CyberTherapy & Rehabilitation

Issue 3 / 2010

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COVER STORY:

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ISSN 2031 - 278

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Letter from the Secretary General and Editor-in-Chief

Professor Dr. Brenda K. Wiederhold

"Videogame expertise may be among the most valuable skills for armed services that depend increasingly on robots. In a battlefield situation, soldiers and pilots grow conditioned to violence, which helps to 'inoculate' them from the effects of stress."

Dear Reader,

Anecdotal reports indicate that pilots who remotely bomb targets in Operation Enduring Freedom using unmanned aerial vehicles (UAVs) may be at greater risk for posttraumatic stress disorder (PTSD) than those who fly combat missions.

Associated Press reporter Scott Lindlaw suggests that there may be several reasons for this.

1. UAV pilots work longer shifts and tours than pilots deployed to a war zone.

2. Unlike manned flights, UAVs are often required to linger and assess the bomb damage, showing the pilot the resultant carnage in high-resolution detail.

3. Very little decompression time elapses between a pilot's bombing run and being at home with spouse and family, resulting in a jarring transition between a virtual reality and a physical reality.

What helicopters were to Vietnam, UAVs are to Afghanistan – essential to the engagement and a symbol of technological superiority. The number of UAVs or drones has grown from less than 200 eight years ago to more than 7,000 today. Each Predator and Reaper aircraft has a two-person crew: an Air Force pilot, who flies the drone, and a sensor operator, who runs the camera and targeting laser. Drone pilots can complete training in just months, versus the years it takes an F-15 fighter pilot. Videogame expertise may be among the most valuable skills for armed services that depend increasingly on robots. In a battlefield situation, soldiers and pilots grow conditioned to violence, which helps to "inoculate" them from the effects of stress. In contrast, UAV pilots talk about the unreality of working with partners they never meet against an enemy that exists (for them) only on a video screen. Perhaps this emotional disengagement is another reason for reports of PTSD: Subconsciously, they may find it hard to justify killing when their lives are not in danger.

But what if you're in a "boots on the ground" position and a robot saves your life? What happens to your emotions then?

"The EOD [Explosive Ordnance Disposal] soldier carried a box into the robot repair facility at Camp Victory, Iraq. 'Can you fix it?' he asked, with tears welling in his eyes. Inside the box was a pile of broken parts. It was the remains of 'Scooby-Doo,' the team's PackBot, which had been blown up by an IED [improvised explosive device]. On the side of Scooby's 'head' was a series of handwritten hash marks, showing the number of missions that the little robot had gone on. All told, Scooby had hunted down and defused 18 IEDs and one car bomb, dangerous missions that had saved multiple human lives. 'This has been a really great robot,' the soldier told Master Sergeant Ted Bogosh, the Marine in charge of the repair yard."

In addition to the UAVs, which range from the 48-foot Predator to the hand-thrown Raven, there are more than 12,000 unmanned ground vehicles such

Letter from the Secretary General

(continued from page 1)

as the lawnmower-sized PackBot deployed to the Middle East and South Asia. Soldiers are projecting their emotions onto these machines, with undreamed-of consequences.

As they begin to bond with their robot as part of the team, they may, for example, promote the robot to private first-class and give him an EOD badge. But this same anthropomorphizing may result in an EOD soldier running into enemy fire to "rescue" his robot – the exact opposite of what was intended by the robot's creation. Perhaps it is because the soldier realizes that he may not be alive without this machine, so he chooses not to view it that way. There is a physiological reason for this: When people look at robots, their mirror neurons fire, indicating that we consider robots alive and deserving of empathy.

"For the time being, the Department of Defense has a unique opportunity to conduct longitudinal studies of drone pilots and other human-robot teams to determine the extent and causes of their PTSD – and to help those who are suffering from this disabling condition. And it's possible that Virtual Reality assisted exposure therapy could be the treatment of choice for this and future groups of videogame-based warriors."

In the future, it may be desirable to create a PackBot with a slightly annoying personality, so that soldiers don't feel so bad when it's destroyed. And perhaps a "drone with a conscience" can someday replace the two-person UAV teams – though the field of roboethics, established in 2004, needs to grow quickly to address increasingly complex issues.

One issue in particular, outside the obvious ethical concerns, will need to be given due attention in the future – the popularized science fiction notion that robots will be able to develop on their own, begin to think for themselves, and end up attacking their own troops. Such instances have been reported, although on a small scale. In 2007 a robot killed nine and injured 14, a report the South African National Defence investigated and blamed on a "mechanical problem" – poor design or modification.

For the time being, the Department of Defense has a unique opportunity to conduct longitudinal studies of drone pilots and other human-robot teams to determine the extent and causes of their PTSD – and to help those who are suffering from this disabling condition. And it's possible that Virtual Reality assisted exposure therapy could be the treatment of choice for this and future groups of videogame-based warriors.

Create your own reality!
Brenda Wiederhold

INTERSTRESS

Interreality in the Management and Treatment of Stress-Related Disorders

INTERSTRESS
is a European-funded project
Instrument: CP —
ICT Grant Number FP7-247685

The INTERSTRESS project aims to design, develop and test an advanced ICT-based solution for the assessment and treatment of psychological stress.

Objectives:

- Quantitative and objective assessment of symptoms using biosensors and behavioral analysis
- Decision support for treatment planning through data fusion and detection algorithms
- Provision of warnings and motivating feed-back to improve compliance and long-term outcome

To reach these goals, INTERSTRESS will use a new e-Health concept: Interreality. What is Interreality? It is the integration of assessment and treatment within a hybrid, closed-loop empowering experience, bridging physical and virtual worlds into one seamless reality.

- Behavior in the physical world will influence the virtual world experience
- Behavior in the virtual world will influence the real world experience

These goals will be achieved through:

- 3D Shared Virtual World role-playing experiences in which users interact with one another
  - Immersive in the healthcare centre
  - Non-immersive in the home setting
- Bio and Activity Sensors (from the Real to the Virtual World)
  - Tracking of emotional/health/activity status of the user and influencing the individual's experience in the virtual world (aspect, activity, and access)
- Mobile Internet Appliances (from the Virtual to the Real world)
  - Social and individual user activity in the virtual world has a direct link with the users' life through a mobile phone/PDA

Clinical use of Interreality is based on a closed-loop concept that involves the use of technology for assessing, adjusting and/or modulating the emotional regulation of the patient, his/her coping skills and appraisal of the environment based upon a comparison of the individual patient's behavioural and physiological responses with a training or performance criterion. The project will provide a proof of concept of the proposed system with clinical validation.

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GENERAL INFORMATION

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C&R Editorial Board

Robots Assist with Stroke Therapy and Rehabilitation

Every year, over one million people in Europe and .7 million people in the U.S. are affected by stroke. Rehabilitation for these patients has been a costly, time, and labor intensive endeavor for decades. Now, aided by robots such as the ARMin (Arm Therapy Robot for Nuerorehabilitation), victims of stroke may have better options available to them during their recovery. Robots enable repetitive training and can even provide biofeedback information to assess the progress of rehabilitation as it occurs.

Robots to Enhance Quality of Life

A recent study concluded that 84% of power wheelchair users would purchase a robotic arm if one were available on the market. Quality of Life Robots have been developed to perform helpful tasks such as reheating containers of food in a microwave and these actions will work towards improving the life of disabled patients.

Conference Participation Report Fall 2010

The American Psychological Association Convention

Cutting Edge Science for Clinicians - Where is Addiction Treatment Going?

San DIego, California, U.S.A/ August 12-15, 2010

The Annual Convention of the American Psychological Association Convention is an important event aimed at the advancement of psychology as a means to promote health, education and human welfare. This year's Convention featured a symposium dedicated to addiction treatment development and psychological implications. As part of the Division 50 on Addictions, the symposium aimed to promote advances in psychological research, technology, and professional training, among many others, with regards to problematic use of addictive substances and behaviors. iACToR Board Members participated in this year's conference on such topics as the benefits of using VR to treat drug and nicotine addiction.

Next year's conference will take place August 4-7, 2011, in Washington, D.C.

For further information, please visit:
http://www.apa.org/convention/

European Conference on Cognitive Ergonomics

Caring Technology for the Future

Delft, The Netherlands/ August 25-27, 2010

The 28th edition of the Annual European Conference on Cognitive Ergonomics proved an opportunity to disseminate information in the areas of cognitive ergonomics, human technology interaction and cognitive engineering amongst researchers and practitioners seeking to enhance the relationship between cognitive sciences and technical information processing systems.

The conference theme "Caring Technology for the Future" addressed the capacity for computer technology to be further implemented in the healthcare sector and to improve patients' mental and physical health and quality of life. This can be done not only in clinical settings, but crisis settings as well, and the conference explored new types of cognitive ergonomics issues in this area.

Next year's conference will be held August 24-26, 2011, in Rostock, Germany.

For further information, please visit:
http://ecce2011.eace.net/

ICT 2010

Digitally Driven

Brussels, Belgium/ September 27-29, 2010

A three-day event, from September 27-29, brought together 6,000 participants from all over Europe, including businessmen, researchers and policymakers. The "ICT 2010-Digitally Driven" conference and exhibition housed more than 100 groundbreaking information and communication technology (ICT) research projects funded by the European Commission. This year's event was hosted by the Belgian Presidency of the EU's Council of Ministers.

The major themes at the conference were digital solutions for sustainable growth in a low carbon economy and the role of ICT in the life of citizens, as well as public participation and support. In keeping with the theme of cooperation, Prime Minister of Belgium Yves Leterme emphasized the importance of intensifying cooperation at the European level as well, needing to act as a union, towards the EU 2020 target.

Alongside this are calls for raising ICT research and innovation to help increase quality of life and overcome social challenges, as well as improve healthcare. Twenty-five to thirty-five percent of the exhibits focused on healthcare, showing that ICT is indeed crucial for the future of medicine. These health-focused exhibits ranged from supporting independent living and offering companionship, to catering to the elderly, battling cognitive decline, controlling and treating seizures, diabetes, cardiovascular disease, epilepsy, and to easing life for the paralyzed.

For further information, please visit:
http://www.ict2011.org/

European Association for Behavioral & Cognitive Therapies

LINKS

Milan, Italy/ October 7-10, 2010

The 40th Annual European Association for Behavioral & Cognitive Therapies Conference took place this year in Milan, Italy, on 7-10 October. In keeping in line with its theme, "LINKS," the event aimed to create networks and LINKS between associations, disciplines, countries, innovations, experts, professionals and students. It further sought to LINK the worlds of clinical practice and theory, classical expression and innovative developments, as well as intervention and prevention.

Next year's conference will be held August 30-September 3, 2011, in Reykjavik, Iceland.

For further information, please visit:
http://www.congress.is/eabct/

Wounds of War II: Coping with Posttraumatic Stress Disorder in Returning Troops

EDITED BY:
Professor Dr. Brenda K. Wiederhold, Ph.D., MBA, BCIA

WOUNDS OF WAR II: COPING WITH POSTTRAUMATIC STRESS DISORDER IN RETURNING TROOPS

On October 18-21, 2009 the NATO Advanced Research Workshop "Wounds of War II: Coping with Posttraumatic Stress Disorder in Returning Troops drew 30 eminent experts from 14 countries to discuss the impact of war-related stress on participants from current and past conflicts, particularly when it results in increased risk and incidence of PTSD. Held in Klopeiner See, Südkärnten, Austria at the Hotel Amerika-Holzer, discussion topics included increased PTSD as a result of missions, as well as how PTSD may be prevented. Often thought of as an "invisible wound of war," PTSD may manifest in very visible ways, affecting behavior, relationships and society. The ultimate aim of the workshop was critical assessment of existing knowledge and identification of directions for future actions. The co-organizers of this workshop alongside Professor Brenda K. Wiederhold included Professor Kresimir Cosic and Professor Dragica Kozaric-Kovacic of Zagreb, Croatia and Colonel Carl Castro from the United States.

Full papers were published by IOS Press

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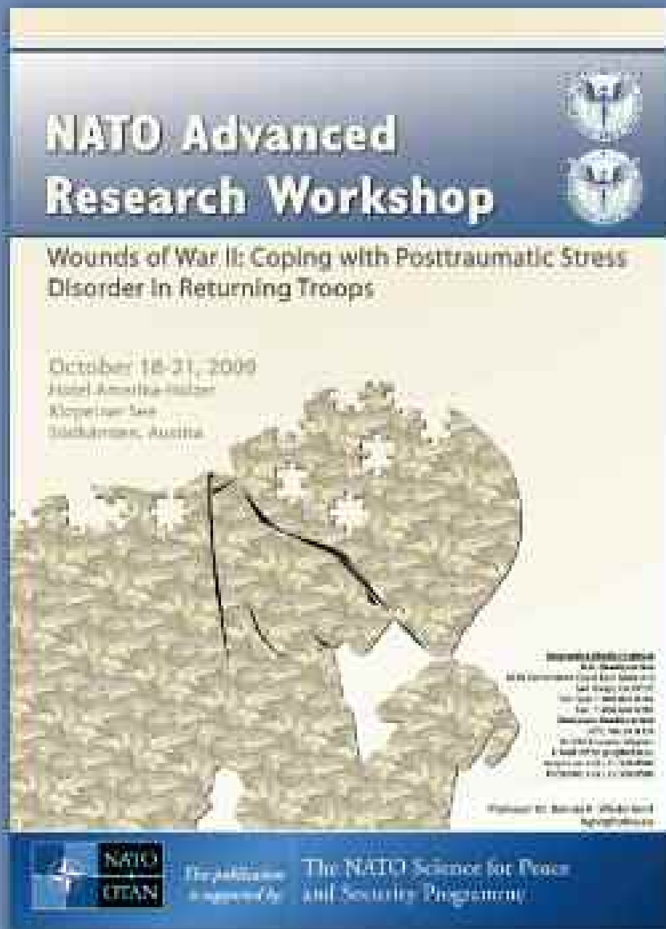

The post-conference book reflects the key topics discussed in the five sections at the workshop:

First Session – Vulnerability

Second Session – Diagnosis and Assessment

Third Session – Training and Treatment

Fourth Session – Technology-Based Training and Treatment

Fifth Session – PTSD and Comorbidity

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Robots: Almost Becoming Commonplace

In the past few decades, robots have become increasingly prevalent, and while many may consider this still a page out of a sci-fi novel, it is now becoming an everyday reality. While it might seem the robotics revolution has appeared to blossom overnight, the ideas driving these technologies have actually been around for centuries.

By Mark D. Wiederhold & Brenda K. Wiederhold

The word "robot" comes from the Czech word robota, meaning forced labor, and drudgery, and was coined by Czech writer Karel Capek in his play R.U.R (Rossum's Universal Robotics), published in 1920. The term "robotics" first appeared in Isaac Asimov's science fiction short-story "Liar," in 1941. While literature conceived robots as supernatural, the concept of robots in real life had actually existed for quite some time. Among his many other scientific blueprints, Leonardo de Vinci had already developed designs for a humanoid mechanical knight robot in 1495. Although mechanical devices were used for entertainment and theater, it wasn't until the 1900s that mechanical robots would start to resemble robots as we know them today. The first industrial robot, Unimate, was created by George Devol in the 1950s, and was used in the assembly lines at General Motors. Factories and large manufacturing companies were the first sector to integrate and embrace robots for their ability to work efficiently and accurately, while also relieving humans from the burden of physical labor. Since the invention of the computer chip in the 1950s there have been three main functions that define a robot. It must be able to: act on environmental stimuli, sense, and perform logical reasoning.

As the baby boom generation reaches retirement age and life expectancy continues to increase, there has been an increasing demand on healthcare needs. People living longer does not necessarily mean that people are living healthier lives, and as the population grows older, care for the elderly has become a dilemma that many people are struggling to address. Robotic technologies have the potential to alleviate some of these issues. Robotic systems not only can perform activities that cannot be performed by humans, but they can also reduce labor costs, increase independence and social participation, and increase quality of care. In recent years, a large amount of robotics research has focused on the prevention and diagnosis of illness, helping the disabled and chronically ill in their daily lives, assisting professional care and assisting surgical procedures, and has also largely focused on rehabilitation. Rehabilitation robotics has extended into the fields of assisted motor-coordination therapy, physical training, and mental, cognitive and social therapy. Not only are rehabilitation robots available to the commercial market, but they can also be used at home, as opposed to only in the clinic, making them accessible and convenient.

