ROBOTIC APPLICATIONS IN MEDICAL REHABILITATION

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Abstract: The following review is a short presentation of the interactions of robots with the rehabilitation medicine domain that can be very favorable and have many advantages for human being (therapist and patient also). The history of robots application in medical rehabilitation is at the beginning, and the development of these technologies must follow a trend of improvement of patient life style, also the addressability and the extending of applications. The number of disable patients that need rehabilitation therapy is increasing, also the costs of the necessary therapy to assure the well being and independence for this persons, so researchers try to find innovative patterns and technologies to speed up the rehabilitation process with human and material lowest costs possible.

Keywords: therapy, robot, rehabilitation, disability, assistive technology

1. INTRODUCTION

Rehabilitation medicine is the process of helping a person to reach the fullest physical, psychological, social, vocational and educational potential consistent with his or her physiologic or anatomic impairment, environmental limitation, and desires and life plans. (DeLisa Joel A.,1998).

The focus of the rehabilitation team is on the well-being of the patient, the common gold that is shared by all the members that work together.

Over the past few decades the advances of the technologies have revolutionized the way doctors practice medicine and rehabilitation medicine also.

Medical advances have raised the survival rate, like survival after an accident, after a medical problem or a disease until now considered lethal (for example the development of the transplantation techniques, cure of cancer or stroke) or the surviving after the birth of a premature child even if he has only 500 grams. All of these medical successes have diminished the mortality rate but not without consequences. The success is also followed by other medical problems that must be carried on by the patient, by the families and by the therapeutic team concerning with the rehabilitation and integration of those individuals with the full support from our society.

Also, nowadays demographics statistics are such that the workforce is decreasing while the percentage of elderly people in the population, who tend to have more disabilities and more needs for special treatments, is going up. We can even talk about an elderly boom today.

For the realistic goals and plans to obtain optimal function despite disability and impairment work together patients, theirs families, doctors, social worker the each and every one of the rehabilitation team. The rehabilitation concept engages the entire health-care system for the well being of the individuals in need and it requires new means for its purpose and goals.

One of the major goals of rehabilitation is to make quantitative and qualitative improvements in daily activities in order to improve quality of independent living. (Heidi Sveistrup, 2004).

It must not be forgotten the fact that all those disables people have some of the low income levels recorded. And also they are those that need the most imperative attention and the most long-term or permanent care comparatively with the other members of human society. Functional and cost are often the dominant design criteria for assistive technology. Robots appear for the first time in medicine in rehabilitation medicine with the purpose to support the rehabilitation team in order to accomplish more results in less time.

2. CURRENT RESEARCH

2.1 Advantages of using robots in rehabilitation medical domain.

The studies about the advantage of rehabilitation robots conducted in research laboratory in the entire world shown a real advantage of these developing new technologies.

For persons with disabilities a robotic system may promote a greater feeling of independence for the user and reduce the sense of dependency on a personal assistant. Advances in robotic systems suggest that for some applications such systems may be cost effective.

Robots are being developed for an extensive range of applications within rehabilitation domain, including use as exercise aids, activity of daily life (ADL) aids, mobility aids, and remote presence/telerehabilitation devices. Of these potential applications, robotic exercise devices have been best studied in clinical research and appear safe and also beneficial.

In the medical field robots are first use in rehabilitation medicine in the ’50s, and since the rehabilitation medicine and robots are developed together, sometimes with smalls but sure steps, robots help clinicians to solve some problems of the disabled people, like in a vicious circle, to develop new treatment using robots and robots are developed for this purpose!

The Robot Institute of America (RIA) defines a robot as a reprogrammable multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks. Reprogramability is a key component that defines robots.

Over the past years, the definition has changed and maybe it will need some adjustments again in the following years, unchanged have remained only the laws that guide the use and the creation of the robots are such as to make thinks easier and help the advance and improving of the well-being of human society.

The Cambridge Advanced Learner's Dictionary defines "robot" as: A machine used to perform jobs automatically, which is controlled by a computer.

In time, from the large class of the worker robots have evolved in two distinct classes: humanoid robots and special robots. Today there are many various areas of application for robots, and each of them requires its own type with features specific to it: industrial robots, medical robots, service robots, anthropomorphic robots, entertainment robots. (Tobias Ramforth, 2006).

Presently, several rehabilitation robotics systems are being developed especially by private, government and university research laboratories as means to assist people with impairments.

