



## NCTI 2010 Technology Innovators Conference

### ***Innovation and Robotics: The Future of AT?***

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**Summary:** We are just entering the new frontier of robotics. The future of AT depends on a reconsideration of the pipeline from product initiation through production to ensure that AT developers have adequate funding and incentives to make them competitive in the commercial market.

### **Discussion**

#### **Introduction from Cathy Bodine**

- Images of robots in old TV shows like “Robbie the Robot” have encouraged kids all over the world to learn about robotics at an early age. They are immersed in the technology—not to simply use the technology, but to learn about it. Engineering students interested in artificial intelligence and robotics want to know how to make these technologies work for people with disabilities.
- Rehabilitation is where the impact of robotics appears in the medical arena. This is also an area that receives money and attention worldwide, but a lot of work has been done in mobility impairments as well. This is the new frontier of robotics. For example, in Japan they have such a significant and staggering issue with providing elder care. There are not enough young people to care for the elderly, so they looked at using robotics in caretaking. For example, an elder washing machine for bathing is being tested now in Japan. There is a massive push around healthcare, care giving, and robotics.
- Surgery is another area where robotics is in heavier use. Many physicians’ heads are in the machines more than in the human body. Medical student rotations now include the study of robotics as surgery changes. And in the area of physical medicine and rehabilitation, there is an increased focus on using robotics to enhance rehabilitation for people to regain cognitive and motor skills.

#### **Kate Seelman**

- **Incentives and Disincentives.** The mainstream technology development pipeline looks different from the assistive technology (AT) pipeline. Mainstream pipelines move from research and development (R&D) to finance to production. In the AT development pipeline, service delivery and reimbursement/payment



steps are added. Essentially, service delivery costs money, thus we have reimbursement. In addition, the R&D requires clinical research to see if it is really appropriate for the people we serve.

- The AT pipeline's distribution of policy resources include reimbursement/payment as results of laws such as ADA, ADAA, the Rehabilitation Act, Medicaid, Medicare, IDEA, ATGA, VER, VA, and out-of-pocket; on the technology transfer side, we are bereft. Only have NIDRR and VA engineering research centers, and the Interagency Committee on Disability Research (ICDR), small business innovation research (SBIR) and small business technology transfer (STTR). However, in regards to quality of life technology, the only real support from government is NIDRR, which has limited SBIR and STTR. While some compensation exists in various regulations and procurement policies, we have not paid as much attention as we should to the R&D, finance, and production sides of the AT pipeline.
- Most company spin-offs end up in the Valley of Death. Technology at the prototype design, discovery, or preclinical development step may never get out to next phase. However, the Patient Protection and Affordable Care Act 2010 gave tax breaks to smaller biotechnology companies. It also provided clarity on some regulatory issues and complex therapeutics. Regulation is very important—these companies maintain 12 years of market exclusivity after FDA approval.
- Barriers to AT technology transfer include (1) market size, because it is not possible to take advantage of high volume production savings, and (2) market diversity, which reduces the profit margin of AT developers since significant resources must be spent in tailoring particular products to individual needs.
- **Case Studies/Models.** There is a wonderful robotics program at Carnegie Mellon University (CMU) as well as geriatrics, occupational/vocational rehabilitation, AT, and physical medicine. One example of direct application in robotics is the Tech-Link Program in which young people of all abilities are encouraged toward technical careers. In the Tech-Link program, students with and without disabilities in middle schools are matched with mentors on the robotics faculty (engineers). Students learn about robotics as part of integrated teams and camps.
  - Additionally, *mobile technology for eHealth* shows where informatics and computer science are so important to our field. We are developing accessibility features for people with visual or motor impairment. The access features for persons who are blind involves an interface with voice command; for those with motor impairment we have mobile apps.

