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Review Article,

A Review on Potential of Robotic Rehabilitation in Health Care System

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Abstract:
Robotic rehabilitation states as the restorative therapy for the which act as the augmented tool for the health care workers. The methodology was to collect the articles from various scholar sites and where the scrutinization for 180 articles were done. Where the need of the study was to create review upon the robotic technology in the health care. They act as the rehabilitative tool for the upper and lower limb which is further classified into endoskeletons and exoskeletons which is having which is having different mechanism of play and different outcome. The need of rehabilitation technology with robots is inclusive of accurate monitoring, surgery, medicine and rehabilitation. There is a history of robotics in health care as begin in 1960's for surgery and in 1990's for rehabilitation and now have expanded in various accessible new technologies that are affordable, having multiple control system with various degrees of freedom and different approach to work. Some of them are highly versatile even can work without any supervision. The need of robotics will increase so as to assist not to remove and gain satisfaction at every end of patient and health worker.
The past to present to the future have been very challenging but are present with great outcomes.
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Keywords: Endoskeleton, exoskeleton, rehabilitation, Robots

Introduction:

Robotics in rehabilitation is defined as the assisted, augmented tool for clinician and for the patient it works as the restorative therapy and ability to increase the ability to function well beyond the neuro-restoration capability. The concept of robotization present as novel role in the health care system allowing various functions varying from diagnosis, communication, visualization and rehabilitation. The rehabilitation is to control the further complications and decreasing upcoming difficulties and dependency, hence it is required with four step method inclusive of assessment to goals setting by therapist to intervention provided by therapist to reassessment. These steps nowadays are followed with the help of robots which came to be successful than traditional therapy, it provided constant training and mechanism present with it providing feedback for the improvement in the impairment ,and changes according to the feedback given by the patient and therapist hence providing the safety and easy acceptance by the patient and the concerned rehabilitation team.

Methodology:

The need to study the article was to study the valuation of the robotic rehabilitation in the health care sectors as upcoming dependency of the humans on robots in the day today work life so the analysis arises whether the robots can be an addition to health care society and be a part of every team member in the rehabilitation team. The study was scrutinized by 180 articles to create a review study where the articles are from 1991 to 2019. The study material was from google scholars, pub med, research gate and science direct where the key words were rehabilitation, exoskeleton, endoskeleton and robot. Type of selection for scrutinizing were abstracts, full text, reviews, systematic reviews and randomized control trail.

Robotic Devices for Rehabilitation:

1. Exoskeletons robotic devices: These are also known as the powered exoskeletons which are easily wearable robotic device that are controlled by hydraulics, motor, lever devices. these are most commonly found in for the spinal cord injury rehabilitation to restore gait. these robotic exoskeletons contain mechanical structures having sensors, actuators, controlling strategies and have the function to execute the motor function. Its best part is that it controls the] best interaction among human and device which is further classified into two as the cognitive human robot interaction also termed as cHRI which play a role as how the user controls the device and other physical human robot interaction also known as pHRI relating with the applied control forces in between the human and exoskeleton. In exoskeleton the user had to face three steps that is the sense, decision and execution. - cHRI gathers the kinetic information with the sensor technology of the sensors, potentiometers, encoder, accelorometer, gyroscopes, strain gage, piezoresistive sensors, force torques sensors. - pHRI gathers activity of muscle function data, brain data, ocular motion data having sensory technology as electromyography, electroencephalography, and electro-oculargraphy respectively. Nowadays the design of exoskeleton that were followed are for upper extremity using the hard association, adding the passivity to the extremity parts and making the arm 4-6 times heavier, requiring the non-physiological invariable muscle strategies in ongoing movement. These ideas are utilized to decrease the inertia of the exoskeleton so that joints are away from motor and work with the joints by utilizing cables and pulley. Examples such as CADEN-7, MEDARM. , , CAREX a novel robotic exoskeleton from upper limb which is 10 times lighter. In upper limb the features by robotic exoskeleton were to assist the need of force to make sure that the upper limb follows within the path of required path of the motion and also termed as the path assistance so as to provide higher accuracy in the motion, and the second feature is that to adjust the weight support so as to remove effect of the gravity leading to assistance of motor learning and removing motor synergies in case of partial weight bearing. , ,