The pathologies that can benefit from the help of robotic devices are: spastic palsy, post-stroke state, disease with modification or diminish functional motor capacities, palsy (traumatic brain injury survivors, other causes) of hands or limb, muscular atrophies and dystrophy etc. All these preoccupations aim to augment human performance and to offer increased possibilities for fast recovery of the functions and even working potential.

2.2 Robot versus human being.

The comparison between robotized and traditional rehabilitation in our days can be more easy systematize in the next table. With reference to human beings many parameters are linked only to the individual training, experience, health status or circadian cycle (that can be very variable during the different moments of the time) of the operator and cannot be repeated.

Tabel 1. Advantages of a Robot versus Human Being

	Robot	**Human Being**
Tactile sensitivity	X	XXX
Precision	X-XXX	X-XXX
Repeatability	XXX	X
Cost/Productivity	XXX	X
Versatility	X-XXX	X-XXX

2.3 Advantages of a Robot

- High repeatability and same quality of the manual rehabilitation like human. It have the great advantage that it don’t became bored or tired even after eight hour of work.
- Possibility to increase complex functions thanks to the software improvement.

- It saves the therapist from the practice of repetitive exercises allowing him/her to dedicate to activities where human presence is required.
- To quantify the performances of the patient in form of applied strength, movement speed and angular range in order to register them and to create an objective chronology of progresses.
- Possibility to manage both manual and instrumental therapeutically practice with programs of study management and of elaboration of the medical records, with obvious organizational advantages.
- The robot can be controlled directly by the user, can be reprogrammable and has also the possibility to be controlled from distance.

2.4 The medical robots used in rehabilitation

Two basic approaches have received substantial attention in the development of rehabilitation robots:
- robotic workstations,
- mobile robotic systems.

Robotic workstations are systems optimized to operate within a semi-fixed environment, like for the use in the kitchen and for a personal office environment. Workstation robotic systems may be mounted to a work surface or on overhead mounting system. More difficult for the researchers are the design of mobile robotic systems for the rehabilitation and use for persons with different types of disabilities with or without another human being help. Mobile robotic system present a greater number of technical challenges because the operating environment is expanded as well as the number of tasks performed by the system studies have been performed to explore the feasibility of low-end mobile robotic system.

For example today only in US are more then 5 million wheelchair users. The researchers struggle to developed new technologies to extend the possibility of locomotion to other assistive devices (e.g. scooters) or to wheelchairs with capacity to drive on all terrains (stairs/curbs), ability to path following while avoiding obstacles, or face movement controls direction of the system's motion, also to have the ability to performs tasks such as turning and moving forward, contains an obstacle avoidance mode that overrides the user's commands. Also are conducted researches for the developing wheelchairs that can be controlled by gesture recognition, voice command, vision based interaction, with sip and puff devices. All of this will give the possibility to users who may lack fine motor control to be more independent and mobile.

Manipulation Aids that are used in recent rehab therapy are: prosthetic arms, feeders, or are used robots that are conceived mostly like exercise machines for neurological patients (Lokomat, Exoskeleton). The purpose of those robots is to re-teach the nervous system in ways that help it to learn to control movement (in a better way than existing training techniques). The human nervous system itself is an adaptive robotic controller, amenable to re-programming and to re-learning. Robot interacts with stroke patients to encourage them to exercise the affected limb(s) (Mataric, *et al* 2006).

Reinkensmeyer consider that robotic training algorithms can speed-up learning of a motor skill in healthy subjects, so the normal state it will be the scale to evaluate and will be also *the final destination* of rehabilitation work.

The achievement of positive results in the rehabilitation therapy can be very slow some time and can be also discouraging and the patient can be considered be the patient without purpose, boring and difficult, or negativity sentiments. The disadvantages of today robots are that they can not yet interact with these human sentiments like a human being can.

So, the design of the robots use in therapy and their interaction with the disable person is very important because motivation is an important factor in rehabilitation and frequently used as a determinant of rehabilitation outcome. (Maclean *et. al* 2000). Several factors can influence patient motivation and improve exercise adherence such as the active engagement towards a treatment/training involvement, which is regularly correlated with motivation.

The challenges for the design robot assistive devices for the rehabilitation is the understanding and identification of disabled persons' needs and capacities, the possibilities to use the device to identify movement training algorithms that maximize motor learning and neural recovery, by combining robotics, brain imaging, and neuro-computational modeling that can be used for all the patients with the same disease for all over the world.