- A case study from Johnson & Johnson (J&J) includes the attempt to move from wheelchairs to robotic mobility. In 2005, J&J introduced the iBOT 4000 to the market and removed it from the market in 2009. What happened? The iBOT 4000 had standard features including four wheels, a balancer, stair climbing capacity, remote control. NIDRR tested it, and those who used it could go down stairs, get books from higher shelves, etc. However, the population size was a narrow demographic. Importantly, CMS decided to reimburse the approximate \$22K iBOT like a regular wheelchair at about \$6K. Also, J&J bypassed the traditional rehabilitation supplier network, and there was an extensive need for practitioner and end user training.
- One model is the Quality of Life Technology (QoLT) Foundry Process at the University of Pittsburgh research center. This engineering research center is a multi-university organization funded by NSF to do transformative R&D, spawn new industry segments, and train the people who will grow the segments. Yet, it is difficult to do R&D and focus on developing products. The process developed by the research center is as follows:

Identify → perform due diligence → validate → cultivate team & prototype → develop preliminary business plan → form a company

The QoLT Engineering Research Center works on biotechnology & health care, energy, sustainability & infrastructure, microelectronics, sensing & information technology. They are funded for 10 years at \$4 million/year from NSF plus 20 percent cost sharing plus industry. After the 10 years of funding ends, they will sustain their work through industrial funding and other federal grants (e.g., NIH, DARPA).
- **Opportunities & Threats.** Following are opportunities and threats of the marketplace and public policies:
  - (1) Innovative technology may travel down private and/or publically subsidized R&D pathways (opportunity and a threat).
  - (2) There is no QoLT industry for innovations in prevention, rehabilitation, and community integration to support inclusion in education, employment, housing, and ICT and community (threat).
  - (3) Large companies such as DEKA and Johnson & Johnson have entered health robotics (threat).
  - (4) Large companies such as Time Warner Cable/AOL are entering the eHealth market (opportunity).
  - (5) AT professionals and people with disabilities are not well represented in the mainstream private sector (opportunity & threat).



- (6) States have model programs to stimulate technology transfer and support small companies (opportunity).
- (7) State technology economic development programs could join together with AT community to sponsor a business plan competition for a particular AT challenge. Winner would receive funding to develop their e-technology and one criterion would be to highly mass market and lower costs. Some mainstream products have materials that have innovative AT apps, such as iPad and AAC (opportunity) but limited end user population size.
- (8) CMS will not reimburse laptop computers desktop computers, PDAs, or other devices that are not dedicated to speech generating because it does not meet the DME definition of Medicare (threat).
- (9) Some wheelchair and hearing aid companies are pursuing commoditization to increase market size and lower costs (threat), prices are lower by eliminating therapy services cost.
- (10) Innovative prevention, rehabilitation, and community support technology lack representation in technology transfer law, federal R&D infrastructure and knowledge networks and information flows (threat).
- (11) NIDRR has an insufficient budget. NIH's tech transfer office and STTR and SBIR programs are responsive to the NIH mission of making important medical advances such as those in biotech. No parallel infrastructure exists (threat).
- (12) CMS requires evidence of product efficacy and effectiveness for reimbursement but offers insufficient incentives to support costs to generate evidence to move AT to market (threat).

### **Corrina Lathan**

- Started company in 1999 as a spin-off from academia, around the time of the dotcom bust. Started robotics company as an interface, human-robot interaction company. Robotics at the time was very exciting. There was the first venture capital firm called Robotics Ventures, they made one investment and that was into iRobot. There was a lot of interest from the Department of Defense to put money into robotics, and business incubators were coming about in state institutions and universities. So it was an exciting time to start a company, but there were challenges.
- First, there was a shift to software instead of hardware products during the dotcom bubble years—venture capitalists lost interest in hardware including small business robotics. Another challenge was the funding of research in AT going to academic institutions rather than small businesses because they wanted to build the credibility of their research environment. But they invested in research, not necessarily products that were going to help their constituents.