In case of lower limb the features are such as by providing the DOF by system of robot which is proficient to perceive the deficiencies in the pattern of gait and the robotic device indirectly applies the forces to train the affected ankles an example such as ankle bot and thus improving balance and gait , There is the other device which provides eight DOF named as LOPES, which is outlined to work for gait rehabilitation and as the passive measurement device. Robotic exoskeletons also decrease the sitting time, encouraging in increase of the walking time leading to increase in the social activities and good quality of life. , Robotic exoskeleton are maximally used in spinal cord rehabilitation, as commercially available for different level of spinal cord injury. , Robotic exoskeletons have the problem of energy efficiency so as to accelerate and decelerate, as the device require higher amount of energy to up come the function for dynamically support the weight against gravity. Nowadays lithium batteries are used to to use for these devices. ,

2. End effector robotic devices:

End effector robots are n contact with the patients on one distal joint, the joint of end effector robots are completely distinct from the human joints. The isolated movement in joint is difficult as the interface in distal is altering the position of further joints due leading to force generated causing, difficult in single joint motion. , End effector in the limb of upper extremity is present at hand, and in case for gait training the device is placed at the foot. Manipulandum is the connection between the robotic device and the arm, it is used as the sensors so as to measure the performance. The best part is it is easily fitted to any body type by minimum modification to the device; hence it is advantageous to the upper and lower extremity. In this device the joints cannot be independently adjusted due to interaction of the device is at the single joint surface. MIT- Manus is the most effective of end effector device, as the manipalandum leading to movement in hand placed at the surface of horizontal position and giving, play at direction in vertical due to springs present, this provides the sensorimotor training which is gathered by the manipalandum and can be treated as video games. The goals ate achieved with the help of screen through interaction by the manipalandum helping to draw out the shapes and moving in the path, allowing to complete the work with the assistance with the robot and provides better results than conventional therapy and generating better outcomes, With the help of manipalandum the results are reliable and are used for the recovery measures in the patients due to

correct kinematic data obtained by the robot. There are also the presence of the passive end effector robots providing to train the arms better and distinctly,, and in mirror symmetrical paired manner too. , , End effector robots give better results in lower extremity due to less complexity as compared to upper limb as present with complexity at distal part. The gait training from end effector robotic device is highly beneficial with positive outcome. , The Haptic Walker is an example of end effector robot which stimulate the stair climbing, locomotion training, as present with the force and torques sensors providing an interaction between control strategy, the data is collected and progress according to the output. There is the similar device as of the end effector named as the G-EO- system, which according to clinical study provided the positive outcomes in the control group, presenting with gait control, locomotion training and stair climbing, minimum effort by physiotherapist and decrease risk of fall.

Robotic Devices In The Market :

1. Robotic devices for upper limb:

A. In motion device providing 3degrees of freedom at the wrist a mounted robot present at planar tip.
B. MIT manus a device providing 5 degrees of freedom to wrist, elbow and shoulder.
C. Movement with mirror image enhancer providing 5DOF an completely specified for elbow and shoulder and can be used as bilateral training.
D. Bi-Manu track providing 1 degree of freedom specially for wrist extension and flexion, forearm pronation and supination
E. Arm robot Armin semi-skeleton for upper limb motion providing their degrees of freedom respectively, and present with audiovisual display.
F. Neuro rehabilitation robot having 3-degree s of freedom, framed on direct drive wire actuation providing patients feedback and easily transportable
G. Rehabrob therapeutic system providing the passive shoulder and elbow movements, and providing all the safety measures against it.
H. Gentle/S providing the 3 degrees of freedom having robotic manipulator and gimbal mechanism combining with the forearm and wrist movements together.

2. Robotic devices for lower limb:

A. Treadmill based exoskeleton devices consisting of the Lokomat , Loko help ,Alex , Lopes , KAFO, AAFO consisting of the motor drive, treadmill drive, Series elastic actuator as the driving modes providing, passive, active, active assisted as training mode and controlled by the force control, impedance control, trajectory, position and posture control as the control strategies.
B. Leg orthoses exoskeleton robots these are consisting of the HAL, BLEEX , , Rutgers ankle having motor, hydraulic and pneumatic drive respectively as driving mode which provides active assisted, active, active resisted and passive motions.
C. Platform based end effector robots such as ARBOT , , parallel ankle robots , , gait trainer, GTI and the driving mode is motor, providing all motions from passive to active with based on trajectory, EMG evaluation and position control as control strategies.
D. Foot plate based end effector robots such as Haptic walker , Geo system and worked on motor drive followed on the passive, active, active assisted, active, motions and the controlled by trajectory, position control.

