious and violent machines that often inhabit Western science fiction." [11] The warning signs that Japan is dangerously close to reaching industry superiority are all present once again in this article. It continues "The government estimates the industry could surge from about \$5.2 billion in 2006 to \$26 billion in 2010 and nearly \$70 billion by 2025." The article tells us that there is a "robotics revolution" and it has been occurring "quietly" unbeknownst to America. I directly quote from the same article, "Robots are the cornerstone of Japan's international competitiveness," [11]. Shunichi Uchiyama, the Trade Ministry's chief of manufacturing industry policy, said at a recent seminar. "We expect robotics technology to enter even more sectors going forward." The article then calms fears about the idea of Japan dominating the market with these statements: "For all its research, Japan has yet to come up with a commercially successful consumer robot." [11] In addition "One of the only commercially successful consumer robots so far is made by an American company, iRobot Corp." Though the Japanese haven't created a *successful* consumer robot, they have only been limited by cost. Not many people want to spend a large amount of money on a robot.

Roomba's are a little over one hundred U.S. dollars and they have been widely advertised and pushed by the media. [12] That is the simple secret to iRobot's success; their robots are cheap and well advertised. One other factor that contributed to iRobot's success is that America was *ready* for their robot. As society moves forward, it expects the futuristic developments of science fiction lore to become reality. Robot vacuum cleaners that actually work fairly well, appear person-friendly and are at a price an average middle income family can afford are part of this vision of the future. Most robots that were around prior to the Roomba fell into either the "complex industrial robot" or "simple toy" categories. The middle ground was non-existent. Ironically, many "complex" industrial robots were less complex than the Roomba. The middle ground is where we will find a successful personal home robotics industry. This classification is lost in the generic term of "robot."

Many Americans are afraid of large complicated machinery. Conventional wisdom says that this is part of our distrust of robots. Despite our distrust of such large mechanical devices most Americans drive cars. For peoples comfort and safety, the kind of robot that will start appearing among us on a daily basis will be small, friendly and won't displace vast amounts of the workforce. Home and personal robots are a supplement for everyday life and are simply automated extensions of what we use commonly (phone, email, cameras, appliances). iRobot is also the most commonly contracted robot company that the military uses. People fear the military robots going haywire in their neighborhoods, however, iRobot has also given the public a robotic vacuum cleaner. Even though there is a clear distinction between military and home robotics, people opposed to home robotics still will argue that there is no distinction because of military involvement with the robotics sector.

Bridgewater State College invited guest speaker Sherry Turkle to speak about the growing distance between humanity and machines. I disagree with many of her opinions, however, they inspire me to consider some questions. I represent a counterpoint to her beliefs. Turkle argues that the line between real living things and machines is being blurred and the result is very often negative. Her accompanying example was that her daughter did not care if turtles at a zoo were real or robots as long as they were interesting (this is a condensed summary of her position). This raises the question, can robots take the place of a living creature in our lives? The answer really depends a good deal on the actual situation. We are in an age where parallels can be drawn between man and machine. But we are still at least a decade away from real overlap between man and machine. By that time robotic limbs driven by a neural interface will likely be common place and autonomous robots with near human appearance will be more than show pieces from the

laboratory. Is it right to "fool" people? Is it right for people to "fool" themselves? I would argue that the 'problem' is its own solution. When biological structures such as endangered species or a person's arm are lost and cannot traditionally be replaced, isn't it alright to find the next best substitute?

Let us move now from sweeping considerations of the philosophical issues behind robot acceptance (or lack thereof). After exploring the overall state of the robotics industries in this country I turned my focus to the local Massachusetts robotics industry. Massachusetts is known as a technological leader in the United States. A closer look at the local robotics industry will give insight into the larger national industry.