Today researcher's work is mainly to establish standards for robot design for the needs of disable people and for this purpose they must interact closely with the rehabilitation doctor and to the patient to better understand of the pathology, clinical changing, the anatomy and the biomechanics.

All the positive results of the robot rehabilitation therapy encourage the researchers to continue their work and to respond to the challenges with practical solutions. Today, many researchers with the purpose for social and work integration field, they focus using these new rehabilitation tools have investigated upper limb rehabilitation effects by means of detailed kinematic analyses before and

after treatment. All those studies refer only to pathologies that are most common in rehabilitation medicine (e.g.: stroke) in order to a better understanding and evaluation, for establishing scales and patterns and discover the gaps and lacks in the robot rehabilitation work.

For example, MIT-Manus (Krebs *et. al* 1998, 2004) and Mirror-Image Motion Enabler (MIME) robots (Burgar *et.al* 2000) were developed for unrestricted unilateral or bilateral shoulder and elbow movement, show that recovery can be improved through additional therapy aided by robot technology. The ARM guide (Reinkensmeyer 1999) which assists reaching in a straight-line trajectory, and the Bi-Manu-Track (Hesse S *et.al* 2003), which enables active and passive bilateral forearm and wrist movement, show also that use of simple devices makes possible intensive training of chronic post stroke subjects with positive results in terms of reduction in spasticity, easier hand hygiene, and pain relief. The Gentle/s system (Loureiro R. *et al*, 2003) is an appealing device that, by coupling models for human arm movement with haptic interfaces and virtual reality technology, can provide robot mediated motor tasks in a three dimensional space. Finally, a robot device based on recent studies of neuro-adaptive control, has been used to generate custom training forces to "trick" subjects into altering their target-directed reaching movements to a pre-chosen movement as an after-effect of adaptation (Patton JL., 2003). This system applies a form of "implicit learning" for teaching motor skills, so demonstrating that it is possible to learn at a quasi-subconscious level with minimal attention and less motivation than more explicit types of practice like pattern tracing.

Slowly all those devices are applied in the research to prove the benefit of application in new diseases like autism, spastic palsy, mental retardation, Down syndrom, muscular dystrophy etc.

With the improvement and development of new material used all this devises in the future will be having the dimensions to feet into the houses or offices and will offer the independence and well being for users. Until now hospital early supported discharge, providing interdisciplinary rehabilitation in the home instead of in a hospital, seems to offer the same benefits as an in-hospital stroke rehabilitation unit, but this concept has only been tested in a less severely disabled stroke patient population. (Robert Teasell, 2003)

The importance of social support and community reintegration continues to be an underestimate factor. Despite the explosion of clinical stroke rehabilitation research, there remain many important unanswered questions. The next few years promise to be an exciting time in robot rehabilitation research.

The first disadvantage that emerge from the use of this introduction of new technologies such as robot devices and virtual reality devices, is that partly reduce the patient-therapist interaction and that could negatively influence the patient's motivation and hence the crucial questions that arise are: how are and how it will be these technologies accepted by the patient, and what design and treatment features can positively influence patient motivation?

By offering the sentiment of participation of the community life, the sentiment of valuable and helpful for the society and for itself, the disable can embrace this technologies and new ways of rehabilitation treatment with his advantages and disadvantages.

3. CONCLUSION

Robotics began as a form of entertainment and has evolved into a technology used in the fields of increased productivity and endurance, sometimes dirty, life threatening or inaccessible, phisical limited for human body. Also, jobs which require speed, accuracy, extremely boring reliability or endurance can be performed far better by a robot than a human.

Robot capabilities continue to expand as technological development continues and in the near future these robots are expected to become an integral part of rehabilitation like an important accessory to traditional rehabilitation approaches.

The use of the robots has well-known history and it will definitively have a bright future beyond any current application. And today a new fashion starts in the robot research field: the developing of a new generation of robot with social-cognitive skills in order to have socially assistive capacities to support people in a variety of task in order to maintain the autonomy of peoples.

Robots first appear in the science fiction books and today they seem to take more and more the place of the real human being, and in the future the new definition for a robot maybe will be just „*human-substitute”*. *In the future the human robot interaction will still be guided after the Asimov laws?*

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