Assisted motor-coordination therapy treats injuries to the brain or nervous system that impair motor skills and coordination. While there is much that is still unknown about how the brain works, repeated movement is believed to eventually lead to the restoration of brain function and the ability to control movement. Robots have been developed to aid patients in repetitive rehabilitation in the upper and lower extremities. These robots help guide the movements of limbs to ensure optimal effects from therapy, and can regulate force feedback. Hocoma's Lokomat is used in gait-impaired patients to improve mobility following stroke, spinal cord injury, and neurological diseases and injuries. A robotic gait orthosis guides the patient's legs on a treadmill, while the machine carefully assesses the patient's movements. The Lokomat is able to preprogram training sessions that are individually adjusted to each patient, allowing for a faster recovery, while also reducing physical strain on the therapist.

Assisted physical training therapy utilizes robots for muscle sustaining therapies based on fundamental and repetitive motor activities. For many of these systems, clinical supervision is not required, allowing the patient to heal from home, with some utilizing only a regular PC.

Assisted mental, cognitive and social therapies have also benefited greatly from robotic advancements. Their controllable behavior and ability for repeated actions allow robots an edge over human therapists since robots do not have the same physical demands as humans, such as patience, frustration, fatigue, and an hourly rate. People with communication disorders, such as autism, as well as disorders of the elderly like dementia where social interaction might be a challenge, have responded well to robotic systems. The commercially available Paro is a soft white-furred seal that is equipped with tactile, light, audition, temperature, and posture sensors. The robotic seal provides the same therapeutic benefits as animal therapy and can recognize the direction of voice and respond to its own name as well as greetings and praise, and can learn to behave in a way that its user prefers. Paro has proved to reduce patient stress and induce relaxation, and improved socialization in patients by stimulating interaction.

Overall, one of the major goals for robotics manufacturing companies is to introduce robots to the general public, and integrate them into people's daily lives. This goal is slowly but surely being achieved. One robot that has already become widely known is the Roomba, developed by the iRobot company, and is a robotic vacuum cleaner that navigates its way through a space, cleaning up scraps along the way. Similarly, the University of Tokyo and the Information and Robot Technology Research Initiative (IRT) have teamed up with major companies like Toyota to develop a robot that performs basic household chores. The Home Assistant Robot is a humanoid that operates on two wheels and has two hands both equipped with three finger graspers. Its main functions are mopping the floor, picking up and carrying a tray of dishes, and doing the wash. The robot has sensors on its head to locate objects in front of it, and is trained to repeat tasks that it fails to carry out properly.

Assistive technologies for the elderly and disabled have become a major focus in developing new robotic technologies. Within the last ten years, Carnegie Mellon University's People and Robots Laboratory, along with the University of Pittsburgh School of Nursing, Stanford University, the University of Michigan, and the Art Institute of Pittsburgh, collaborated on a project for developing a robot nurse. The NurseBot project aimed to develop a personal service robot that can assist the elderly with everyday tasks. Their prototype, Pearl, a four-foot-tall autonomous mobile robot with a humanoid face can recognize speech and is able to communicate through a touch screen mounted on its torso area. Their next step is to program Pearl to remind patients to take medication, go to the doctor, and prevent them from getting lost. Pearl would be a live-in robot assistant to elderly who are ill or who have no one to help care for them, providing an alternate option to nursing homes, and helping individuals live independently for a longer period of time. Pearl is also being used as a tool to observe how people respond to humanoid robots by assessing which physical features are appealing, what tasks are most important to a patient, as well as developing an increased vocabulary to improve the overall robot experience.

As the baby boomer generation reaches retirement age and life expectancy continues to increase, there has been an increasing demand on healthcare needs. People living longer does not necessarily mean that people are living healthier lives, and as the population grows older, care for the elderly has become a dilemma that many people are struggling to address. Robotic technologies have the potential to alleviate some of these issues.

Increasing mobility and agility in robots is important when attempting to apply human tasks to robots. Japan has been working diligently on this challenge since the 1980s when Honda Motor Co. began working on a bipedal robot. In 1996, they released the very first autonomous bipedal humanoid robot, and in 2000, created an updated version of the initial prototype that was more compact and lightweight, appropriately calling it ASIMO which stands for "advanced step in innovative mobility." ASIMO has been greatly improved in the meantime, includes an infrared and CCD camera, and an array of sensors such as optical, ultrasonic, and floor surface sensors. It can walk, run six kilometers in an hour, swerve from left to right, grasp objects with grip force sensors, and walk alongside someone, holding their hand, while maintaining the same speed as the person.

Japan is a worldwide leader in robotics and their development of improved robotic technologies has not only skyrocketed in the past few decades, but the country is swiftly embracing robots into their culture. This past year Japan introduced Geminoid-F, a "fembot" who took the stage alongside human actors while being controlled by humans backstage. Japan has also been developing robots for the purpose of learning. Assistant and substitute teachers have been introduced to classrooms throughout Japan, and their presence is welcomed as being an aid to education. Japan's robotic innovation and swift embrace of robots stems from their overall outlook on technology, and their point of view differs significantly from the attitudes expressed in many Western cultures. Japan's history of Shinto and Buddhist teachings emphasize the interconnectedness with all things and a respect for both animate and inanimate beings. Robotic innovation in Japan dates back to the 17th century with a tradition of making mechanized dolls called karakuri ningyo that were used in performances similar to puppet shows. By contrast, the U.S. has focused on an ongoing discussion about the dangers and potential threats of robots.

Medicine has profited greatly from new robotic technologies, allowing, for example, robot-assisted surgeries so intricate and complicated that the human hand often struggled to accomplish them. The da Vinci Surgical System made by Intuitive Surgical was introduced to the world of medicine in 2000 and has since grown in popularity. The da Vinci system consists of a surgeon's console, a patient-side cart that includes four interactive robotic arms, an InSite Vision System, and EndoWrist surgical instruments. Sitting at the console, a surgeon views a 3-D image of the surgical field, while grasping the master controls below the display. The system scales and filters the surgeon's hand, wrist, and finger movements, and translates them to the surgical instruments on the patient-side cart where the actions are then performed on the patient in real-time. With its excellent range of motion, fine tissue manipulation, and intuitive control as well as minimal invasiveness, the da Vinci is a remarkable tool for surgeons dealing with areas of the body that require immense care and require tiny, intricate procedures.

Assisted mental, cognitive and social therapies have also benefited greatly from robotic advancements ... People with communication disorders, such as autism, as well as disorders of the elderly like dementia where social interaction might be a challenge, have responded well to robotic systems. The commercially available Paro is a soft white-furred seal that ... provides the same therapeutic benefits as animal therapy.

Robot-assisted surgery is also becoming more common as products such as the ROBODOC are introduced to the market. Approved by the FDA to assist in orthopedic surgeries, ROBODOC has been particularly successful in assisting with hip replacements due to its specialized high-speed drill that surpasses manual precision with a less amount of trauma to the patient. Urology has also benefited greatly from robot-assisted surgery due to the level of precision required to manipulate the tiny vessels that reside in that part of the body.

Over the years the military has invested considerable time and resources in the development of robotics. Foster-Miller, a U.S.-based military robotics manufacturer has developed a line of military robots called the TALON Operations. TALON robots are divided into "families" by size and function and range from explosive ordnance disposal (EODs) that remove and dispose of grenades, to Modular Advanced Armed Robotic System (MAARS), a remotely-operated vehicle that has weapons such as rifles, machine guns, and grenade launders mounted directly on top.

The Defense Advanced Research Projects Agency (DARPA) also works to develop new technologies for the military. One of their latest projects is the Autonomous Robotic Manipulation (ARM) program. ARM is a four-year program that is trying to lift some of the limitations in robots' function and execution. The goal of the program is to develop software and hardware that will increase the autonomy of robots and reduce the amount of human interaction required by the robot, while improving the execution and performance of the tasks performed. DARPA is also planning to release a similar system for the public to experiment with, which will allow anyone to write tasks and watch a robot carry them out.

The Telemedicine and Advance Technology Research Center (TATRC), part of the U.S. Army Medical Research and Material Command, has developed the Battlefield Extraction-Assist Robot (BEAR). BEAR is roughly the size of an adult male and is designed to lift and carry large objects up to 500 lbs. for long distances and set them down gently, maneuvering through rough terrains, over obstacles, and even up and down stairs, adjusting its speed to adapt to its surroundings. BEAR is remotely operated and includes motion control, pressure and touch sensors, and has tank-like tracks on its corresponding thigh and calf areas that allow it to balance upright on its hips, knees, and lower wheels, standing upright. It can also crouch low to the ground and even move while almost lying flat, slithering on the ground while holding a person or object. BEAR's main purpose in the battle zone is to find wounded soldiers and carry them to safety and BEAR has been especially useful when rescues need to be carried out in dangerous environments or for disaster rescue missions. Similar designs have been adopted by health care systems for the transport of elderly and disabled patients.

TATRC has also focused energy on improving medical robots, especially for military use. From electronic information carriers (EICs), a portable wireless storage device that carries soldier's medical records, to a non-invasive brain ultrasound that assess cerebral vascular activities and measures accurate blood flood flow velocity in patients who have experienced traumatic brain injuries, TATRC's technological progress has allowed medical care to become more mobile and accessible, creating instruments that are easily transported and provide accurate information.

The U.S. has also utilized the development of unmanned aerial vehicles (UAVs), one of the most popular being the Predator drone. While UAVs are used for reconnaissance, they have recently been armed with missiles, and are increasingly being used for attack missions. This has caused much controversy, as some people feel that there are unresolved ethical questions regarding responsibility of a robot's actions, especially as they become more and more autonomous. A common question is "Who is to blame when there is a malfunction that ends in unintended casualties?" No international laws have been developed so far concerning robots, and the question of how to regulate them remains unanswered. Indeed, robotics has come a long way in the past century, from the first industrial robot to humanoid robots that can speak and even act somewhat independently. While this is true, it is evident that robots still have a long way to go, and like their human creators, have many flaws that still need to be addressed. Accuracy and precision can be further enhanced and learning how humans respond to robots in everyday life is an ongoing project. Robots are an important part of our future, and the time to research them is now.

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Quality of Life Technology Robots for People with Disabilities and Older Adults

There is great room for growth for robotics to address rehabilitation needs, both physical and mental. Robots act as caretakers in a way, and this relationship "can be called quality of life technology (QoLT) systems that create a symbiosis of human and technology maximizing the use of the abilities of the person and the capabilities of technology in natural environments."

By Rory A. Cooper et al

The Quality of Life Technology Center (QoLT) was started as a result of funding from the National Science Foundation as an Engineering Research Center, for which it receives support. Within the QoLT Center there are four research thrusts, and four system integration testbeds. The research thrusts include human systems interface, perception and awareness, mobility and manipulation, and person and society. The person and society thrust ties the research of the technical thrusts together, and ensures that the QoLT Center is well grounded in the needs of consumers, caregivers, and clinicians. The four system integration testbeds are safe driving, virtual coaches, home and community health technologies, and quality of life technology robots.

The system integration testbeds serve as a critical path in the research pipeline of the thrusts, and provide the important role of integrating research through realistic systems. Of course, the systems and thrusts are essentially in a continuous feedback-feed forward loop. The focus of this paper is the two QoLT center quality of life technology robots (QoLTBots): the Personal Mobility and Manipulation Appliance (PerMMA) and the Home Environment Robotic Butler (HERB). PerMMA is a collaborative project with the Department of Veterans Affairs, and the HERB is similarly a collaborative project with Intel Research in Pittsburgh.

PerMMA was developed starting in 2006, and has served as a platform for research and development in bi-manual manipulation on a robotic wheelchair base to provide functional assistance and expanded mobility to people with disabilities and older adults. This groundbreaking robotics system has the potential to spawn a number of research projects and industrial applications, gaining visibility both in the research community and the media at large. Robotic systems have emerged as a rehabilitation engineering solution to ameliorate disabling conditions. A survey by Prior showed that 84% of power wheelchair users would purchase a robotic arm if it were available.

Home Environment Robotic Butler (HERB) is designed to provide assistance to older adults and people with disabilities in their homes.

An emerging area of technology to help people with disabilities (PwD) is to seamlessly combine mobility and manipulation. Some PwD cannot retrieve a remote control, book/magazine, or a drink if not placed in their immediate proximity. Frequently, PwD will have a family member or assistant pre-prepare their meals and place them in their refrigerator; thus requiring only reheating or simply removing and eating. Therefore, work is being done to de-

The Home Environment Robotic Butler (HERB) is preparing to grasp the drink bottle, while the leader of the HERB project, Sidd Srinivasa, grabs the end-effecter to show that it is possible for humans to safely interact with HERB.

velop symbiotic systems to retrieve real-life objects through user, remote, and autonomous methods in a time-efficient, safe, acceptable, and reliable manner.

A core aspect of symbiotic systems is the melding of robotics and its traditional approach to develop autonomous systems with assistive technology which are user operated systems to produce what can be called quality of life technology (QoLT) systems that create a symbiosis of human and technology maximizing the use of the abilities of the person and the capabilities of technology in natural environments. The capabilities to remove a sealed plastic container from a refrigerator, place it in a microwave oven, heat it, open it, and place it where the user can eat it are tasks that may be well suited for QoLT systems, and of great potential value to PwD. One novel approach is to use a remote caregiver to provide assistance by remotely operating a robotic device to perform difficult tasks. This could result in robotic mobility and manipulation devices being deployed for use by PwD faster. PerMMA is one research project that aims to provide these capabilities and more, both within the home and within the community at large. PerMMA is not a wheelchair with "added intelligence" and arms; it is an integrated mobile robotic manipulator with full seating and electric powered wheelchair functions for the person.

HERB is intended to be an autonomous robotic assistant within the home environment. The goal of HERB is to be able to provide meaningful assistance with home chores, such as meal preparation, unpacking and storing food supplies, cleaning dishes, light cleaning and organizing clutter. HERB may perform these tasks in cooperation with a person in the home. For example, HERB may move or lift a piece of furniture while the person cleans underneath the furniture. Long-term HERB work will focus on providing physical assistance to the user through physical contact to perform such tasks as transfers, or assisting someone after a fall. HERB moves autonomously within the home and must safely interact with and negotiate around people. However, it may also work more directly with a person as well. One of the areas being investigated is closed-kinematic chain activities where, for example, HERB may lift and carry one side of a table while a human lifts and carries the other side, requiring HERB to work collaboratively with the person. Home environments present some interesting challenges for robotic assistants. A home is partially structured as people tend to have routines, and there are a number of fixed built environment features; however, there is also a significant degree of randomness. A lot of the randomness includes clutter; imagine taking items out of a grocery bag and putting them away. Even removing the correct object desired by the human user from a refrigerator is a substantial technical problem. Thus far we have made some important breakthroughs in motion planning, recognizing objects and their orientation, identifying objects within a cluttered environment, grasp planning for natural objects, and pose control such as keeping a pitcher of water upright as it is moved. There is much work that remains such as human-robot interaction, completing realistic activities rather than discrete tasks. We are working towards realistic tasks such as actually preparing chocolate chip cookies.

While both of our QoLTBots have made tremendous progress, and are breaking new ground in the area of robots working symbiotically with a human end-user; there are extraordinary hurdles to overcome. Working in human environments (e.g., home, school, work, communities) and in close proximity and in some cases actual contact with humans is a daunting task that requires a large and diverse group of talented and dedicated people. However, the pay-off in terms of making a positive difference in people's lives can be huge.

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Probo, a "Huggable" Robot for Interactive Therapy

"Social robots" are showing promising growth and can fulfill multiple applications for therapy. One example is Probo, which serves as a multidisciplinary research platform for human-robot interaction (HRI) focused on children.

By Jelle Saldien

A new generation of robots is being created to live among humans and become a nearly ubiquitous part of our day-to-day lives. These robots will be better accepted if they measure up to a certain standard of social interaction and human-like communication, achieving the label of "social robot." No robot today can fulfill the role of a fully social interactive robot, but new research domains such as human-robot interaction (HRI) are gaining vastly more interest. In this context there is a strong need for robotic platforms that support this HRI research. One specific subclass of HRI focuses on the use of social robots for therapeutic purposes. Based on the positive effects that have been found in Animal Assisted Therapy (ATA), the first robots are being tested for similar purposes (termed RAT – Robot Assisted Therapy). These social pet-type robots are being used for therapy targeting children and elderly patients.

Figure 1: The prototype of the huggable robot Probo interacting with children.