- We developed a system for rehabilitation and education called Cosmobot in the early years, and due to a variety of factors, we had to put that work to the side. The idea for this Cosmobot system began when I was a professor of biomedical engineering. I decided to take a leave of absence to start the company, because I saw that the world of traditional assistive technology was expensive, low tech, and boring. The exciting things that were going on in the world had to do with this intersection of robotics and virtual reality and new educational technology and toys.
- Kids all have the same design specifications—they all need to learn cause and effect. One child might learn it sooner or later than another, but they've all got to learn it. They all strive toward language. Started the company with essentially this idea of instrumentation of a child so that they could use whatever capabilities they have to interact with their environment. Company initially funded with a grant from DARPA, part of a rehabilitation engineering center, and a Department of Education grant on tele-rehabilitation. I managed to diversify our R&D side of the company enough such that we've grown every single year in our eleven years from the R&D side, and it's also enabled us to escape the valley of death that Kate Seelman mentioned.
- Early on, Cosmobot developed by looking at the needs of kids with disabilities, although these are needs of all kids. Kids need to play, they need to manipulate and explore their environment, they need to be able to use the technology for a wide variety of uses. Therapy, education, and play are intertwined and the tool has to motivate the child over a long period of time and be of use in different environments—home, clinic, and school. And of course we need evidence-based practice, to be able to actually collect data and assess progress. This required that the tool must be more than just software, it must function as a system—a toy that can be used to explore the environment, which implied wireless, adaptable interface, programmable, data collection, etc. So we designed a system, an interactive robot that moved and talked while being controlled by the user either as an avatar of the child or interaction with the child using a mission control, and we proposed it to NSF and received an SBIR grant. Mission control was our system; we had a therapist module that mediated this interaction. It had a user-centered design and was very iterative.
- We began with Jesterbot. In a video shown, the therapist is in a separate room speaking through Jesterbot, which sits with a little girl and her mother to conduct speech therapy with the girl. The robot is able to build a relationship with the girl. The speech therapist hated Jesterbot, because she couldn't see where the girl's tongue was placed—a valid point. However, the mother loved Jesterbot, because she said whenever the therapist was in the room she put words into the child's mouth and wouldn't let the child respond naturally. The mother reported that after eight weeks of playing with Jesterbot, she started pretend play at home. This was a five-year-old who had never done pretend play at home. The mom was



convinced that this sort of relationship building was what transferred into that next cognitive, social, and emotional development.

- Then we moved to Cosmobot, which enabled us to do more programming. We received an NIH grant to work specifically with kids with autism for social cognitive skill development, and the social cognitive modules progressed. The first Cosmobot would enter a room where a child was playing alone and it would try to get the child's attention. The next most basic step was encouraging joint attention; the Cosmobot encouraged joint attention after several minutes of repetition.
- In 2005, we finished our NSF phase 2, but there was no more funding to be found, no venture capital to be had, and we were about to dive into the valley of death. Then NSF offered a match of 50 cents on the dollar if we could raise \$1 million. Since we knew that we could not get investment into an R&D company, we did spin off a company and raised the money—then we realized that \$1.5 mil is not enough to commercialize a product. We looked at manufacturing, but could not find one in the U.S. willing to do a run of only 500 robots. We looked at China, but even with low per unit costs, there were other costs that prevented us from moving forward.
- Cosmobot is a disruptive technology, hard to bring to market, and expensive—yet we had money to spend. Then we realized that the interface, mission control, is a pretty great interface. We had great reception from kids with problems that ranged from severe physical disabilities to behavioral issues, so we decided to partner with test software companies with mission control. We reviewed all the educational software out there and realized that if we really wanted to develop a system we would have to come up with our own software that had much more of what we would call interaction, proportional control of objects in the environment, while remaining accessible. So we developed another system using mission control that is now a computer interface with activators, dimmer switches, an on-off switch, the ability to plug in traditional assistive technology switches, and a built-in microphone. It can be used with a computer, and that's either as a mouse alternative or with our software, starring Cosmobot. We brought the character to life in the software playground discovery that's developmental for ages three to five, although we have used it with kids as old as 16 depending on cognitive and behavioral goals.