As I began my in depth research with companies in Massachusetts, I discovered the Massachusetts Robotic Cluster. [13] This cluster is comprised of most of the major robotics companies and institutes in Massachusetts. The first company I interviewed was Vecna. [14] Approximately 90% of Vecna's employees are MIT graduates. MIT is one of the premiere robotic graduate programs in the country. Vecna has produced notable robots. The first is the BEAR robot, a military robot that helps lift wounded soldiers and items from the battlefield. The second Vecna product is robotic healthcare kiosks operated either by telepresence or by remote control. I interviewed a representative robotics engineer, Andrew R. Allen and he gave me some interesting insights into the robotics industry. [15] The company is successful due to fulfilling military contracts. Allen told me that this is what most robotics startups have to do in order to get enough funding for other projects. This trend has made most US robotics projects military orientated rather than suited for home use. There is little to no federal funding for home robotics research. Companies try to turn a commercial profit by working on side projects and introducing them into the market. Allen also told me that home robotics is not seen as a national consumer priority. Allen explained what the industry needs are more standard platforms and a safe, expandable robot that people can comfortably afford. Allen's comments raise the question: why isn't there more funding and focus on basic home robotics? Once basic home robots are developed, the industry and technology could help health care and other industries that find difficulty in gaining employees.

My correspondence with Smart Robots [16] leads to some similar answers. Joe Bosworth of Smart Robots gives the rundown of his company: "We are a small start-up firm which manufactures and sells educational mobile robot systems for use by schools, universities, research groups and individuals as development systems for various applications or for use in the classroom in teaching/learning computer programming, AI,

wireless networking, web interaction, electronics, mechanical systems, etc.” [17] Oddly enough, they have no clients in Massachusetts. Bosworth makes the point that they aim to be in the commercial market but do not expect to be in the “home” market. I consider the commercial market and the home market one and the same in terms of safety and use by the general public. Smart Robots actively seeks international partners and sees other countries as the best clientèle. When it comes to Japan however, I directly quote Bosworth:

It is my belief that when the home robot tsunami hits, it will hit from several places at the same time – most likely the U.S., Japan and Korea. As for the timing, it’s not a tool-up issue, it’s a leap of vision issue. All the technology pieces are there. The first products that break – seriously break – will be surprises – like the Wii – something very new and unexpected. In general, I believe that we in the robot industry today are too close to, and a bit blinded by, the technology and our enthusiasm for the technology and regularly underestimate what we can or need to accomplish, in order to truly connect with the opportunity that stands waiting. [17]

This is very revealing in that it shows the danger and potential high returns possible in the home robotics industry and the robotics industry in general. While huge opportunity awaits, there is no single driver at the wheel, but a group of individuals and companies taking turns navigating otherwise uncharted territory. This is due to the fact that there is no planned timetable in America for robotics achievements and little funding outside of the Defense department. One could even say robotics is merely the Defense department’s small side project, even though autonomous robot vehicles are one of the department’s highest profile “research” projects. In reality, not much research is actually performed by DARPA itself. DARPA instead allots money as contest prize which are given to the robotics team that wins its competition of “challenge”. Teams from four foreign countries even applied in the second year of the DARPA competition. That is outsourcing a national security project: something one might consider to be a political faux pas. While award competitions are good to spark an industry, it is far from supplying the lasting energy to keep industry progress moving forward.

The robot industry success story that is iRobot began with mainly funds from military contracts. After creating its military multi use robot, the Packbot, the company saw opportunity in the home robotics market and created the Roomba, the previously mentioned well known vacuum robot. The company is constantly making robots now for different home applications.

While this idea of drumming up money with military projects and then branching off into home based robotics did work for iRobot, it doesn’t seem to me to be the best method to build an industry. Military contracts are competitive and don’t just fall into an engineer’s lap. It was quite difficult to get a hold of a representative from iRobot to answer my questions. When iRobot received the speculative questions I posed, they declined to comment on any “forward looking statements” and denied any insight into their expectations for the robotics industry citing fear of giving insight into their business strategy. iRobot did confirm that they are in fact the current leaders of the mobile home robotics industry. [18] This correspondence demonstrates one of the underlying problems of the home robotics industry. Not commenting on the future leaves people with an uneasy feelings towards this up and coming industry. Harboring a guarded business plan also discourages teamwork of any kind, local, national or globally.