With a special focus on hospitalized children, Probo can contribute to this new research domain. A hospitalization is a serious physical and mental occurrence, especially for children. Besides therapy, Probo can play an important role in the preparation of children to reduce anxiety for medical operations. Reports of the incidence of preoperative anxiety in children have varied over the years but are estimated to effect around 60% of children. Preoperative anxiety in young children undergoing surgery is associated with a more painful postoperative recovery and a higher incidence of sleep disturbances and other problems.

Reduced motivation and drop out are often encountered during therapy for children. However, artificial creatures, games and robots receive a lot of their attention. Recently, a new game concept named "Probogotchi" (Figure 2) has been developed as part of the Probo project. It is a successful game where the user has to keep an artificial creature alive and satisfied through interaction with a stuffed animal with sensors. The idea is to start a CBT relaxation therapy with this game, where this new form of social interaction can play an important motivational factor. This interactive game play builds upon the online CBT treatment for relaxation. Various experiments are now being performed to explore whether this innovative device, Electronic Relaxation Therapy Interface (ERTI), offers advantages over currently utilized therapies.

The robot Probo is an imaginary animal that looks similar to the ancient mammoths. The main aspects are a huggable appearance, an attractive trunk or proboscis, animated ears, eyes, eyebrows, eyelids, mouth, neck, and finally, an interactive belly-screen.

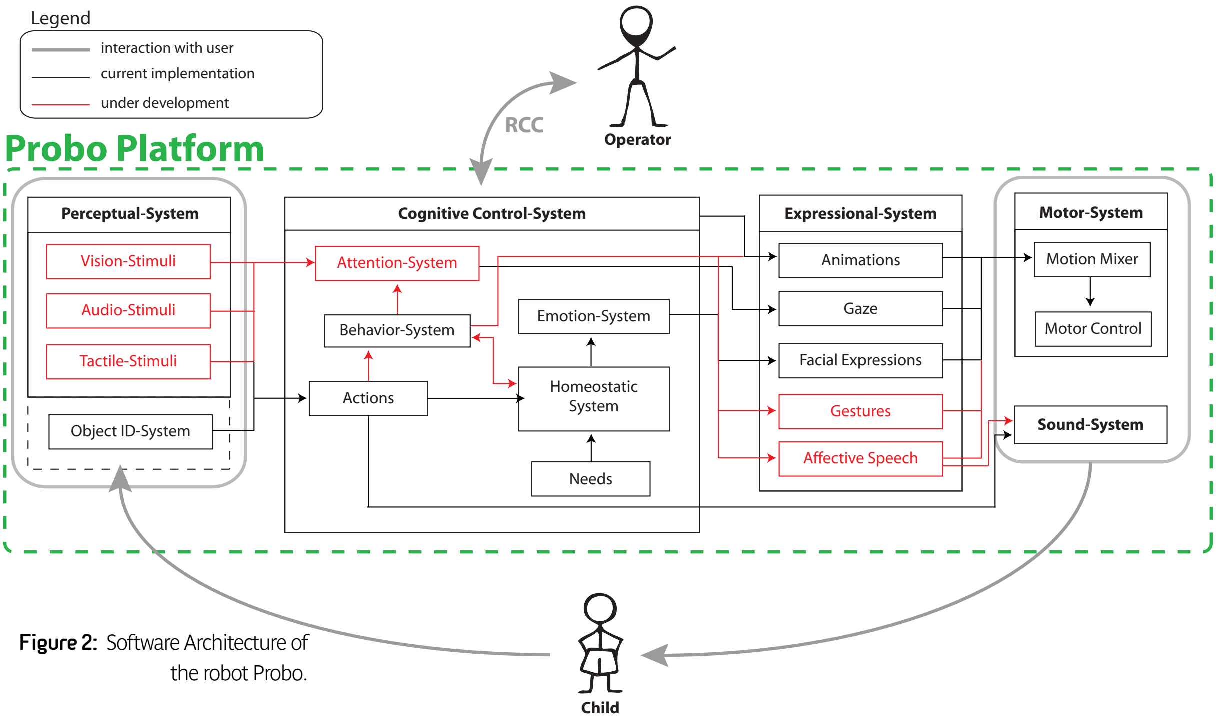

Figure 2: Software Architecture of the robot Probo.

The internal mechanics of the robot are covered with foam and a removable fur-jacket, in such a way that Probo looks and feels like a stuffed animal. With this approach, choosing an imaginary animal as the basic design, there is no exact similarity with a well-known creature and consequently, there are no specific expectations towards the behavior of this creature as would be the case for a cat or dog.

Probo's purpose is to serve as a multidisciplinary research platform for HRI focused on children. In terms of a social robot, Probo is classified as a social interface supporting non-verbal communication. Probo's social skills are thereby limited to a reactive level. To close the gap with higher levels of interaction, an innovative system for shared control with a human operator is introduced. The software architecture defines a modular structure to incorporate all systems into a single control center for the operator named the Robot Control Center (RCC). The robot reacts on basic input stimuli that it perceives during interaction with children. The input stimuli that can be referred to as low-level perceptions are derived from vision analysis, audio analysis, touch analysis and object identification. The stimuli will influence the attention and homeostatic system used to define the robot's point of attention, current emotional state and corresponding facial expression. The recognition of these facial expressions has been evaluated in various user studies.

The degrees of freedom (DOF) in Probo's head are based on the Action Units (AU) defined by the Facial Action Coding System (FACS) developed by Ekman and Friesen. AUs express motion of mimic muscles as 44 kinds of basic operations, with 14 AU to express the six basic emotions – anger, fear, disgust, sadness, happiness, and surprise. In contrast with other robotic heads, a special body part, namely the trunk, is added to intensify certain emotional expressions and to increase interactivity.

Safety is ensured through Probo's soft body and intrinsic safe actuation systems. To convey the illusion of life in a robotic creature, tools for the creation and management of motion sequences are put into the hands of the operator. All motions generated from operator-triggered systems are combined with the motions originating from the autonomous reactive systems. The resulting motion is subsequently made more smooth and transmitted to the actuation systems. To facilitate interaction with children, Probo has an identity and corresponding history. The name "Probo" is derived from the word proboscidea. Proboscidea is an order that now contains only one family of living animals, Elephantidae or "the elephants." The history of Probo starts in the Ice Age where he lived among other similar species such as the mammoths and mastodons. For thousands of year he remained frozen under an ice cap in the North Pole, but arrived at Mainland Europe after global warming melted large chunks of ice, setting them adrift in the open sea. Now Probo's quest is to help children overcome their difficulties and diseases and to make there lives happier and more fulfilling. With future applications to come, Probo is an ideal platform to create a friendly companion for hospitalized children.

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Arm Therapy Robot for Neurorehabilitation

Rehabilitation for victims of stroke can be a costly, labor intensive, and time intensive undertaking. With the aid of robots, rehabilitation could be improved by reducing the number of therapist hours needed, and increasing the duration and number of patient training sessions. While physiotherapists' work load would be lightened, patients would have a more effective rehabilitation experience and as a result, increased quality of life.

By Tobias Nef and Robert Riener

Motivation for Robot-supported Training

Stroke is the leading cause of long-term disability. It affects more than one million people in the E.U. and more than 700,000 in the U.S. each year. The major symptom of stroke is severe sensory and motor hemiparesis of the contralesional side of the body. Restoration of arm and hand function is essential for the patient to cope with activities of daily living (ADL). Sensorimotor movement therapies have positive effects on the rehabilitation of the upper limb function, and relevant factors for successful rehabilitation training include a high level of intensity, sufficient duration, and repetitive but variable movement tasks. However, with respect to these criteria, one-to-one manually assisted training has several limitations. It is more labor intensive, time consuming, and expensive.

In contrast, robot-assisted arm training can reduce the number of therapist hours, whereas the duration and number of training sessions can be increased and well monitored. Furthermore, a robot enables repetitive training and can provide quantitative measures, stimulating biofeedback functions and supporting the assessment of the rehabilitation progress. The possible benefits of the robotic training are multifarious, if projected into the future. Patients may benefit from a more effective and diversified rehabilitation leading to an improved quality of life, while physiotherapists would benefit from a less physical workload, as well as resulting in a lower cost of healthcare.

ARMin III
Robot with a healthy test person

Technical Components of the ARMin-robot

The ARMin arm therapy robot has been developed and tested at the ETH and University of Zurich in Switzerland. It has an exoskeleton structure that is empowered by six electric motors. The motors and gears are backdrivable and equipped with redundant position sensors, allowing the device either to control the position or the interacting force. The device can be used for left and right arm training and usually connects to the most affected arm. It can be operated in three modes:

passive mobilization; active game-supported arm therapy; and active training of ADL.

For passive mobilization, a teach and repeat procedure has been implemented, where the therapist can move the patient's arm on an arbitrary but patient-individual trajectory, while the robot actively compensates friction and gravity. The recorded movement can be repeated by the robot while the patient is instructed to behave passively.

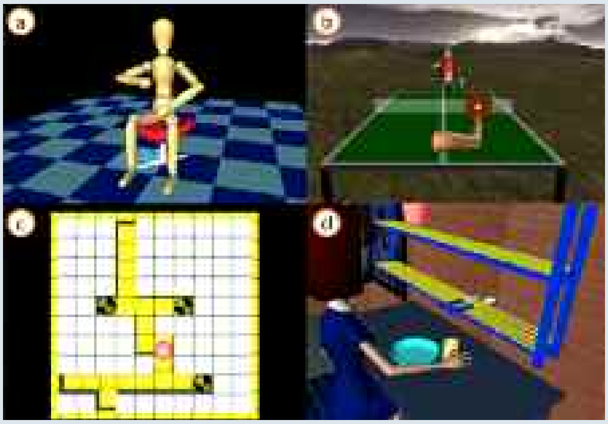

Figure: Graphical display for the ARMin training. The computer screen (a) is shown during passive mobilization, screen (b) and (c) during game training, and screen (d) during ADL-training.

In game mode, ARMin serves as an input device driving a graphical object (e.g. a ball or a cursor) inside a game scenario (e.g. a ping-pong scenario). The robot detects the contribution of the patient to the movement and assists as much as necessary. In the ADL training mode, the patient has to solve an ADL task presented by the audiovisual display (e.g. set a table, fill a glass and drink).

A key feature in the game and ADL mode is a specific patient-responsive strategy that supports the patient only as much as needed. Current ADL training tasks include setting a table, cooking, filling a cup, drinking, eating, personal hygiene, using a ticket machine, and playing the piano. We expect that the training of functional movements will facilitate the carry-over of gains in motor abilities into improvements that are relevant to ADL.

Clinical Testing of the ARMin-robot:

After approval from the institutional review board, preliminary tests were performed on more than 20 stroke subjects in order to evaluate the technical and ergonomic functionality of the different ARMin versions – I, II and III. A first pilot study with three chronic stroke subjects was performed in order to investigate whether the arm training with the robotic rehabilitation device ARMin I improves motor function of the paretic upper extremity. The study had an A-B design with two weeks of multiple baseline measurements (A), eight weeks of training (B) with respective measurement, and a follow-up measurement eight weeks after training. The training included shoulder and elbow movements induced by ARMin I. Two subjects had three one hour sessions per week and one subject received five one hour sessions per week.

The main outcome measurement was the upper limb portion of the Fugl-Meyer Assessment (FMA). It showed moderate, but significant improvement in all three subjects ($p<0.05$). Most improvements were maintained eight weeks after discharge. However, patients stated that the daily use of their paretic arm in the real world did not change. This could be explained by the fact that mainly non-ADL related proximal joint movements were trained (with only three degrees of freedom).

Therefore, another study was performed to investigate the effects of intensive arm training on motor performance, using the ARMin II robot, incorporating distal joints and ADL tasks were. This study included four chronic stroke subjects that received robot-assisted therapy over a period of eight weeks, three to four days per week, one hour per day. Two patients had four one hour training sessions per week, and the other two patients had three one hour training sessions per week.

The primary outcome variable was the FMA of the upper extremity. Secondary outcomes were the Wolf Motor Function Test (WMFT), maximum voluntary joint torques, and further scores to assess transfer effects. Three out of four patients showed pronounced and significant improvements ($p<0.05$) in the main outcome measure, and were in line with improvements in the secondary outcome measurements as well. Most improvements were maintained, and some even further increased between discharge and the six month follow-up. The data clearly indicate that the intensive arm therapy with the ARMin robot can significantly improve motor function of the paretic arm in some stroke patients. Even those who are in a chronic state yield sustainable results. These findings encouraged us to start a subsequent controlled randomized clinical trial.

Conclusion and Outlook:

The prospective controlled and randomized study started in 2009. Its goal is to compare task oriented robot-aided therapy to conventional therapy with respect to promoting functional recovery of the paralyzed arm. The study is ongoing and a total number of 80 chronic stroke patients will be included. Meanwhile, an industrial partner (Hocoma AG, Volketswil, Switzerland) is commercializing the ARMin technology. The commercial version of the ARMin robot is named ArmeoPower® and is expected to be available for sale in 2011. We expect that the data that has been collected within the prospective randomized clinical trial and the commercial availability of the device will facilitate its transfer from the research lab into rehabilitation clinics.

Acknowledgment:
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Robot Assisted Radical Prostatectomy

Minimally invasive surgery utilizes robotics in certain specialty areas. Although the daVinci Surgical System manufactured by Intuitive Surgical was originally conceived for heart surgery, radical prostatectomy for prostate cancer now successfully implements this technology.

By David I. Lee

Prostate cancer is the most commonly diagnosed cancer in men in the U.S. It is estimated that nearly 200,000 men were diagnosed and nearly 28,000 men died because of prostate cancer in the U.S. in 2009. While a myriad of treatments exist including external radiation, brachytherapy, proton radiation therapy, high intensity focused ultrasound, cryosurgery and active surveillance, many men opt for surgical removal. Radical prostatectomy, or complete removal of the prostate and seminal vesicles including reconstruction of the bladder to the remnant urethra, has been shown to reduce the incidence of distant metastasis and death from prostate cancer as compared to active surveillance. However, open surgery involves significant side effects and morbidity including incontinence, impotence, pain, significant blood loss, and a lengthy recovery process.

Robotics in Surgery

The innovative work of Menon and colleagues showed that the use of the daVinci Surgical System manufactured by Intuitive Surgical in Sunnyvale, California, could benefit the surgeon in allowing a difficult laparoscopic radical prostatectomy to be performed with the advantages that the robotic platform provides (see Figure 1). These benefits include a visual system that can provide 3-D vision. Un-

Figure 1: The daVinci Surgical System pictured here has become the platform that is widely used for robotic prostate surgery.

like standard laparoscopic systems where the image is sent to a video monitor, the camera system transmits a dual image captured by a dual lens and dual camera head. When seated at the console, the surgeon views each image with a different eye and thus can see in 3-D inside the patient. The image is also magnified tenfold.

The robotic instruments are available in a variety of shapes and functions including scissors, monopolar and bipolar cautery instruments, needle drivers, forceps, etc. However, the differentiating feature of the robotic instruments is a hinged wrist near the instrument tip (see Figure 2). This robotic wrist mirrors the flexibility of the human wrist. Because this wrist is miniaturized, it allows exceptional mobility deep within the operative field, thereby facilitating dissection and suturing.

The robot interface also provides several advantages to the surgeon. The console is very ergonomic, allowing the operating surgeon to be seated with arms supported, thus greatly reducing fatigue. When performing surgery, the hand controls or "masters" have the ability to filter hand tremor. With the additional ability to scale the motion of the robot instruments, incredibly delicate and fine work can be performed. This dexterity allows even very complex skills such as laparoscopic suturing to be performed with amazing ease. With these multiple benefits provided by the robotic platform, the application of laparoscopy to prostatectomy has become a much more feasible option.

There are some limitations to the ability of the robot. There is no tactile feedback to the robotic instrument and this can be a considerable hurdle for experienced open surgeons when adapting to the robotic approach. Many steps of the radical prostatectomy are facilitated by feel. Therefore, the improved visualization that the robot provides must be substituted during these steps. This, however, does represent a significant learning curve.

Robotic Versus Open Radical Prostatectomy

The gold standard for treatment of early stage prostate cancer has been open radical prostatectomy. In 2009, it is estimated that more than 80% of all radical prostatectomy cases in the U.S. were performed with robotic assistance. Post-operative stress, urinary incontinence, and erectile dysfunction can result from either open or robotic surgery and cause a considerable decrease in quality of life. However, with increased experience comes improved outcomes. Data from reputable centers with radical prostatectomy demonstrate excellent results in regard to maintaining continence and potency. Generally large series report 90% pad free rate by 12 months and 80% potency after complete nerve sparing procedures for robotic prostatectomy and open radical prostatectomy. It is important to note, one clear benefit of robot prostatectomy is convalescence. Our patients at the University of Pennsylvania leave the hospital on the first day 96% of the time, where the stay after open radical prostatectomy is typically 2-4 days. Our patients resume full unrestricted activities within 3 weeks. This takes 6-8 weeks after an open radical prostatectomy. This likely results in a large societal benefit, both in worker productivity and decreased overall costs due to a shortened recovery period. There is increasing evidence that there are fewer medical and surgical complications after robot prostatectomy, further improving the cost balance.