Also, we developed a curriculum-based measurement that allows for up to a hundred kids on the software and the ability to track different educational goals aligned with national standards as well as the state standards. We ended up with AT kids and the Cosmos learning system, which is Cosmobot the character and mission control.

- To bring it back full circle, we just received a new grant from the Department of Education to focus on kids with autism in the classroom with a robot to facilitate

multi-child interaction. There has been a huge amount of publicity and I think the field of social robotics is making a resurgence.

**Cathy Bodine –**

- We have a rehabilitation engineering center for cognitive technologies, and we are developing socially assisted robotics for babies up to three years old with neurodevelopmental disabilities. The key to this is in our RERC—we have research projects and we have development projects. In the Center, everything goes through our product testing lab for usability testing. The intriguing aspect about our research center that is unusual for much of AT development is that we have a full complement of engineers and a full complement of clinicians, and I make them share offices to learn each other's lingo.

A key issue with AT is that in addition to the consumer and the product we have to consider the caregiver as part of our process. When we think about usability testing we also need to think about the clinician or the parent or whomever the caregiver might be, and have that as part of our process.

- We have created an animated agent that is both mobile and can be available on basically any monitor, any device that you want to use, and in this project. Additionally, we developed algorithms to help the user. When the user is on track and an error or exception occurs, linear prompting does not allow the user to get back on track. We are developing nonlinear methodologies to help users and prompt them when they need to be prompted. We can use this technology and our animated agent on mobile platforms with ease of access cognitively as well as physically.
- We then decided to create a socially interactive early childhood robot. We wanted to see what we could do with robotics for children who are born with developmental disabilities. These babies don't reach their developmental milestones quickly enough. Parents don't have time or energy to do the thousands of repetitions, such as motor patterning repetitions or vocalizations because they have so many things to do. Speech or occupational therapy requires many hours a week and is constrained by insurance. We wanted to develop a strategy to employ that would enable children to have the opportunity to do all of these repetitive tasks in order to develop their early milestones.

We came up with the notion of socially assisted robotics and we developed some control systems to elicit these behaviors that we want to see happen with babies. We used our usability testing lab to develop our case. Using video clips of babies interacting with the clinicians, then working with the engineers to develop a use case, we determined what we want the child to do, what technology is needed in order to elicit a response, and then had our engineers and clinicians discuss how to accomplish this. We don't call our tool a robot, but essentially that is what it is—a toy that can engage the child and help facilitate those thousands of

repetitions that kids need to get their neurons firing in the right direction and to reach developmental milestones.

- One thing we have demonstrated in today's presentation is that this is a nascent arena, and whether we think about disability in terms of Kate's points on market size, or Corinna's points on the path from a product idea to actual development including timing, I think about some of the depth of the research that you have to do in order to pull it together. I think that three to five years from now we're going to see a lot more in this day-to-day robotics application work, much like where the medical rehabilitation work is today.

### Discussion and Q&A

**Question:** All three of you mentioned the market space and that it's a really small market space. Cathy and Corinna both showed tools that work in the mainstream. Are you anticipating more breakthroughs into the consumer market for general technologies that people could purchase for their home for whatever child?

- **Corinna Lathan:** It is more an issue of market model than market size. We need to shift to a consumer model versus an education versus medical models, which are really your only three choices. Each of those is very different, and come with their own pros and cons. So, yes, I think probably a cross between consumer and education is where the market is going. I think the medical model has diverged, and the education model has been very, very narrow in their market model.
- **Cathy Bodine:** We have another product in tech transfer, and we're doing due diligence in both the mainstream consumer market and the AT product market to determine what's the most logical strategy to get this to the families that we think would really benefit from it. You have options—you can get picked up by Wal-Mart for example and the product will be cheap, but also cheaply produced. If you go through an AT market, then you can justify to a preschool teacher or a school that this is a product they should buy, so it's available for the kids who need it whose families don't have the money.