Procedure for Robotic Rehabilitation:

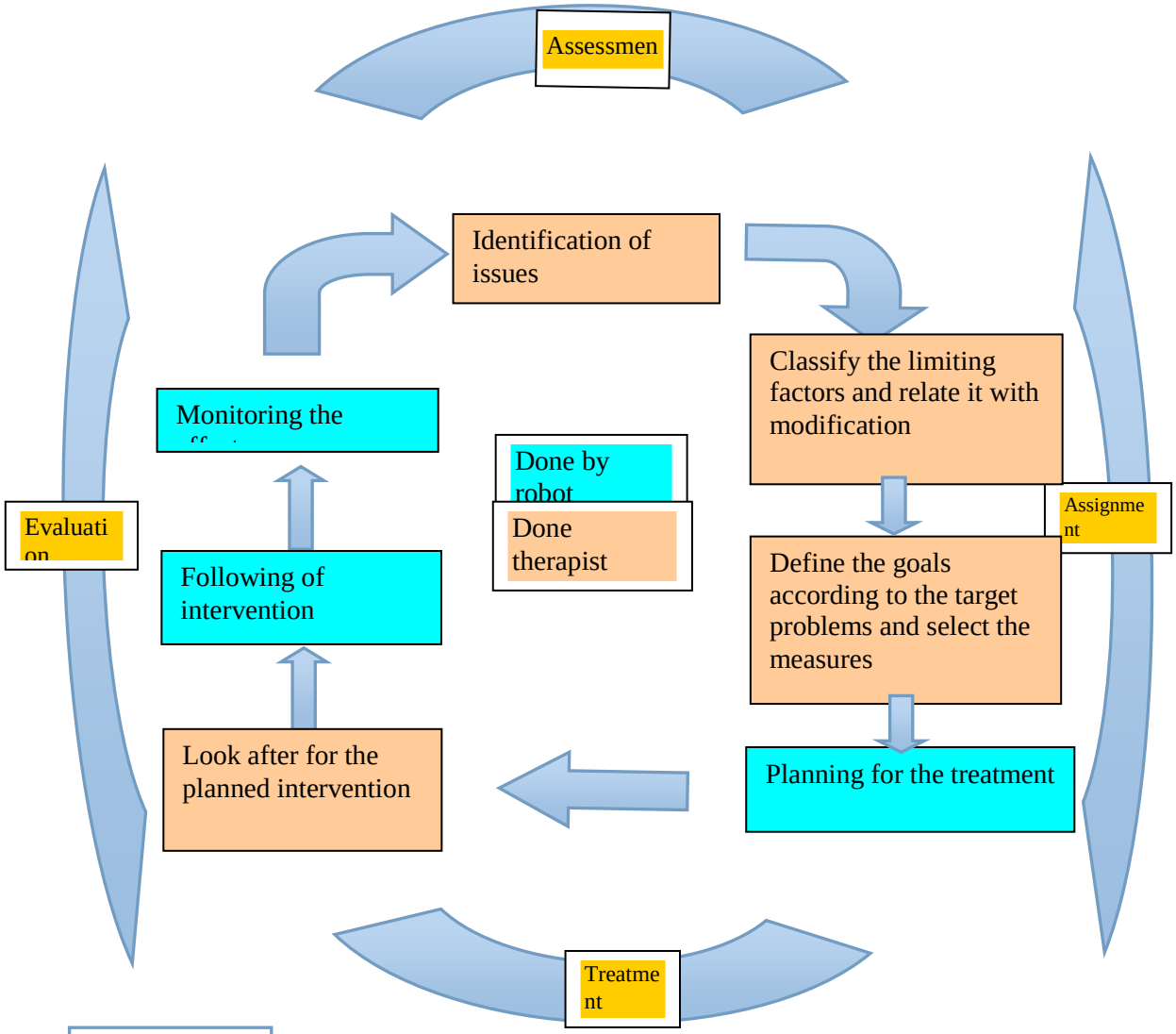
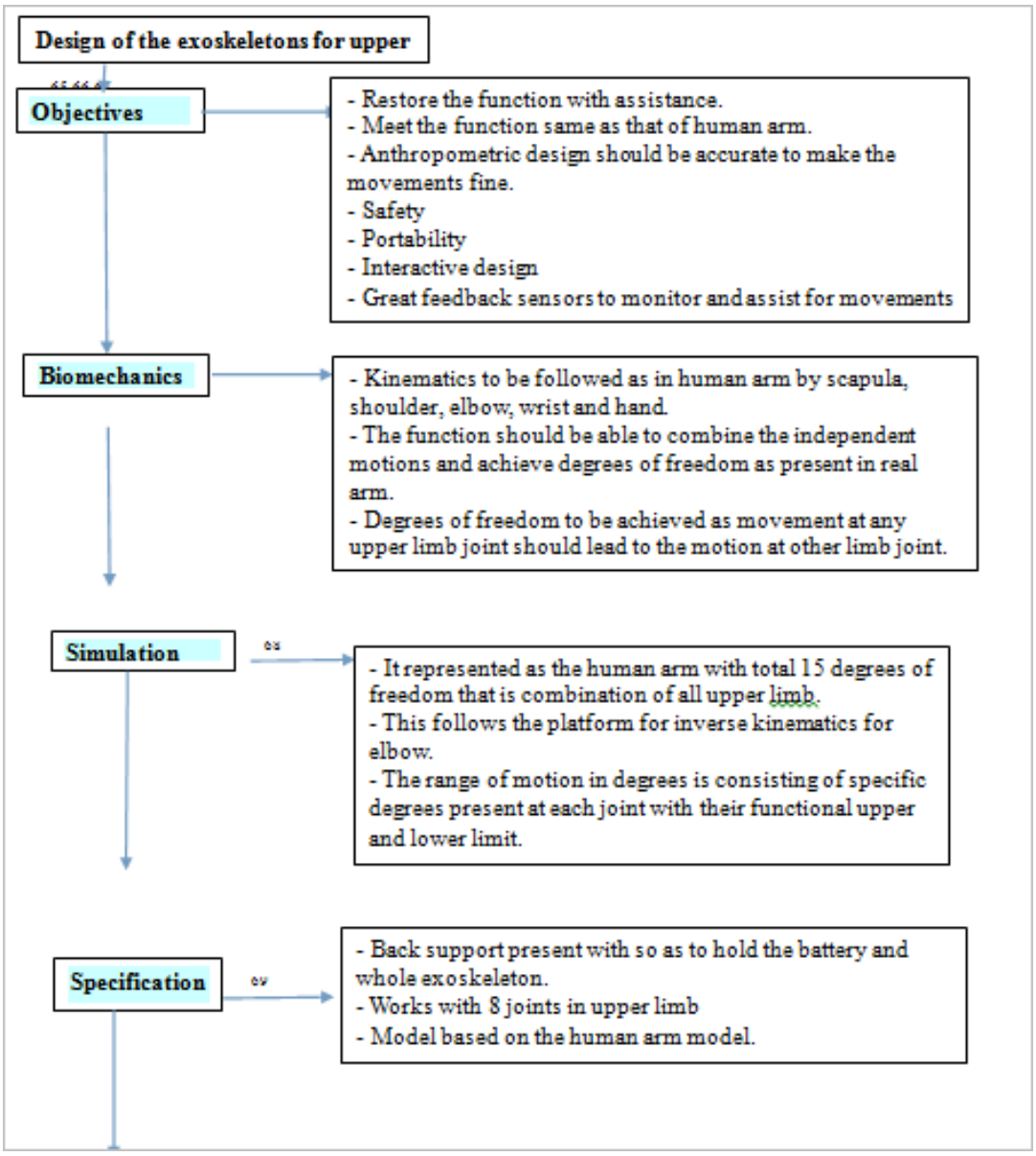