The Penn Technique

Our technique for performing robot prostatectomy is quite similar to many other centers with a few modifications. We utilize a six port transperitoneal approach. By using a transperitoneal approach, the peritoneum must be incised to gain access to the bladder and prostate. This is performed over the anterior abdominal wall. With the bladder dropped, the endopelvic fascia is visualized and incised to mobilize the prostate from the surrounding levator muscles. We then use a laparoscopic stapler to ligate the dorsal venous complex (see Figure 3). The bladder is then divided away from the prostate and the seminal vesicles and vasa are divided next. The rectum is then mobilized away from the prostate and erectile function nerve sparing can then be performed. We do this in an athermal tech-

Figure 2: Significant advantages of the system include 3-D vision for the operating surgeon. Robotic instruments are controlled by the surgical masters and allow for very precise movements to be transmitted to the robotic instruments.

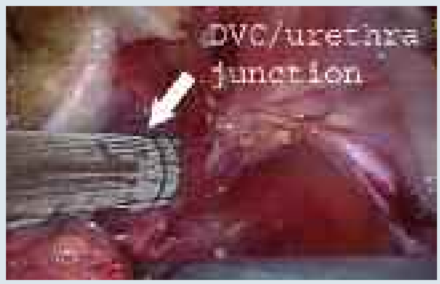

Figure 3: The laparoscopic stapler is here shown being inserted around the deep dorsal vein complex to provide rapid and precise ligation and hemostasis.

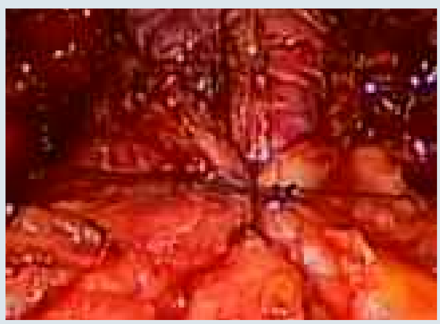

Figure 4: Our technique has pioneered the use of a plication stitch pictured here. This helps to funnel the bladder neck allowing men to have more rapid control of continence postoperatively.

nique which avoids any heat sources such as cautery to avoid additional injury to the neurovascular bundles. The urethra is then divided, freeing the prostate and a long urethral stump is left to increase the speed of continence return. The prostate is placed into a laparoscopic entrapment sac until the rest of the case is completed. A lymph node dissection can easily be performed if indicated. Reconstruction is then performed. Our technique has pioneered the use of an anterior plication stitch as shown in the diagram (see Figure 4). This helps to take tension off the anastomosis and to perhaps lengthen the functional length of the urethra. We have noted that since we have been using this stitch that continence has returned earlier on average than without the stitch.

Indications

We have found that we can perform this robotic operation for most men who have had previous abdominal surgery, regardless of their body habitus or size of the prostate. For example, this operation has been successfully performed on men weighing up to 360 pounds with a prostate weighing up to 250g (a normal-sized prostate is about 30g). Many surgeons have worried that previous hernia repairs could lead to complications with open radical prostatectomy. However, we had little difficulty, even in cases where patients had previous laparoscopic hernia repairs with mesh. Therefore, virtually all men who are candidates for open radical prostatectomy may be candidates for robot prostatectomy as long as they have what appears to be localized prostate cancer.

Positive Surgical Margins

A positive surgical margin is defined as the presence of tumor cells adjacent to the inked surgical margin. Increasing experience has been shown to be a large determining factor for the incidence of positive margins in the setting of open prostatectomy. This is likely true for surgeons performing robot prostatectomy as well. Our margin rates have steadily improved to the point where we have seen rates of 4-5% for organ-confined disease and 11-12% overall.

Conclusion

Robot prostatectomy is the new preferred method of performing radical prostatectomy in the U.S. Patients convalesce more quickly and experience fewer complications. Functional outcomes seem equivalent and may be improved. Cancer control in the form of margin rates and early PSA recurrence are also comparable at this point. Future improvements will allow improved prostatectomy results and wider application of the robotic platform to other procedures and specialties.

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"How Was Your Day?"

Virtual Agents as Companions

Using the simple phrase "how was your day?", a virtual companion could effectively engage their user in natural conversation and begin to build a meaningful, personal relationship. Here, the author discusses ways in which this scenario is becoming plausible.

By Marc Cavazza

Recent progress in affective dialogue systems makes it possible to consider a new application for Embodied Conversational Agents (ECA), which can become virtual companions to their users. Previous research has mostly developed ECA as personal assistants, which served as interfaces to various services, such as electronic TV guides or e-commerce sites. By comparison, a companion agent should be able to depart from task-based dialogue, engage in natural conversations with its owner, and establish personal relationships. The COMPANIONS project addresses this research challenge, and has recently released its final demonstration. The system presents itself as an ECA with which the user can engage in an

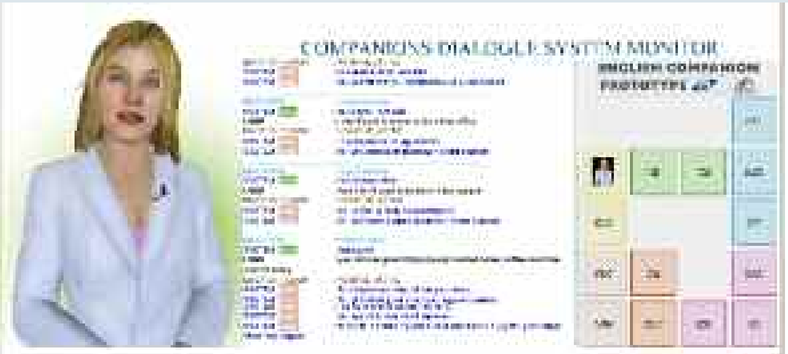

Figure 1: The Companion Prototype.

open conversation, albeit on a limited number of topics. As an application scenario, we wanted an everyday life domain that would support conversation with some affective content. We opted for a scenario in which the user, a typical office worker, returns home and complains about their day in the office. We refer to this as the "How was your day?" (HWYD) scenario. The prototype currently supports over 30 work-based topics of conversation corresponding, for example, to representative events such as meetings, company restructuring, relationships with colleagues, and others, across a range of situations whose discussion is likely to include emotional elements.

One specific innovation of the project has been to develop a *conversational* approach to dialogue, departing from task-based dialogue, and allowing long user utterances as well as user interruptions. A natural conversation is an important prerequisite for affective dialogue systems, since users may naturally get carried away in their descriptions of events. In a similar fashion, they may have strong reactions to long tirades from the agent, leading them to interrupt these. The system implements a real-time interaction strategy supporting different feedback loops and backchannels to preserve the quality of interaction. These include mechanisms for accepting user interruptions during agent utterances and processing the contents of these interruptions as part of the conversation.

In such a context, the need for robustness in speech understanding has led us to explore different natural language processing solutions, such as Information Extraction, a set of methods originally developed for text analysis, which instantiate event descriptions from user utterances up to 60 words in length.

This prototype supports end-to-end affective dialogue, from the emotional content of the user's discourse to the generation of multimodal expressions for the conversational agent. User input is analyzed for emotional content both at speech and text level, resulting in an emotional category being attached to each event description. This will be used to determine the appropriateness of the user's emotional reaction to the events he/she is reporting.

The companion uses an affective strategy to influence the user, which is based on its perceived appropriateness of the user's emotional reaction. Depending on its analysis, it will choose to comfort the user or provide some warning about the possible evolution of the situation. The affective strategy is composed of a set of influencing operators whose sequence is meant to gradually convey the message to the user, for instance, by initially expressing agreement and empathy.

The sequence of influence operators is translated into a tirade of automatically generated system utterances. Each of these is also associated with emotional content, which is expressed by the companion using Text-To-Speech parameters and real-time animation of facial expressions and gestures.

The following dialogue example illustrates the companion affective strategy when it concludes that the user's attitude may be unrealistic or inappropriate. In this case, the user is reporting worrisome news but user input analysis detects a positive mood.

<User>: We've just learned her department is going to be merged with the Barcelona one I've always liked working in the finance department

<System>: What do you think will happen next?

<User>: I heard some people will be moved to the other office in the next couple of months hopefully I won't get laid off or forced to move with them

<System>: You seem to be in a good mood.

<System>: But are you sure this is appropriate for the situation?

<System>: I also think the merger will go ahead.

<System>: What is more the merger is likely to create redundancies.

<System>: I'm worried that this may mean more stress for you.

<System>: Remember that the consequences of the merger are likely to be bad.

The latest developments in the project consist of incorporating some form of computational humor in the agent, enabling it to use irony as part of its persuasive strategy.

More information about the project, including consortium members can be found at http://www.companions-project.org/.

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Robotic Arm Exoskeletons for Rehabilitation

By Craig Carignan

Blockbuster hits like "Ironman" have made exoskeletons more readily recognizeable to the public and their use in rehabilitation is a realistic option to be used in medicine today. Here, the author discusses a portable arm exoskeleton to be used to treat many different types of injuries.

Exoskeletons have been gaining increasing notoriety in the media for their superhuman strength capabilities on display in several Hollywood blockbuster hits. In the 1986 epic "Aliens," Captain Ripley used an exoskeleton munitions "Loader" to battle the mother alien and save her crew from certain doom. In the more recent movie "Ironman" released in 2008, Tony Stark builds a fusion-powered armored exoskeleton suit to escape his captors and wreak havoc upon the enemy. However, what many people don't realize is the vast potential of exoskeletons not so much as super soldiers but as rehabilitation tools in the clinic.

While the real life version of Ironman, the Sarcos XOS-1, is a marvel of modern engineering, it does not actually give the wearer super strength. Like its counterpart in the animal kingdom, the exoskeleton functions as a shell to allow the user to apply higher forces without having to directly bear the load. When coupled with powerful actuators, it may give the appearance of having superhuman strength by allowing the wearer to lift heavier objects than they normally could. But the exoskeleton can actually be regarded as a robot with a human pilot onboard that is commanded by the arm and leg movements of its occupant.

Figure 1: Side view of exoskeleton shows the shoulder and forearm assembly with hand grip (bottom right).

By contrast, rehabilitation exoskeletons are designed specifically to assist (or resist) the movement of the person wearing it. These exoskeletons are attached at various points along the arm or leg so that forces can be applied directly to the limbs. This allows the exoskeleton to move individual joints during therapy, much like a physical therapist would do. Rehabilitation exoskeletons also have the ability to precisely control forces and generate movement in multiple planes, an ability not afforded by standard exercise machines. Moreover, position and force feedback from embedded sensors can be used for quantitative assessment, allowing the patient's progress to be monitored during therapy.

The Maryland-Georgetown-Army (MGA) Exoskeleton is the result of a collaborative effort between the Georgetown University Medical Center and the University of Maryland to build a portable arm exoskeleton for treating a wide range of injuries. The exoskeleton has six joints

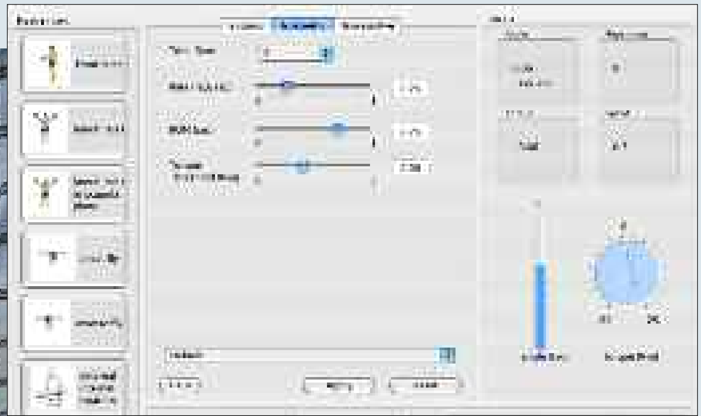

Figure 2 (left): Force sensors (blue discs) located at the upper arm cuff and hand grip provide force feedback to the control system.

Figure 3 (above): Graphical user interface panel for shoulder rotation exercises.

(one passive) and weighs approximately 11 kg. Its five powered joints are driven by brushless DC motors coupled to harmonic drives and can provide torque comparable to the average adult male (120 N-m at the shoulder). Three joint axes intersect at the ball-and-socket joint of the shoulder (Figure 1), while a joint mounted on the torso elevates the whole shoulder assembly to replicate "shoulder shrug." A single pitch joint drives elbow flexion/extension, and a passive forearm roll joint allows forearm supination/pronation. The scapula, upper arm, and forearm links are passively adjustable to accommodate different arm geometries. Force sensors mounted at the upper arm cuff and hand grip provide force feedback to the control system (Figure 2).

The large range of motion (ROM) and high torque capacity of the exoskeleton enable a wide range of muscle degradations to be treated. A patient with a low muscle grade could thus progress from a passive condition in which he cannot move his own limb, to resistive therapy where he can move his limb against maximum external resistance. Different control modes are used to realize different therapeutic modalities. For example, isometric mode is used for strength assessment once the patient surpasses the passive condition, while isokinetic mode is used to modify resistance over the ROM until the patient has restored almost all normal strength. Isotonic mode is typically used in the latter stages of therapy and for healthy individuals.

Several shoulder rotation exercises were developed to demonstrate the ability of the exoskeleton to replicate standard exercise machines. In these "isolateral" exercises, the exoskeleton constrains the rotation to occur about a single axis, such as about the humerus during internal/external shoulder rotation or the shoulder abduction/adduction axis as shown previously in Figure 1. The graphical interface used to set up the shoulder exercises is shown in Figure 3. The exercise selection is on the left side of the panel, and the mode is at the top. The level of resistance, speed, and range are then selected using sliders. Telemetry such as range of motion and torque level is displayed on the right.

The exoskeleton can also be coupled with Virtual Reality (VR) to create novel rehabilitation protocols for functional training. In this scenario, the patient views a simulated task on a computer graphics display while the exoskeleton provides force feedback to the subject's arm as it makes "contact" with objects in the virtual environment. Thus, when the patient's hand pushes against a wall or picks up a bucket in the virtual environment, the exoskeleton will replicate the appropriate reaction forces on the arm. Functional training that emphasizes a sequence and timing of sensorimotor stimuli similar to those encountered in daily tasks has been shown to accelerate recovery from neurological deficits caused by stroke and traumatic brain injury.

A virtual wall-painting task designed to increase reaching ability in subjects with impaired arm movement is shown in Figure 4. In this scenario, the exoskeleton simulates forces exerted by contact with a virtual wall as the subject "paints" with a roller brush. An icon of a paintbrush is drawn on a plain background and tracks the position of the exoskeleton hand grip. Movement of the exoskeleton hand causes movement of the paintbrush in the graphical interface. When the roller makes contact with the wall at a certain force threshold, a green swath is painted along the surface. A bar graph superposed on the wall indicates the level of force to the user who attempts to keep it within a specified range.

The exercises developed so far only begin to tap the potential of the exoskeleton as an exercise and functional training tool. While the ability to vary the parameters of an exercise at the touch of a button is a powerful feature, the real advantage of the exoskeleton is its ability to execute multi-axis motion with precise levels of resistance which cannot be done on a standard exercise machine. For ex-

Figure 4: The exoskeleton being used for a virtual wall-painting task shown in the graphical display on the right.

ample, the "empty can" (EC) exercise mimics lifting a can with the hand and pouring out the contents and thus involves rotation about multiple axes of the shoulder. This exercise has been shown to be very effective at rapidly increasing strength following a rotator cuff injury, but therapists are reluctant to prescribe it because improper performance can lead to shoulder impingement. However, the exoskeleton could be easily programmed to guide the arm along the correct trajectory to avoid injury.

Arm exoskeletons designed for treating stroke, Parkinson's disease, and other neurological conditions are already undergoing clinical trials in several major rehabilitation centers worldwide. While these exoskeletons are not powerful enough to treat orthopedic injuries (typically only 10-20% human strength), they are already making serious inroads as powerful "neuro-rehabilitation" tools. As these exoskeletons gain acceptance in rehabilitation centers, the door will hopefully open for more powerful treatment tools such as the MGA Exoskeleton that can be used to treat musculoskeletal injuries as well.