**Comment** (John Williams, ATech News): I get a lot of questions this time of the year from parents and grandparents of children with disabilities who want to know about robots they can purchase for their child. I think there is a market for this product.

- **Cathy Bodine:** Yes, no, and maybe. We started a tradition in Colorado years ago where we do Christmas in July and it's a whole day-long workshop on accessible toys for grandparents and parents so that they can come in and understand what's out there. We used to share the Toys R Us catalog and those kinds of things. When you look at robots today, what you really look at are remote toys, toys that are remote controlled, and you look at toys that are starting to do cool things. However, when you look at the kind of developmental needs that our kids have, they're not necessarily at a price point that's easily affordable, able to do what we need them to do.

- **Kate Seelman:** I just want to say that it is very, very difficult for the rehabilitation engineering research centers to transfer technology. They don't get assistance from the larger research and development community so it is very, very difficult. Also, the mainstream developers, whether they're university-based or not, do not work with clinicians. That's one of the big problems with the iPad—I don't think it is interoperable with input devices for people with severe disabilities. There's a big gap, and there also needs to be more of a bridge between the mainstream technology community that wants to see how their technology can be applied in our world and bringing some of you all into it.

**Comment** (Cheryl Volkman Knight, Ablenet): I think it's interesting too to think about the *motivation* for the product. I remember the first time I saw a virtual reality technology available in the AT field, and I thought it was just pie in the sky—but look at what can be done today, those technologies are now in every product. There is an issue of need for a driver in robotics. If you look for an AT robotic toy, there isn't enough of a driver for that as a parent given all the other products that are available or that parents might be able to do themselves. For rehabilitation there is a driver, but the market is smaller. I think there is still this confusion about motivation.

- **Cathy Bodine:** I think that's absolutely true. We have so little evidence-based research in our field, and so that's the other piece of the puzzle that is also critically needed. We need to be able to point to why this is a good idea, and add luster to your reasoning.
- **Corinna Lathan:** I think there's a really promising trend of informal robotics moving into the classrooms, including middle- and high-school teams competing nationally. And there is a big push now in STEM curricula, that's a very promising trend because it's going to be completely integrated into education. In fact, NSF just put out an SBIR on digital gaming, and then there's a joint SBIR out from NIH, DHS, DARPA, NSF, and USDA on robotics. And the White House put out an SBIR call for proposals on robotics.
- **Cathy Bodine:** We found another interesting trend when we launched a new bioengineering school in March. We expected four doctoral students and we had 17 highly qualified students show up. In bioengineering alone there's a projection of a 72 percent job growth rate over the next several years. I met with the School of Mines in Colorado last week, and they have a 27 percent influx of female students in their premed, and in bioengineering they have 51 percent females. And all of their students, male and female alike, are saying that they do not want to build bombs, they do not want to dig holes, and they do not want to go offshore to drill for oil—they want to do something to help human beings, and I'm hearing this from a lot of different engineering schools. I think that also is a lovely trend that is going to facilitate growth. I think for those of us that have been the purveyors of the industry, it's going to be a compelling progression in our industry over time.



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- **Kate Seelman:** The model for engineering education has to change. At the moment it's a reductive model that brings in very little participation at the idea or prototype stage from those in the context, the end users, people in industry, regulators, or clinicians. Both CMU's robotics program with a disinclination to include human subjects and U of Pitt's more applied capability thanks to our medical center and our bioengineering approach, both have important perspectives. We are sharing our new educational model, which has been developed as a participatory model, with NSF. It needs to be disseminated so that we have more interdisciplinary organization within engineering and basic science at the appropriate time.