Understandably, iRobot’s main business goal isn’t to advance home robotics on a global level generically but rather to specialize and profit in select areas of home robotics. Lack of a unified effort in pushing forward general home robotics needs to be addressed on a global level. An effective course of action for creating a widely usable, functional home robot would be to team up the best researchers and developers in robotics. Unlike the repeated pattern seen in a wide range of niche robots on the market today, I believe that variety in home robots should be encouraged only after a broad, robust and adaptable base system is developed and standardized.

In this paper I’ve explored government funding for robotics, however, we have a tradition of private funding for many of the most notable of our innovations in this country. Where is all of the venture capital money for robotics? Doesn’t anyone believe this industry is worth building? Since the robotics industry is so broad and fits under many product categories, the industry has a hard time building a group of venture capitalists dedicated to robotics projects. An article in the Pittsburgh Business Times [19] goes into depth why venture capitalists haven’t given to robotics: “Some believe the word “robotics “ actually carries a stigma that hurts the company’s chances of funding.” The article also mentions that many businesses don’t believe they should be classified as robotics companies when they are working on only a piece of a robot: for example, a company working only on vision systems. Companies are actually avoiding the term robot in fear they will lose funding. Robots do carry a multitude of expensive parts and sensors. Code for a smart robot would also require expensive software programmers. One could infer that smaller venture capitalists are afraid to fall into a hole of ever expanding financing needs. This could also be an

indication why the only entity funding robotics companies is the government, the largest financial entity.

In a 2008 paper, known robotics enthusiast Joanne Pransky [20] looks at the issue of venture capitalist investment in robotics. In the paper, Pransky discusses the NVCA (National Venture Capital Association) and its listing system. The list shows companies that have venture capital and their self described industrial classification. The amount of companies listed under “robot” or “robotics” is scarce. The leading companies listed under robot descriptors are more closely identified with motor vehicles, medical health related or sometimes just the ubiquitous “other”. Even on the list itself, there is no unified definition for robot. Software companies could label their program a ‘robot’. There are even companies not classified as robotics companies that make medical robots. Venture Capitalists are searching for high rate of returns in five to ten years, and no matter what the classification, money exists to fund smart, profitable robotics companies. For now though, companies don’t want to scare venture capitalists away with the often complex conceptual ‘baggage’ associated with being a ‘robotics company’ so they simply modify their self described classification. Until the industry of social and home robotics is widely accepted, direct funding for robotics won’t be common for venture capitalists. Pioneers of the industry need to convey that robotics can be a highly profitable business. Unfortunately, this fact forces research and development to be rushed. Going into the home robot industry with an existing stable product that requires minimal initial funding to convert to home use is ideal.

After finding Pransky’s report I decided to contact her and ask her opinion on the home robotics industry. [21] Her opinions echoed that of Allen and Bosworth. The general public wants a “safe, nonthreatening, inexpensive, user-friendly” assistant. Pransky also mentions a valuable detail often overlooked: “... people that want a home robot may not be the same people that make the home purchasing decisions.” While an amazing home robot with multiple uses is not a reality, unfortunately there is not a huge demand for a robot of those credentials to become a reality. The experts in robotics I interviewed were in consensus that the American government and venture capitalists are not doing enough to fund home robotics. Not enough robotics teams that span international boundaries are being brought together either. If some entity doesn’t start to guide the robotics industry then the industry could become even more disjointed, disorganized that it is now. This will likely lead to wasted time and money on research and development that has already been conducted elsewhere. Japan has the motivation to push the robotics industry forward. “For Japan, the robotics revolution is an imperative. With more than a fifth

of the population 65 or older, the country is banking on robots to replenish the workforce and care for the elderly.” (Tabuchi) Whether America decides to compete, join or do nothing is up to the robotics industry, venture capitalists, the United States government and the consumer.

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