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MindMentor "Robot Psychologist" acts as Online Mental Coach

▸ By Jaap Hollander

In 2006 Dutch psychologists started developing MindMentor, an online computer program that acts as a mental coach. To state it in a more popular fashion: they developed a robot psychologist (pictured, right). The MindMentor computer program guides clients through a series of psychological steps and helps clients solve problems and achieve goals. It does not present clients with standard answers based on problem-solution relationships from a database, but stimulates clients through a series of generic process steps to look inside, understand their inner mental processes and strategies, and then offers them algorithms to find their own solutions. The MindMentor process takes about an hour. You can find it – and actually try it for yourself – at http://www.mindmentor. com.

The program has a generic structure and will work with any type of human problem or goal including stress, family problems, relationship problems, motivation, life mission questions, sleepless nights, worrying, conflicts with friends or colleagues, etc. Apart from severe disorders like schizophrenia, bipolar disorder, and drug addiction whose sufferers could use MindMentor as a resource but who need live support from a psychologist or a psychiatrist as well, research

shows that MindMentor can help clients solve a wide range of problems and achieve a wide range of possible goals.

Tenets of the MindMentor Approach

The MindMentor approach is based on five psychological systems, most of which have a solid scientific background and may be considered evidence-based.

Neurolinguistic programming (NLP) is MindMentor's main tenet and a model for personal development that emerged in California in the early '80s. NLP helps clients change the structure of their subjective experience. Even though NLP is still often not considered evidence-based, recent scientific research has shown NLP to be quite effective. Based on the NLP model, the MindMentor program asks the client for specific situations in which encouter the problem and analyze their inner experience with questions like, "What do you say to yourself?" or "What do you find most important?"

Once the client has defined their problem and MindMentor has analyzed their thinking and emotional responses, the program looks for counterexamples – a moment when the circumstances are more or less the same, but the client does not experience the problem – and analyze their subjective experience in that context and contrast this subjective experience with the problem thinking it has found before. In this way, it helps clients find a more effective way of mental processing, more effective self-talk, more productive mental imagery, and more effective values.

Some solutions are worse than the problems they were designed to solve. The MindMentor program helps clients check their solutions for problematic consequences or unwanted side effects. Does the problem have advantages that they will lose when they solve it? If so, the program retraces its steps to find new solutions without these drawbacks.

To complete the process, the MindMentor program completes a detailed mental practice session with the client. Neurophysiologic research shows that mental practice is important for behavioral change. The mind mentor program helps clients imagine how they will use the solutions in future situations, both from within (first person associated position) and as an observer.

Projective testing is a series of techniques widely used by psychologists including the ink-blot Rorschach test. Projective testing brings unconscious knowledge into the consciousness. MindMentor utilizes this approach for verification of both the client defined problem and solutions. Rather than evaluating clients' responses based on a fixed interpretative system like the Rorschach test, the MindMentor system uses a pattern detection approach. Clients are asked to associate pictures with for their problem, as well as solutions, and these pictures are then connected to verbal statements. The process is then repeated again clients are stimulated to detect a recurring pattern.

Provocative therapy is an innovative system of psychotherapy and mental coaching which helps clients by challenging them. In order to preserve a positive relationship with the main character the robot MindMentor, this function is represented by a separate robot, ProvoBot. who will barge into MindMentor's office and say thing like, "For heavens sake, MindMentor! You're such a dumb pile of rust! Don't your see who you are working with here? This is Marcin we're talking about. How could he ever achieve this?"

Client centered therapy is a very common type of psychotherapy that helps people gain clarity by approaching them with a very positive attitude (unconditional positive regard) and restating what they have said.

Pavlovian conditioning connects certain mental and emotional responses to images. This is MindMentor's way of helping people to easily connect or "anchor" inner resources to the situations where they need them. MindMentor mostly uses colors – problem states, general process states, creative or meditative states and solutions states are all associated with different colors.

Responses from the Field

Some psychologists have responded positively to their robot colleague, and some have reacted with great skepticism. Said David Van Nuys, Ph.D. of Sonoma State University said, "At the end of the hour-long session, I have to say my outlook and spirits were lifted considerably. It was smart, supportive, fun, and funny, and helped me to focus in on the central issue. I find the blend of artificial intelligence, NLP, and other goal-directed therapeutic techniques effective." But some of Hollander's colleagues have responded with deep skepticism, especially being concerned that MindMentor will not be able to handle severe psychological disorders. Said Hollander in an interview in Dutch national newspaper 'Trouw': "People with severe psychological problems, like bipolar disorders … hard drug addictions or disabling phobia's … still need help from live professionals. For them, MindMentor may be an interesting adjunct but never a replacement of live treatment."

Encouraging Research Results

In 2006, 1,600 clients from roughly 25 countries participated in the MindMentor process. The process used at the time was a much simpler form of the MindMentor program than the version online today, but the process was roughly the same. Clients who finished the process were asked how many days they needed to try out the solutions they had found. After the designated number of days, are MindMentor contacted participants with a survey an average solution percentage of 47%.

Future Directions

Plans for MindMentor in the short term are to restructure the process, which can now take up to 90 minutes, into a series of 5-7 shorter sessions of approximately 10 minutes each. Each step will end with a tested milestone and be connected to the users real life social environment involving friends, family, coworkers, etc. Hollander hopes this will lead to more widespread use in toda fast-paced culture, give the client more time to think about their responses, and counterbalance the justified concern of some colleagues that using MindMentor might result in less real, live social interaction. Longer term plans include having MindMentor users with similar problems connect anonymously and give each other advic, as well as creating specific MindMentor procedures for specific problem areas like cigarette smoking, allergies, and relational discord, among others.

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Product Comparison Chart: Medical Robots

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The vast field of robotics applications covers many industries, from manufacturing to education. A largely important and growing field that we focus on in C&R is robotics as they apply to medicine, both physical and mental, and rehabilitation, in particular. These robots can save money, provide better care for patients, and even avoid potential mistakes. Here, we offer a list of some examples of products currently on the market.

PRODUCT	DESCRIPTION OF PRODUCT	MANUFACTURER
The da Vinci® Surgical System	a surgical robot containing a surgeon console, patient side cart with four interactive arms, EndoWrist instruments, and a vision system to treat a wide variety of conditions including different types of cancers, kidney and uterine disorders, coronary artery disease, and obesity	Intuitive Surgical, Inc.
Sensei® X Robotic Catheter System	a flexible, purely robotic platform that combines the latest in 3-D catheter control and 3-D visualization to achieve accurate results in placing the catheter inside patient's hearts	Hansen Medical
PROBOT	a robot for prostate resection that allows surgeons to define a volume to be automatically cut within the prostate without further interference from the surgeon	Imperial College London
CyberKnife® Robotic Radiosurgery System	a premier radiosurgery system within the field of radiation oncology that delivers extremely accurate high doses of radiation to anywhere in the body	Accuray Incorporated
ROBODOC	ROBODOC incorporates 3-D pre-surgical planning with active robotics for precision and comfort in patented total joint hip and knee replacement surgery	CUREXO Technology Corporation
PinTrace	in initial clinical use for hip fractures, the PinTrace is based on robot assistance (for increased levels of surgical precision and a reduction of cumulative exposure time of radiation) and an open configuration for input data	Medical Robotics
CosmoBot (V3)	used to motivate children with and without developmental disabilities to participate in therapy and education more extensively	AnthroTronix
PARO	the Paro Therapeutic Robot allows for the benefits of animal therapy to patients in environments where animal therapy poses difficulties. Found to reduce patient stress and improve relaxation, motivation, and improve socialization between patients and caregivers	PARO Robots U.S., Inc. - Developed by AIST
Lokomat®Pro	a driven robotic treadmill that guides gait-impaired patients' legs to improve mobility in those who have incurred stroke, spinal cord injury, cerebral palsy, multiple sclerosis, and neurological injuries and diseases	Hocoma
iARM	(iARM) is a wheelchair attachable, customizable mobile robot. The iARM assists disabled people by enabling a vast amount of daily activities and functions that were previously unachievable	Exact Dynamics

Product Comparison Chart: Military Robots

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Product	Description/Function	Manufacturer
TALON Responder	operated from a laptop controller, it is used for pubic safety missions as well as by fire and rescue organizations. It includes a disruptor-ready manipulator arm, wrist and gripper, and three infrared cameras	Foster-Miller, a subsidiary of QinetiQ North America
SMSS (Squad Mission Support System)	six wheeled robotic vehicle with a platform that can carry up to 1,000 pounds designed to carry equipment and supplies to support a single squad	Lockheed Martin
BEAR (Battlefield Extraction-Assist Robot)	life-size humanoid robot that is designed to search for wounded soldiers on the battlefield and transport them to safety – equipped with wheels and tracks it can move standing straight up and also while lying almost flat to the ground	Vecna Robotics (sponsored by TATRC)
EOD (explosive ordnance disposal)	in use since 2000, designed to safely move and dispose of live grenades	Foster-Miller
ARIES (Acoustic Radio Interactive Exploratory Sensor)	remote-controlled submarine that is used for research as well as underwater mine detection	Naval Postgraduate School
Throwbot	compact two-wheeled reconnaissance robot intended to be thrown into an environment capturing real-time images in order to evaluate the surroundings before entering the area	Recon
Global Hawk	unmanned aircraft that flies at high-altitudes to survey tens of thousands of squares miles a day, sending the images back to a control station on the ground	Northrop Grumman
Predator	unmanned aerial vehicle (UAV) used for reconnaissance missions as well as carries missiles or similar weapons	General Atomics
MAARS (modular advanced armed robotic system)	remotely operated vehicle the size of a lawn mower, armed with weapons including machine guns and a grenade launcher	Foster-Miller
CBRNE (chemical, biological, radiological, nuclear, and explosive) /Hazmat	utilizes joint architecture unmanned systems (JAUS) software used for detection, has the ability to plug in up to seven different devices to collect audio and visual images using its various sensors	Foster-Miller
Goalkeeper	close-in weapon system (CIWS) that defends ships from incoming missiles and ballistic shells	Lockheed Martin
BigDog	stands on four legs, roughly the size of a mule, designed to accompany soldiers in terrains too rough for vehicles, carrying with it supplies and other equipment	DARPA
PackBot	series of military robots designed to perform multiple tasks that assist missions such as bomb removal, reconnaissance, route clearance, and hazardous materials detection	iRobot

Virtual Reality for Robot-Assisted Gait Training in Children

"Recent achievements in rehabilitation engineering resulted in the development of several robotic systems that aim to improve walking ability in patients with neurological gait disorders. These robot-assisted gait training (RAGT) devices, such as the Lokomat® (Hocoma AG, Volketswil, Switzerland), appear promising, since they might intensify locomotor training by increasing both the number of steps per training session as well as the training frequency, while decreasing the therapist's manual assistance."

By Karin Brütsch

Impaired movement, particularly walking, is frequently observed in patients with neurological disorders. Recent achievements in rehabilitation engineering resulted in the development of several robotic systems that aim to improve walking ability in these patients. These robot-assisted gait training (RAGT) devices, such as the Lokomat® (Hocoma AG, Volketswil, Switzerland), appear promising, since they might intensify locomotor training by increasing both the number of steps per training session as well as the training frequency, while decreasing the therapist's manual assistance.

However, despite these positive effects, one complication of implementing robotic devices might be the patient's passivity in the driven gait orthosis. It is believed that passive guidance is less effective for motor learning and restoration of walking when compared to active performance. Another possible shortcoming in RAGT might be the fact that rehabilitation training is indeed repetitive and repetition tends to "decouple" the mind and reduce patients' motivation. Indeed, clinical experiments revealed that children in particular show little motivation towards the training process in a conventional repetitive RAGT, because this training is rather monotonous and provides little incentive to continue for longer periods of time. Thus, pediatric rehabilitation centers using RAGT try to boost the patient's motivation by simultaneously showing DVDs or playing music. Such strategies, however, may distract children from the actual gait training, causing them to become completely passive and inattentive during the Lokomat® training. Therefore, in RAGT, it appears essential that patients participate actively rather than just letting themselves "be walked."

Figure 1: The Lokomat setup with a virtual reality game in front of the patient.

An advantage of RAGT devices combined with Virtual Reality (VR) (Figure 1) is that it has the capability to create a rehabilitation environment with individualized treatment needs while providing standardization of assessments and training protocols. During a training session the duration of training can be adjusted, as well as other factors such as intensity of training, the amount of force needed to support leg movements, walking speed, and provided support of body weight. A device like the Lokomat® provides consistent assistance and moves the patient's legs along a predefined fixed trajectory, while also assessing forces between the patient and the leg orthoses. Indeed, these man-machine interaction forces at hip and knee joint linear drives provide feedback values and can be used to quantify the participant's level of activity and participation during RAGT. By controlling and manipulating feedback parameters, VR games can be adequately adapted to the children's cognitive and physical capacity, thereby keeping the level challenging and providing motivation without losing focus and attention on actual gait training. Several studies support the fact that patients' motivation plays a crucial role in determining

Figure 2: Different samples of the virtual planet Gabarello (© GABARELLO).

the outcome of therapy. Moreover, in certain patient populations it may even be the most critical factor in defining the success of rehabilitation training (e.g. children, stroke patients).

Indeed, preliminary studies demonstrated the success of adding virtual environments to RAGT and enhancing motivation of the patient during therapy. It was demonstrated that patients with neurological gait disorders and healthy children participated more actively – quantified by biofeedback values or leg EMG amplitudes – with VR-based RAGT than with other supportive interventions, such as watching DVDs or encouraging instructions by therapists. The gaming aspect of VR keeps children highly engaged during repetitive tasks.

In collaboration with different institutes, a new serious game was developed – Gabarello ("GAme BAsed REhabiliation for LOkomat") – to counteract the problem of adequately maintaining children's motivation during consecutive training sessions and to improve the quality of VR design elements and immersion. In this VR game Gabarello, the patient is immersed in an environment on another planet. A large monitor in front of the patient (Figure 1), portrays an astronaut exploring the planet's surface by scouting different routes, collecting objects and planting plants that start blooming. By shifting the height of the legs, the color and the speed of the avatar, the environment reflects the patient's active participation in the Lokomat® (Figure 2). In other words, the man-machine interaction forces of the patient in the Lokomat® control the VR game. The level design of the game requires deliberate changes in exertion of the patient and therefore meets therapeutic goals.

Despite these new VR developments, our previous studies also showed that the therapist is still an important motivator, which might be of interest for defining optimal RAGT protocols. Indeed, according to our clinical experience, the use of VR during rehabilitation therapy should not replace the physical therapist, but rather provide an additional means of enhancing training efficiency and motivation. Further research should reveal whether an increase in motivation and active participation leads to a better functional outcome, as a result of patient cooperative strategies such as VR.

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Robots that Care

Some beneficial effects of human-robot interaction in healthcare

By Jeroen Arendsen & Agali Mert

Robots are a type of technology that interacts with people in a special way. They can be put to good use in all kinds of domains, of which healthcare is, at the moment, a very important one. Here, an overview is given of current developments in the field of human-robot interaction and of some potential beneficial effects this might have in healthcare. This field of scientific study – sometimes referred to as "social robotics" – is very young. Published controlled and randomized studies are still sparse and importantly, they represent only a small fraction of the fast pace of developments. Therefore, this overview also includes hypothesized and speculative effects.

Features

Naturally, it is essential for a robot to be able to move on its own (or be

Human-robot interaction features and their effects

Feature	Effect (proven or hypothesized)	Example
Being and moving with us	Captures attention, can relay 'presence' and conversation	Asimo, Nao, Care-o-Bot, RP-7 (remote presence), Telenoid
Comfortable weight	Activates associations with familiar handling actions (e.g. holding a baby)	Paro
Responding to handling	Engages play, stimulates motor activity, pleasant somatosensory experience	Paro, TriBot
Respond to affectionate touching	Engage caring instincts, pleasant tactile experience, emotional bonding	Paro, Alive Cubs, Probo
Support, lift and carry people	Less physical demands on caregivers, higher mobility	Hal 3, Sarcos, NESS L300 & H200
Assisting with embarrassing things	Less shame; higher self esteem; less depression	Avant Santelubain 999, Roxxy
Aid independent eating	More satisfaction; higher self esteem	Meal Buddy, MySpoon
Making eye contact	Captures personalized attention	Paro, Opto-Isolator, Probo
Looking away & blinking	Reduces tension (prolongs interactions)	Opto-Isolator
Frowning or smiling at you	More personal, emotional interaction; conveys attitude to input	Jules (and others from Hanson Robotics)
Establishing joint attention	Helps therapy, less social problems	Keepon, Asimo, Leonardo
'Minimal design'	Better focus, less distraction, less anxiety (autism)	Keepon, Paro
Imitating human movement	Stimulate motor activity, easier transfer of knowledge (social learning)	Bandit, ALICE framework
Gesturing	Richer communication	Leonardo, MDS
Pointing	Greater shared situational awareness	Melvin, iCub, Asimo
Seeing gestures	Stimulates motor activity	Robots using AGR or game console input (Wii, Kinect, Eye-Toy)
Talking	Stimulates responses, suggests intelligence	iCat, Kismet, Leonardo, MDS, Probo
Understanding speech	Stimulates spoken communication	Robots using ASR (many), i-Sobot, Robosapien, Leonardo
Person recognition	More personal interaction, higher adaptation to individual characteristics	Paro (voice)

steered by remote). The "mere" feature of being able to move alongside us allows robots to capture most people's attention much longer and stronger than computer programs on a screen, especially if the robot walks and moves likes us (with feet and hands), as do Asimo and its smaller brother Nao. These robots can navigate our man-made spaces better and engage in shared activities, such as imitation games or dances. In many robots, such as Care-o-Bot, vision is supplemented with extra-human sensing capabilities (e.g. Lidar, GPS, beacons) to move around quickly and safely. Being and moving together with people is also a feature that drives "telepresence" robots, like RP-7, that can relay conversation and attention of a distant doctor to a patient's bedside. Robots like Telenoid are designed to enable dutiful Japanese sons to (virtually) visit their distant fathers more often without the hassle of travel.

One of the oldest available means of interacting with robot animals and interactive dolls is by handling them. Having robots respond to being handled can engage people's attention, stimulate motor activity of, for example, inactive elderly people, or generate a pleasant, soothing somatosensory experience. Paro was "designed for handling" with a weight reminiscent of that of a human baby. It also senses being touched or stroked, due to advanced surface tactile sensors in its body (which it likes) and whiskers (which it doesn't like) and will respond with sounds.

Vision is a very important feature for robots. Fitting one or two cameras, preferably as eyes, into a robot's head is easy, but making sense of the video input is often challenging. Seeing where people are enables robots, like Paro and Opto-Isolator, to look at us and make eye contact. Robots can express non-verbal actions to create a very lifelike impression, capture our attention, and set the stage for prolonged personal and emotional interaction. For example, blinking and looking away now and then, instead of staring people down, is an important mechanism to reduce tension in social interactions. Seeing also enables robots, like Bandit, to imitate and understand our actions.

Gesturing, defined as acting with an intention to communicate, requires robots to move body parts, to address people and to understand what an action means or communicates. Automatic Gesture Recognition (AGR) is an area of development that is immature and, at the moment, mostly independent from robotics research. Some robots use AGR technology to see and understand gestures, like Asimo or Nao. Perhaps most powerfully, gestures can be used together with speech to create a convincing talking robot. Gestures and facial expressions are used by the MDS (Mobile Dexterous Social) Robot, for example, to make robots appear lively and capable of expressing emotions.

Most robots can listen and respond to speech by using the automatic speech recognition (ASR) technology that has developed over the last fifty years (but which is still awkward in many respects). Users can use their voice to control robots like i-Sobot, Robosapien, Robopet and many others, which stimulates interaction. ASR technology also includes identification of people's voices, which Paro uses to know who is handling it and to adapt its behavior accordingly.

Talking is an art mastered by only a few robots. Most robots can play soundbites or use Text-To-Speech (TTS) engines to read out text, but do so without lip or mouth movements which can appear somewhat strange and disrupt the illusion of artificial life. However, robots like iCat, Kismet and MDS speak with their mouths, combined with facial expressions (MDS also integrates head, arm and hand gestures). This makes robots more equal, interactive partners and gives robots a greater power to stimulate desirable behaviour. In this way, the iCat has been used to stimulate elderly users to participate in fitness exercises.

Caring

As discussed above, users can obviously handle robots, but robots can handle humans as well. Robot nurses RIBA and RI-MAN lift patients from their bed, carry them and help to relieve the heavy physical demands placed on nurses. Likewise, nurses can strap on exoskeletons Hal 3 or Sarcos. Disabled people can also use (partial) exoskeletons to regain their own mobility or rehabilitate better (e.g. NESS L300 Foot Drop System). Other nursing activities are also being marked as robot jobs. Having a robot wash patients or help them with their bath (e.g. Avant Santelubain 999) can be useful because with these activities people, both patients and nurses, can experience feelings of shame or embarrassment (especially in societies with strict social conventions). This is even more so with assistance in sexual activities for which robots are also available, such as Roxxxy.

Robots can also help people in their Activities of Daily Living (ADL). Robot feeders, such as MySpoon, Meal Buddy, or the Mealtime Partner Dining System, help disabled people eat independently. This makes eating more satisfying and it lifts a time-consuming burden from nurses. Robot arms, like Focal's Jaco or Bridget, can help people with limited arm function to grab things, open doors, etc. This improves their independence and self esteem, and makes robots suitable for training ADL functioning.

Robots, equipped with many interactive features, as described above, are also outfitted with ever more sophisticated cognitive models. Their perception of us is interpreted on pragmatic, semantic, intentional, or emotional levels. In turn, their responses, speech, gestures, and other expressive actions are shaped according to rules of empathic and social interaction. Does that mean they actually care? They act like they care and sound like they care, so the human brain, under the right circumstances, creates meaning from this interaction.

The Road Ahead

There are robots like Asimo or Probo, for example, which seem to integrate nearly all of the available features. Asimo was originally presented as a robot who could help out in a house or a hospital by, for example, bringing people coffee. After some 15 years of development, it is one of the most sophisticated and expensive robots on the market. It is mostly a showcase and entertains people in Disneyland. Probo is designed as a "research platform to study cognitive human-robot interaction (cHRI) with a special focus on children" and is loaded with features that it may or may not need for actual healthcare applications. For example, children with autism, one of the stated target research groups, may prefer not to have to interpret difficult emotional expressions or the meaning of a raised trunk.

For the future, we may do well to let successful designs like Paro, Keepon, the NESS L300 Foot Drop System, or Care-o-Bot inspire us. These robots share a quality, which is that they were designed without compromise to fulfil a specific goal and only have the features they really need. Apart from robots that are successful, it is just as important to identify those projects that were not as successful. They also give insight into key elements of robots for successful interaction with humans. Even more so, knowing the circumstances under which the human brain is willing to postpone its disbelief that interaction with robots is actually mediated, is in this stage of robot development a practical research and development focus.

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Assistive Social Robots for Elderly Care

"... there are numerous scenarios in which [elderly patients'] independence would strongly increase if a robot is around to assist."

By Joost Broekens, Koen Hindriks & Martijn Wisse

Delft Personal Robot

The developed countries face a serious demographic challenge. In these countries, almost one fifth of the population was aged 60 or older in the year 2000, and by 2050, this Developed countries face a serious demographic challenge. In these countries, almost one fifth of the population was aged 60 or above in the year 2000, and according to the UN, by 2050, this proportion is expected to reach one third. The aging population will require more elderly care than is available and could impede the elderly population's wish to maintain an independent life at home for as long as possible. However, without assistance for physical and cognitive functions (i.e., there may be problems with walking as well as with remembering to take medicine), staying independent is impossible.

According to Statistics Netherlands, functional limitations of the elderly can be categorized into four groups, namely hearing, seeing, mobility and speaking. Mobility problems are by far the most prominent limitation for the elderly, and this problem increases significantly with age. Fourteen percent of men above 65 and 33% of women over 65 have mobility problems. Within the age group of 75 and over, these percentages are higher with 23% of men and nearly 50% of women affected.

The general advice to elderly with mobility limitations is to stay active as much as possible. Nevertheless, there are numerous scenarios in which their independence would strongly increase if a robot is around to assist. Such a robot, for example, could perform fetch-and-carry tasks in order to tidy up the floor and other surfaces, or handing objects such as a phone, remote control, food, or drink to the elderly person.

The feasibility of fetch-and-carry robots has already been demonstrated by mounting an intuitive point-and-click interface on a mobile robot with a robotic arm. A typical example of such a fetch-and-carry robot is provided by the Delft Personal Robot (see Fig. 1). For large-scale usage of a robot like this the robot design should be low-cost and support grasp adaptivity required for long-term operations in an environment with a broad variety of objects. The Delft Personal Robot is able to fetch, carry, and hand over objects with a variety of shapes such as towels, paper cups, phones, etc.

Fetch-and-carry robots will operate in an environment surrounded by elderly people that are novice users of such technology. Apart from operating effectively and safely, it is very important that the interaction between the robot and the user is intuitive and feels natural. This means the robot must be able to understand and follow commands, as well as be able to respond to various forms of spontaneously communicated positive and negative user feedback concerning performance of the robot. This requires that the robot is able to interpret explicit and implicit feedback signals provided via body language (pointing, nodding, shaking), emotional expressions (frowning, smiling), and affective speech (no, yes, good job, nice robot) by a human. This natural communication often involves a component of emotion. Therefore, future service robots and fetch-and-carry robots in particular, need to be social robots that will be accepted and usable in long term scenarios. Experiments have demonstrated that social functions of robots are very important in elderly care settings.

A recent exhaustive review of assistive social robots showed that, although there are promising results, much work still has to be done. A large number of studies show positive effects of either the robot or its placebo version. Furthermore, the elderly seem to be open to this kind of technology. The review provides several observations and recommendations that need follow-up. In summary, it states that large-scale experiments are needed that are rigorously set up, and an adequate methodology is needed to perform such studies and to compare them. Setting up arge scale, national and international European programs to establish the merits of these, and related, assistive social devices, is of great importance for the elderly, as well as for technology-assisted healthcare.).

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The Need for Cognitive Systems in Medical Care

"Not every system is a robot — in fact, hardly any systems are robots. System-level thinking means thinking about patients, their friends, partners, parents and dependents, doctors and other health-care professionals, homes, hospitals, streets and — where available — intelligent technology."

By Joanna J. Bryson

The idea of cognitive systems for medical care might conjure a frightening image of a silent, insensitive hospital full of unheeding robot nurses. But not every system is a robot — in fact, hardly any systems are robots. System-level thinking means thinking about patients, their friends, partners, parents and dependents, doctors and other health-care professionals, homes, hospitals, streets and — where available — intelligent technology. A system is a gestalt of interconnected parts. In a cognitive system, some of those parts are able to sense, evaluate, plan, and interact. But this does not necessarily imply robots replacing human nurses. Patients — that is, each of us — require human contact and attention for our mental and physical wellbeing. This is something any health-care system needs to take into account.

Even if we were to banish robots entirely from patient care, contemporary hospitals and health care more generally could certainly benefit from cognitive systems approaches. Many of the most tedious tasks in a hospital, such as cleaning, do not require contact with patients, yet are essential to patient care. Adding cognitive capacities, such as intelligent sensing of infection, scheduling of cleaning, tracking of equipment and so forth, could increase the reliability of cleanliness while actively decreasing the amount of patient disruption. A human cleaner of wards might need to operate in a particular sequence every day in order to ensure all rooms are attended to, but with the help of AI, either a human or a robotic system could safely resequence a particular room if entering it at a particular moment would inconvenience someone. With the help of AI, this resequencing could be done without danger that the room would be forgotten from the day's schedule.

However, health care is not unique to hospitals only, and care giving is not provided primarily by professionals. Our society is increasingly recognizing the role of caregivers fulfilled by parents, children, partners, friends and even just concerned neighbors. Again, as with any caring task, while some aspects of the task may be very personally rewarding, there are also immensely tedious parts of care giving. For example, people with dementia lose their short term memory and may try to "double" check whether they have locked their door hundreds of times in a single night. For a human caregiver monitoring and correction of this sort of behavior for days and years on end might be maddening. Technology, on the other hand, is perfect for repetitive tasks. Sensors can be utilized to check whether doors are open or locked, and to notice when someone is getting out of bed. It is now technically feasible for a home itself to offer assistance, either by reporting the state of the doors via voice or touch-screen interface, or to provide lighting or verbal prompts to help people remember and stick to their intended schedules and tasks.

None of the above is to say there is no role for personal robotics in healthcare. For example, one of the great inconveniences of a disability can be the perceived debt of social obligation that comes from having to accept help for even trivial tasks. For a paraplegic, having robotic assistance for lifting a glass can make the difference between

While an apple a day may still be a challenge for humanoid robotics, cognitive systems more generally have a role in health care and well being.

whether a trip to a cafe is a pleasant diversion or a socially-distancing event. Robotics in this situation can be seen as an extension of an individual's self, as it is the human owner that determines what the robot will do. But these robots still benefit from intelligence for determining how and when that thing should be done. The more the robot is able to sense, appreciate timing, adapt and act in a coordinated way, the more use it will be to its user, and the less control the user will be obliged to be able to exert in order to exploit the benefits of the robot.

A healthcare system should be considered to include the entire community around each of us — our selves, our neighbors, our governments, private companies, public hospitals, libraries and Internet services all have roles to play in helping us maintain our health and wellbeing. Artificial cognition can be introduced at many points, for example, online agents that help us keep track of our medications and schedule of treatments regardless of our location; intelligent homes can help us maintain a warm, secure environment well-stocked with food and medicines; social networking sites may alert designated friends or family if we seem to have dropped out of contact for too long and might be facing injury or depression; robot companions might help us engage in exercises to recover from a stroke or tutor us to help us overcome autism. Cognitive systems may sound scary if we think of them as something taking power away from us, but no artificial system "naturally" seeks power. It is up to us and our society to decide how we incorporate artificial intelligence into our lives, including our health. Cognitive systems should be seen as extensions of our own minds and powers, there to help us achieve our goals and allow us to focus our attention on the things we consider most worthwhile.

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Social Robots for Self-management of Health-promoting Activities

"With contributions from different disciplines — computer, health and social sciences — various social robot applications have been developed that support self-management, e.g. for exercises, pediatrics, and autism therapy. To foster progress and application of "social robotics for self care," coordinated efforts between research institutes, companies and end-users are being set up."

By Mark A. Neerincx

In Western society, the need for health-promoting activities of young and old citizens is increasing vastly. Assistive technologies are being developed that help to prevent or cope with chronic diseases like obesity or diabetes (which are often life-style related), and incidents like falling down or allergic reactions. By integrating social robots into these care systems, the self-care capabilities of citizens can be substantially enhanced. With contributions from different disciplines — computer, health and social sciences — various social robot applications have been developed that support self-management, e.g. for exercises, pediatrics, and autism therapy. To foster progress and application of "social robotics for self care," coordinated efforts between research institutes, companies and end-users are being set up.

Personal Assistance in Context

Figure 1 provides an overview of the environment of a "social robot" – it communicates with its user ("patient") at home, the equipment and sensors in the home, the medical dossier, and other "personal agents" (e.g., medical and technical specialist). This framework was developed in the SuperAssist project on digital assistants for chronically ill, e.g. a (virtual) iCat robot to reduce the Body Mass Index of persons with obesity. Fig. 2 presents a picture of the iCat.

For older adults, current research focuses on the provision of daily assistance for medication usage, healthy, regular meals, exercises for physical and mental fitness, reminders of events and activities, and

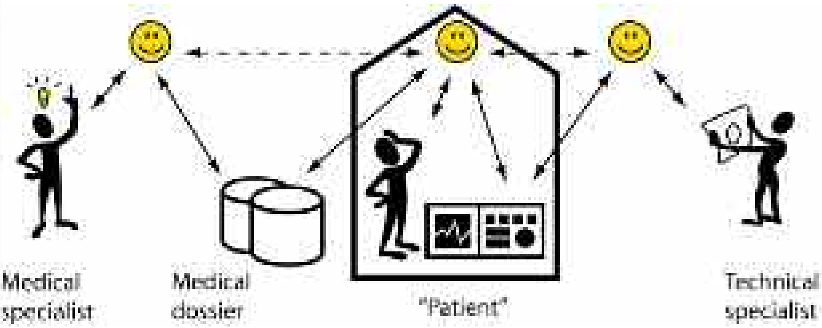

Figure 1: Social robots act in a social environment, communicating with human and technical actors.

warnings to avoid dangerous situations or accidents. For effective persuasion, the assistant should express social behaviors, be trustworthy and show empathy. Based on the principles from motivational interviewing and social human-technology interaction, we designed and tested a set of social robot behaviors including high-level dialogue acts (semantics, intentions), natural cues (e.g., gaze, posture), emotion expressions (e.g., compassionate face), and interaction conventions (e.g., turn taking). In an experiment on a "one-week diabetics scenario," older adults viewed a robot character as more empathic and trustworthy than a conventional text-based assistant, and expressed more conversational behavior with the robots.

Based on these findings, we are developing and testing different robot behaviors for three scenarios – to stop wandering behavior (e.g., leaving the house in the middle of the night), to assist when a possible fall-down has been detected, and to support regular drinking behavior. The research question is how to optimize the different social behaviors of the robot. It should be able to offer direction to stop wandering, ask whether the person has fallen and needs further assistance, and motivate elderly patients to drink regularly by providing friendly hints.

For children, current research focuses on the development of a "buddy" for learning routines, for improving motivation to adhere to medical recommendations, and for playing (educative) games. The ALIZ-E project started in 2010, developing methods for designing and testing interactive, mobile robots which will be able to interact with children over extended periods of time, i.e. a possibly non-continuous succession of interactions which can refer back to, and build forth on, previous experiences (EU-funded FP7 project, grant number 248116). ALIZ-E will instantiate and evaluate these methods in working systems that interact with hospitalized children undergoing diabetes treatment, using the Nao robot platform (see Fig. 4).

In conclusion, we are currently developing methods and technologies for social robots that support personal self-management and well-being on five aspects – comprehension, persuasion, resilience, mitigation and mood. Comprehension of an individual's state is being improved, because the robot can complement automatic monitoring systems with systematic questions. Factual questions can be posed ("What time did you awake?"), as well as affective questions ("How do you feel this morning?"). Persuasion of desired behavior is being established by attuning the feedback of the robot to the patient's general state and specific external conditions. Positive hints improve adherence to medical procedures (e.g., taking medication or blood sugar monitoring), and can be tailored to personal goals. By providing personalized medical background information, patients can be educated and coached. It can be expected that their resilience is improved by better understanding and therapy adherence. Furthermore, the information should help to cope with possible incidents, like a hypo for diabetes. When incidents are monitored, the robot can initiate or support mitigation activities, such as alarming and giving advice. Last but not least, the robot can help to improve a patient's mood by acting as a buddy and potential actor during play games.

Figure 2 (top): An older adult is assisted by an iCat robot to maintain fitness levels.
Figure 3 (middle): A child who plays Tic-Tac-Toe with an iCat robot.
Figure 4 (bottom): The ALIZ-E project uses the Nao robot to develop robot support for children with diabetes.

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Enhancing Robotic-Assisted Gait Training in Children with Cerebral Palsy via Interactive Gaming

The combination of interactive gaming and robotic-assisted gait training carries significant potential to address the need for fully engaging children with cerebral palsy in robotic-assisted therapy, thus leading to maximizing rehabilitation outcomes.

By Paolo Bonato

Recovering gait function after a neurological injury such as a stroke or a traumatic brain injury is a major goal of rehabilitation. Gait is a key motor task for activities of daily living and the ability to walk independently is important for quality of life. Consequently, a great deal of effort has been devoted to developing effective gait training interventions.

One approach that is widely used in individuals requiring assistance walking is training patients on a treadmill while providing weight support via a harness and manually guiding a patient's limbs. For therapists, this technique can be both labor intensive and potentially injurious. As a result, researchers and R&D engineers have begun to focus on an easier and more effective rehabilitation technique – robotic-assisted treadmill gait training.

The first robotic systems were designed for adult populations with spinal cord injuries but there is now a growing interest in using this technology for children with conditions such as cerebral palsy. Our group at Spaulding Rehabilitation Hospital in Boston, Massachusetts and the group led by Dr. Meyer-Heim at University Children's Hospital in Zurich, Switzerland have been the first to study robotic-assisted treadmill gait training in children with cerebral palsy.

Preliminary results are encouraging. Our own results, consistent with results published by Dr. Meyer-Heim's research group, show average improvements in gait function of 20-30% when using clinical scales such as the Gross Motor Function Measure Scale or using clinical measures of gait speed and endurance such as the 10-meter walk test and the 6-minute walk test. There is one caveat, however. Whereas average group results demonstrate large improvements in walking ability in children following robotic-assisted treadmill gait training, a closer inspection of results on an individual basis shows a large variability in response to the intervention. This observation has caused a major effort by several research groups aimed at optimizing training procedures on an individual basis.

Why do some children respond positively to robotic-assisted treadmill gait training while others don't? Is it because children who respond to gait training are different at baseline from those who do not respond? Is it because the training procedures are not properly optimized for all children? Would an individualized training approach lead to positive rehabilitation outcomes in all children? These are the questions we need to answer in order to identify all potential sources of variability in children's responses to robotic-assisted treadmill gait training.

One area, among others, that is currently under investigation in an attempt to answer the above questions is the matter of how engaged a child may be during training. The team led by Dr. Meyer-Heim at University Children's Hospital in Zurich and our team at Spaulding Rehabilitation Hospital in Boston have explored the possibility of increasing a child's involvement in robotic-assisted treadmill gait training by using interactive games. Fig. 1 (opposite page) shows the setup both groups have used. A robotic device (the Lokomat system by Hocoma AG, Zurich Switzerland) provides robotic guidance to a child during a training session while a large video screen ahead shows an avatar walking in a virtual environment.

Dr. Meyer-Heim's research team has performed an assessment of the above-described technique based on measures of the magnitude of the forces generated by children walking in the robotic system with the use of the interactive game versus those without. This is an intuitive and reliable measure of the level of engagement of the child during the training session. The results show that patients generate forces of larger magnitudes (i.e. are more engaged in the training session) when using an interactive game.

Our own study shows similar results. A case series led by Dr. Patritti at Spaulding Rehabilitation Hospital indicated that better outcomes are achieved when interactive games are used along with robotic-assisted training. In the study, we compared results achieved in children with cerebral palsy using the robotic system combined with interactive games with the results achieved when the robotic system was used on its own. In kids using the interactive games, we observed larger improvements in walking function (as measured using the Gross Motor Function Measure scale), walking speed (as measured using the 10-meter walk test), and walking endurance (as measured using the 6-minute walk test).

The above-summarized results are preliminary and need to be confirmed by future studies on large groups of children with cerebral palsy. However, additional factors are likely to play an important role in gaining a better understanding of how robotic-assisted treadmill gait training should be modified for better outcomes. An intriguing factor affecting motor gains using the treadmill is the baseline ability of the child to respond to the interaction with the robot. This is a fundamental question concerning if and how motor learning can be achieved via interaction between the robot and the subject.

To further explore this question, our group is conducting an experiment on the lower limbs that was originally designed to understand motor adaptations of upper limb control. The original experiments were performed by Dr. Mussa-Ivaldi and Dr. Shadmehr, and showed that healthy subjects respond to perturbations introduced by a robot during arm reaching movements by generating a force that compensates for such perturbation. They also showed that the magnitude of the force generated by subjects to compensate for the perturbation introduced by the robot decreases gradually over time once the perturbation is removed. Our own study using the same principle was translated to the lower limbs and paralleled observations previously gathered for the upper limbs. Now a question of great interest is whether such an ability to adapt to perturbations introduced by robots is maintained in children with cerebral palsy. An intriguing hypothesis is that only children who have maintained such ability have the potential to respond to robotic-assisted treadmill gait training. Future studies are needed to confirm this hypothesis.

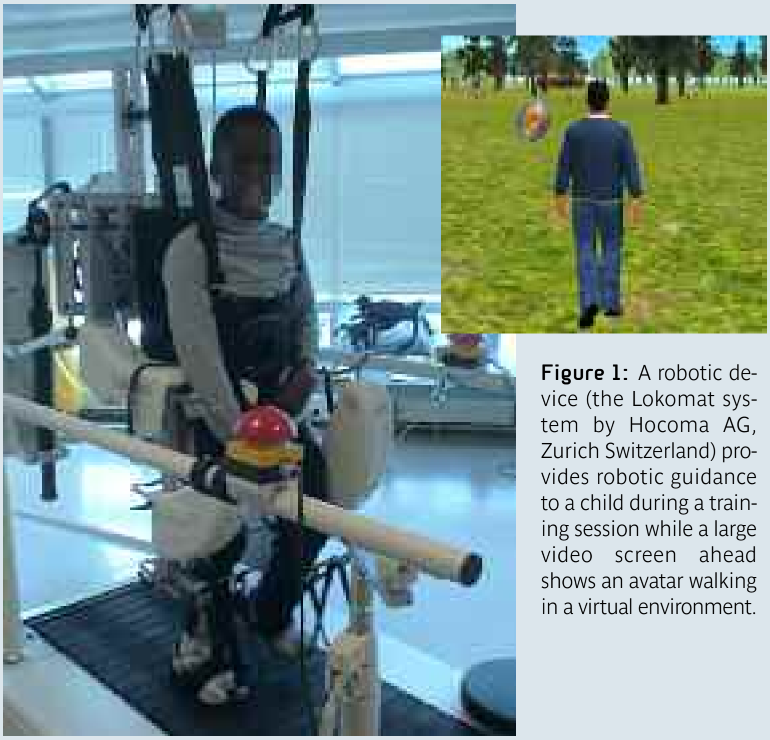

Figure 1: A robotic device (the Lokomat system by Hocoma AG, Zurich Switzerland) provides robotic guidance to a child during a training session while a large video screen ahead shows an avatar walking in a virtual environment.

A final question intriguing researchers is whether the lack of positive rehabilitation outcomes in certain children is due to an inability to translate improvements they achieve during treadmill training to level ground walking. In other words, should robotic-assisted gait training on a treadmill be combined with robotic-assisted gait training over ground? Researchers are attempting to address this question by developing exoskeleton systems for gait training. An example of such systems is the Active Knee Rehabilitation Orthotic Device (AKROD), developed by Dr. Mavroidis' research team at Northeastern University in Boston, that we are currently testing at Spaulding Rehabilitation Hospital. Though results are still preliminary and challenges still exist, the first commercially-available exoskeletons are now coming to market (e.g. the Tibion Bionic Leg and the eLeg exoskeleton by Berkeley Bionics). *This suggests that we will soon achieve better gait training results in children with cerebral palsy as well as in adults with neurological conditions such as stroke or spinal cord injury. Thanks to progress in robotics and the science of gait training, we hope to soon see the day when mobility is not hindered by disability.*

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ACROSS THE POND:
DARPA Leads Revolution in Prosthetics

By Colonel Geoffrey Ling and Kent Pankratz

Nearly 300 Warriors have lost arms in combat since 2001. The Defense Advanced Research Projects Agency's Revolutionizing Prosthetics Program aims to provide them a chance to regain near-normal function.

Col. Geoffrey Ling

Kent Pankratz

For Colonel Geoffrey Ling, the DARPA Program Manager who leads the program entering its fifth year, two main tasks remain. The first is for performers to gain regulatory approval to transition the arms for commercial sale. The second is for performers to initiate clinical trials of the implantable micro-electric arrays that will enable brain control of the prostheses. Colonel Ling views the program as keeping a pact – restoration to near-normal function – with the warriors that have made tremendous personal sacrifice for the nation.

DARPA has committed nearly $150 million to improve the entire upper limb prosthetic system, including sockets and control software. Two performing teams have produced two different prosthetic arm systems. DARPA contracted with one team to develop a "strap-and-go" system that could be donned and controlled by the user with no additional surgery. The other team is developing implantable micro-electric arrays that will record and translate the user's brain signals to control the prosthesis.

Both teams created virtual reality environments to assist prosthetists, engineers, and users to collaborate in development of the arm system. Users can visualize completing tasks while clinicians calibrate control software.

The virtual arm images move using the signals sent to the actual limb, allowing engineers to compare intended motions with actual arm movement.

More than 300 engineers, scientists, and medical professionals have contributed to the program, which also serves as a model of interagency collaboration. The Department of Veterans Affairs has conducted an optimization study using 26 volunteer subjects with all levels of upper limb amputation. Feedback from these subjects provided valuable insight into design of the final non-invasively controlled arm. Users performed more than 3,000 hours of daily living tasks, many of which are not possible with the limitations of current split-hook prostheses.

DARPA is expanding the user community for its Revolutionizing Prosthetics program to include patients with spinal cord injuries and victims of stroke and other neural disorders.

Photo credit:
DEKA Integrated Solutions Corporation

Figures: Split-hook prostheses, most widely used and available on today's market, do not allow for great range of motion or dexterity. To better address the needs of upper limb amputees, subjects, like those pictured above, performed over 1,500 hours of daily living tasks using new prosthetic systems created by DARPA's teams.

By addressing the needs of these individuals, the addressable market increases along with the chance of attracting commercial partners. Goals for commercialization are 2011 for the non-invasively controlled arm and 2013 for the brain-controlled system.

FURTHER AFIELD:
Japan: Leading the Way in Elderly Care with Rehabilitation Robots

By Lingjun Kong

The use of assistive and therapy robots in rehabilitation has rapidly evolved in Japan for several reasons. There is a growing need for improved technology as the average age of the country's population is quickly increasing. Due to a falling birth rate, a miniscule net immigration, and one of the highest life expectancies in the world, over a quarter of Japan's population is expected to be 65 years or older by the year 2020. The aging society has created an increased demand for the development of practical robotics applications in lifestyle-related areas, specifically healthcare. The tradition of having the young take care of the old has shown to be inadequate and is steadily declining in the culture. Moreover, many children of the elderly may be aging as well, and are in need of caring for themselves. Thus, robotics has been a commonly sought solution for the care and treatment of the aging population in Japan.

Fortunately, Japan has been the leading pioneer in robotics in the past few decades, especially with humanoid machines. Many of its citizens grew up watching cartoons with robot protagonists, which corresponds with the country's many technological advancements in humanoid robotics. The International Robot Exhibition is the largest robot trade fair in the world and is held annually in Tokyo due to the multitudes of exhibits from Japanese researchers. A few of the recent unveilings include the newest model of Actroid, originally developed by Osaka University, modeled after a young woman of Japanese descent that can mimic speaking, breathing, and blinking, and Telenoid R1 Robots, created by Dr. Hiroshi Ishiguro at Osaka University, which are humanoids that can sense facial expressions and mirror them with their own face. Currently, Japan occupies a dominant position in the global robotics market; 70% of the world's industrial robots are made by Japanese companies.

For many years, the use of robotics in Japan has deeply penetrated the medical field. From surgical robots used in coronary artery bypass operations to androids used as test subjects in medical school and robot nurses used in retirement houses, automated technology is found in various forms of healthcare. This is especially due to the increasing number of disabling age-related diseases, such as stroke and other chronic diseases. Rehabilitation, in particular, has been one area where robotics has truly shined.

Prosthetics and robotic devices for locomotion and manipulation aids have been widely developed in Japan for physical rehabilitation purposes. Many studies have focused on a robotic hand that has sensory capabilities and neuromuscular controls. These studies have led to the development of several different forms of hand devices, including exoskeletons that are worn by the human hand, haptic devices that interact with the human hand, and prosthetics that imitate the human hand. Similar products have also been developed for lower limb rehabilitation as well. In addition to mind-controlled wheelchairs to aid in mobility, exoskeletons that support the legs are used as gait trainers to regain walking ability. Active knee and ankle joints give flexibility and mobility to those with lower extremity disabilities. Recently, high performance actuator technologies and control strategies have greatly improved robot-assisted gait rehabilitation for mobility and manipulation rehabilitation. Exoskeleton-based orthoses, such as knee-ankle-foot orthosis, hip-knee-ankle orthosis, and polycentric knee orthosis, now move much more smoothly and comfortably. Furthermore, robot-aided assessment and feedback present patients' gait performance in feedback values with the use of the robot device sensors, ultimately helping the patients adapt their movement patterns and improving the user experience.

Robotic mechanical devices are being effectively applied not only to physical rehabilitation, but to cognitive rehabilitation as well. A great example is the use of the mirror neuron system for the revitalization of the control of upper extremity muscles after stroke. The mirror neuron system encourages the development of motor neurons through imitation. Observation followed by execution is a more effective method for gaining motor memory compared to motor training alone because observing another's movements activates the primary motor cortex, the premotor cortex, and the appropriate muscles. Repetitive use of this biological system through observation and execution, known as "mirror therapy," can help stroke patients regain the ability to control their limbs through the aid of robotic devices to support movement. Recent clinical results have shown that the use of therapeutic robotics is an effective method for post-stroke rehabilitation.

Virtual Reality (VR) has recently been utilized to supplement robot-assisted therapy and treatments. At research centers such as Osaka University and Gifu University, rehabilitation systems are now equipped so when patients are placed in a virtual environment and equipped with haptic devices, patient interactions with objects in the virtual environment will actually generate feedback forces. This interactive rehabilitation gives disabled patients a method of enabling muscle and bone to regain strength through repetition and goal-oriented objectives. By taking advantage of the plasticity of the brain to help rewire damaged neuronal networks and exercising limbs, combining robotics and VR can improve patient performance in both cognitive and physical treatments. In addition, the visual feedback of the virtual world provides a more interactive experience to enhance training outcomes.

There are many technical difficulties to be overcome with the expanding field of rehabilitation robots; however, the real challenge is to help people live happier, longer lives. In a place with high healthcare costs and limited human therapeutic services, the development of assistive and therapeutic robots is more than necessary to aid the aging population. As the rest of the world faces similar situations, Japan's pioneering advancements in robotic rehabilitation will lead the way towards a better quality of life.

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Transforming VR into a Reality for Behavioral Healthcare:

The NeuroVR Project

By Giuseppe Riva, Andrea Gaggioli & Cinzia Vigna

Here, the authors discuss why Virtual Reality is not more widely used in a clinical setting by health care practitioners, but rather in the investigational stage. Ways in which this might be changed are addressed, particularly with the help of their NeuroVR 2 software.

Although the papers in previous issues of C&R have shown that Virtual Reality (VR) has come of age for clinical and research applications, the majority of them are still in the laboratory or investigational stage. Data presented at the 2010 Cybertherapy conference held in Seoul, Korea, showed that the real impact of VR in European behavioral health is still low:

> The penetration of VR in behavioral health care/research centers is minimal: around 0.5/1%

> The penetration of VR between behavioral health professionals is even lower: less than 0.001%

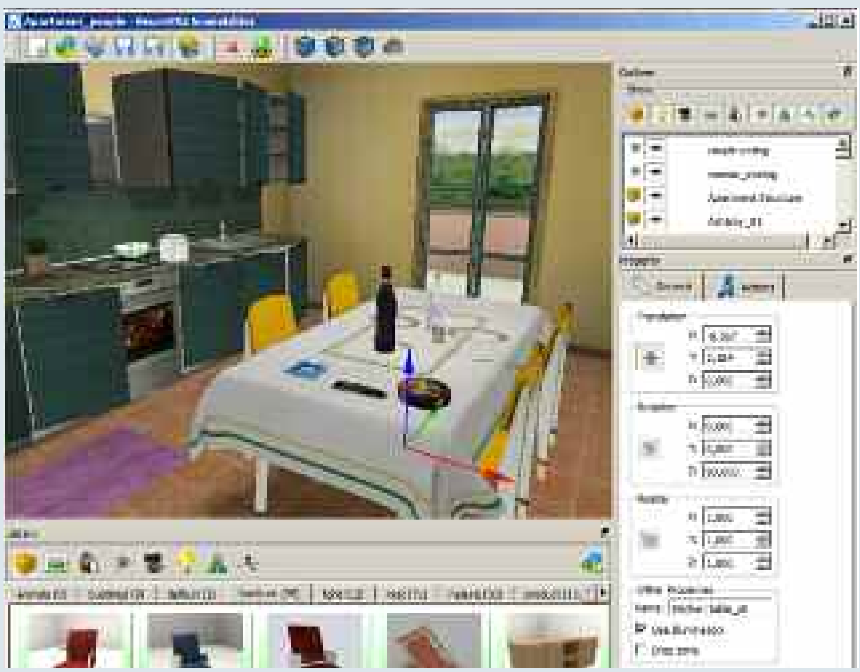

Figure 1: A view of the NeuroVR 2 SceneEditor software.

Why is VR more virtual than real for many health care practitioners? From the experience of the current researchers involved in this area it is possible to identify four major issues that are limiting the use of VR in psychotherapy and behavioral neuroscience:

the lack of standardization in VR hardware and software, and the limited possibility of tailoring the virtual environments (VEs) to the specific requirements of the clinical or the experimental setting;

the low availability of standardized protocols that can be shared by the community of researchers;

The high costs (up to 100.000 €) re-

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quired for designing and testing a clinical VR application;

most VEs in use today are not user-friendly; expensive technical support or continual maintenance is often required.

To address these challenges, the European funded project Interstress (http://www.interstress.eu) is developing NeuroVR 2 (http://www.neurovr2.org), an advanced version of the cost-free NeuroVR platform based on open-source software that allows non-expert users to easily modify a virtual environment (VE) and to visualize it using either an immersive or non-immersive system (http://www.neurovr.org). NeuroVR, originally developed by the Virtual Reality & Multi Media Park (http://www.vrmmp.it) for the Italian MIUR Firb NeuroTIV and IVT2010 projects, received the 2007 Laval Virtual Science Award for the best VR science application worldwide.

The majority of existing VEs for health care are proprietary and are closed source, meaning they cannot be tailored from the ground up to fit specific needs for different clinical applications. NeuroVR 2 addresses these issues by providing the clinical professional with a cost-free SceneEditor, which allows non-expert users to easily modify a virtual scene to best suit the needs of the clinical setting.

The VR suite leverages two major open-source projects in the VR field: Delta3D (http://www.delta3d.org) and OpenSceneGraph (http:// www.openscenegraph.org). Both are building components that integrates with ad-hoc code to handle the editing and simulation. The NeuroVR2 SceneEditor's GUI is now based on the QT cross-platform application and UI framework from Nokia (http://qt.nokia.com/) that grants an higher level of editing and customization over the editor functionalities, while the graphical rendering is done using OpenSceneGraph, an open source high performance 3D graphics toolkit (http://www.openscenegraph.org/projects/osg).

Using the NeuroVR 2 SceneEditor (see Figure 1), the psychological stimuli/stressors appropriate for any given scenario can be chosen from a rich database of 2D and 3D objects, and easily placed in the pre-designed virtual scenario by using an icon-based interface. No programming skills are required to carry out these steps. In addition to static objects, the NeuroVR 2 SceneEditor allows objects to overlay on the 3D scene video composited with a transparent alpha channel. The editing of the scene is performed in real time, and effects of changes can be checked from different views including frontal, lateral and top.

"...the neuro platform is used in the assessment and treatment of obesity, alcohol abuse, anxiety disorders, generalized anxiety disorders and cognitive rehabilitation."

Currently, the NeuroVR 2 library includes different pre-designed virtual scenes representing typical real-life situations such as a supermarket, an apartment, or a park. These VEs have been designed, developed and assessed in the past ten years by a multidisciplinary research team in several clinical trials involving over 400 patients. On the basis of this experience, only the most effective VEs have been selected for inclusion in the NeuroVR 2 library.

An interesting feature of the NeuroVR 2 SceneEditor is the ability to add new objects to the database. This feature allows the therapist to enhance the patient's feeling of familiarity and intimacy with the virtual scene, i.e., by using photos of objects/people that are part of the patient's daily life, thereby improving the efficacy of exposure.
The second main component of NeuroVR 2 is the Player, which allows navigation and interaction with the VEs created using the NeuroVR 2 SceneEditor. The player offers a set of standard features that contribute towards increasing the realism of the simulated scene. These include collision detection to control movements in the environment, realistic walk-style motion, advanced lighting techniques for enhanced image quality, and streaming of video textures using alpha channel for transparency.
The player can be configured for two basic visualization modalities – immersive and non-immersive. The immersive modality allows the scene to be visualized using a head-mounted display, either in stereoscopic or in mono-mode; compatibility with the head-tracking sensor is also provided. In the non-immersive modality, the virtual environment can be displayed using a desktop monitor or a wall projector. The user can interact with the virtual environment using either keyboard commands, or a mouse or a joypad, depending on the hardware configuration chosen.

A future goal is to provide software compatibility with instruments that allow collection and analysis of behavioral data, such as eye-tracking devices and sensors for psycho-physiological monitoring. Actually, the neuro platform is used in the assessment and treatment of obesity, alcohol abuse, anxiety disorders, generalized anxiety disorders and cognitive rehabilitation (see Table 1 for a list of published papers that used the NeuroVR software)

Beyond clinical applications, NeuroVR provides the VR research community with a free "VR lab," which allows the creation of highly-controlled experimental simulations for different behavioral, clinical and neuroscience applications.

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C&R in Romania

After the fall of communism, the health and education systems of Romania collapsed, poverty triumphed, and people struggled to get back on their feet. Ceausescu's regime left behind irreparable damage, and a nation that had to reconstruct itself from scratch. The country continues to suffer from the anteceding 60 years, but modern efforts have quickly sprung to the rescue.

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Mental healthcare suffered a great blow when Ceausescu banned psychology departments across România, as psychologists were deemed a threat to the regime. Mental illness was treated with psychiatric medication and nothing more. No talk therapy existed for those patients who would have benefited from psychotherapy, such as those who suffered physical and mental abuse in prisons and detention centers.

In 1949, psychiatric abuse was introduced in prisons as a way to instill terror and destroy the personality of the individual. This aimed to impose conformity and punish those suspected of fascism, treason, or propaganda. These "re-education" programs, as they became known, were imposed on over 780 detainees, which were tortured, beaten, psychologically abused and threatened. Many others committed suicide to escape subjugation to such tactics, while others became mad and suffered mental illnesses. Rehabilitation would aim to repair the damage caused by the deliberate psychiatric abuse for political reasons during Ceausescu's regime, yet it took another 14 years for any university to open for students of psychology and introduce psychotherapeutic curriculum. Since then, the number of nurses working in the mental health system is estimated at about 2000, and only a few have any specific training in psychiatry besides their on-site preparations. The number of psychiatric doctors and other mental health staff is undoubtedly insufficient, and the prospects of psychiatric care only diminish the further one gets from the capital.

O Lume Sanatoasa Intr-o Minte Sanatoasa

România's GDP allocated to healthcare has lingered around the 3% mark, increasing only .2% since 1999, and only 3% of that has been dedicated to mental health alone. WHO statistics place România in third to last place with regards to a budget for mental health. The NGO sector in the field of mental health services is scarce, as are funds and mental health experts. Yet unfortunately, neuro-psychiatric disorders are the second main cause of death, claiming 19.3% of the population. The figures account for an estimate of 1,018 new cases of mental disorders per 100,000 per year.

Another challenging factor in the mental health sector has been scarcity of legislation related to rights of mentally ill civilians. Such persons face extreme challenges in the employment area. Many workers who leave a place of employment for medical reasons are not guaranteed to retain their work post, or to find a new one. This is

Population (million)	22.2
Percentage of Urban Population	54.9%
Unemployment Rate	7.6
Life Expectancy (Years) Male/Female	61/65.2
Fertility Rate	10.53
Mortality Rate	11.88
Physcians (per 1000 Inhabitants)	1.26
Hospital Beds per 1000	6.4
GDP on healthcare	3.6
Suicide Rate (per 100,000) Male/Female	4.9/18.5
Extrapolated Prevalence to Eating Disorders (total)	410,947
Extrapolated Prevalence to Schizophrenia (total)	180,816
Extrapolated Prevalence to Anxiety Disorders (total)	3,666,310
Extrapolated Prevalence to Depression (total)	1,184,844
Extrapolated Prevalence to PTSD (total)	427,385

a major contributing factor of suicide, the rates of which are above the EU27 average, and is the main cause of death among Romanian males and second greatest cause of death among Romanian females.

Children and young adults are particularly at risk for mental disorders and suicide. It is estimated that one in five children and adolescents suffer from a mental health problem. This is also true for the many children left alone by families working abroad. A National Strategy for Protection and Promotion of Child Rights has been implemented to provide special protection for children separated from their parents.

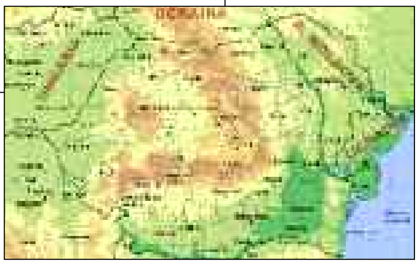
Unfortunately, the strategy does not cover orphans, who are at an especially high risk of mental illness as a consequence of years of government-sanctioned child neglect and abuse. This type of deep-rooted psychological stress is almost irreparable.

It seems difficult to justify that România would allocate the little economic means they have to prevent mental diseases, when a staggering 41.2% of the total population has neither a bath nor shower in their dwelling, and an overwhelming 42.5% have no indoor flushing toilet in their household.

Towards Improvement

Romania has taken huge leaps to improve its mental health care system. International cooperation has played an important role in pushing forward these changes. America, Britain, Japan and Switzerland are some of the most active donors in the area of mental health. A particular UK/Romanian charity known as the “Relief Fund for Romania” has opened a day care center that provides physiotherapy, mobilization programs, and counseling, among other activities, for elderly people, children and the mentally ill. The charity offers several therapeutic programs, such as art therapy for disabled patients, who take part in dance, music, art and sensory training sessions. Estuar, the leading mental health charity in Romanian, provides rehabilitation for adults who want to reintegrate into the Romanian community through similar programs.

In 1990, mental health professionals founded the Romanian League for Mental Health, which was the official organization involved in mental health reform. They formulated the National Mental Health Programme, which engaged prevention and rehabilitation, community psychiatry, legislation and communication with other health care sectors. Since then, mental health care has picked up the pace.



The 1998 National Programme for Mental Health and Prophylaxis in Psychiatric and Psychosocial Pathology confronted the issues of discrimination, lack of coherence between decision-making bodies, poor psychiatric care conditions, and insufficient mental health personnel. The Law on Mental Health Promotion and Protection of Persons with Psychiatric Disorders, adopted in 2002, dedicated a specialized section to persons with mental disabilities, guaranteeing their rights, confidentiality, and recognizing their civil, political, economic, social and cultural rights. The current central institutions involved in the healthcare of the nation are the Ministry of Public Health and the National Health Insurance Fund. The Ministry of Public Health is responsible for the health of the nation through implementation of policies, strategies, health programs, and allocation of funds, while the National Health Insurance Fund administers and regulates the social health insurance system.

Viitorul Ne Surâde

România has taken quite a leap in the field of telemedicine, eHealth and ICT in medicine, which has the potential to accelerate health-care reform. In 2005, România became the first country in Eastern Europe to have successfully performed a robot-assisted surgery using the Da Vinci system. By 2008, the Center of General Surgery and Liver Transplantation of the Fundeni Clinical Institute purchased its own Da Vinci system, and the Institute has since performed over 200 robot-assisted surgeries.

In September 2007, România participated in its first telemedicine project - HealthOptimum. The goal was to introduce virtual-assisted healthcare services into a wide range of medical specialties – from cardiolog, to psychiatry – as well as offer rehabilitation to those recovering from alcohol problems, monitor the elderly at home and provide general medical advice.

A research program out of Constanta known as “TELEMEDICINE APPLICATIONS IN DANUBE DELTA” and financed by Românian Space Agency, aims to build a unique health care program comprised of mobile telemedicine using a satellite link. The project’s main purpose is to cater to mentally ill people from the Danube Delta region who do not receive adequate care and connect them with trained specialists.

In 2007, a 27 month long project was inaugurated. TELEASIS sought to offer social and medical tele-assistance to elderly persons in their homes, with the hopes of improving lifestyle quality and efficiency in healthcare institutions, and easing communication between patients and healthcare providers.

România and Medic4all, a Swedish company of telemedicine technology and services, launched Medic4you, the world’s first customer oriented cellular e-health service, which allows patients the ability to engage more closely with their own health and well-being. Doctors will be able to review clients’ medical information, prescribe drugs and offer consultation. Alongside this service, a WristClinic health-monitoring device is supplied, which automatically measures blood pressure, pulse, ECG, cardiac rhythm, level of oxygen saturation, and many other medical features. The envisioned goal is connecting millions of users with health professionals to support wellness and disease prevention
.

By 2011, the Românian government expects to provide its citizens with electronic health insurance cards, which will hold personal information about the individual, from blood type, to any information about life-threatening medical diagnoses. It is an important step in computerization, and an even greater leap towards improved healthcare.

Interest and engagement is piquing. Researchers, scientists, and professionals are discussing the future of Virtual Reality environments for pre-surgery planning, rehabilitation medicine, learning, and tele-rehabilitation. The future rests on incoming generations, decision makers and ICT shoulders to make significant improvements, for both mental health professionals and citizens.

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