Fig1. Robotic Rehabilitatio n system

Algorithim

1. **Exoskeleton for upper limb**

The exoskeletons robots are easily wearable device which is automated and is surround to the articulated structures of the upper limb ad worked upon the kinematics for upper extremity and arm of robot is articulated with, powered motors allowing the degrees of freedom with the joint sensors.


Design of the exoskeletons for upper
Objectives
- Restore the function with assistance.
- Meet the function same as that of human arm.
- Anthropometric design should be accurate to make the movements fine.
- Safety
- Portability
- Interactive design
- Great feedback sensors to monitor and assist for movements
Biomechanics
- Kinematics to be followed as in human arm by scapula, shoulder, elbow, wrist and hand.
- The function should be able to combine the independent motions and achieve degrees of freedom as present in real arm.
- Degrees of freedom to be achieved as movement at any upper limb joint should lead to the motion at other limb joint.
Simulation
- It represented as the human arm with total 15 degrees of freedom that is combination of all upper limb.
- This follows the platform for inverse kinematics for elbow.
- The range of motion in degrees is consisting of specific degrees present at each joint with their functional upper and lower limit.
Specification
- Back support present with so as to hold the battery and whole exoskeleton.
- Works with 8 joints in upper limb
- Model based on the human arm model.

Draft for joints → There are 8 joint layouts specific one for one joint and its DOF in case for hand, wrist, elbow, shoulder and scapula.

Dynamics →
- Present with inertial matrix
- Coriolis effect and centrifugal force or joints and their velocity having acceleration
- Present with the vectors representing friction, torques, gravity
- Present with dynamic model
- Represented recursive dynamics due to more degrees of freedom.

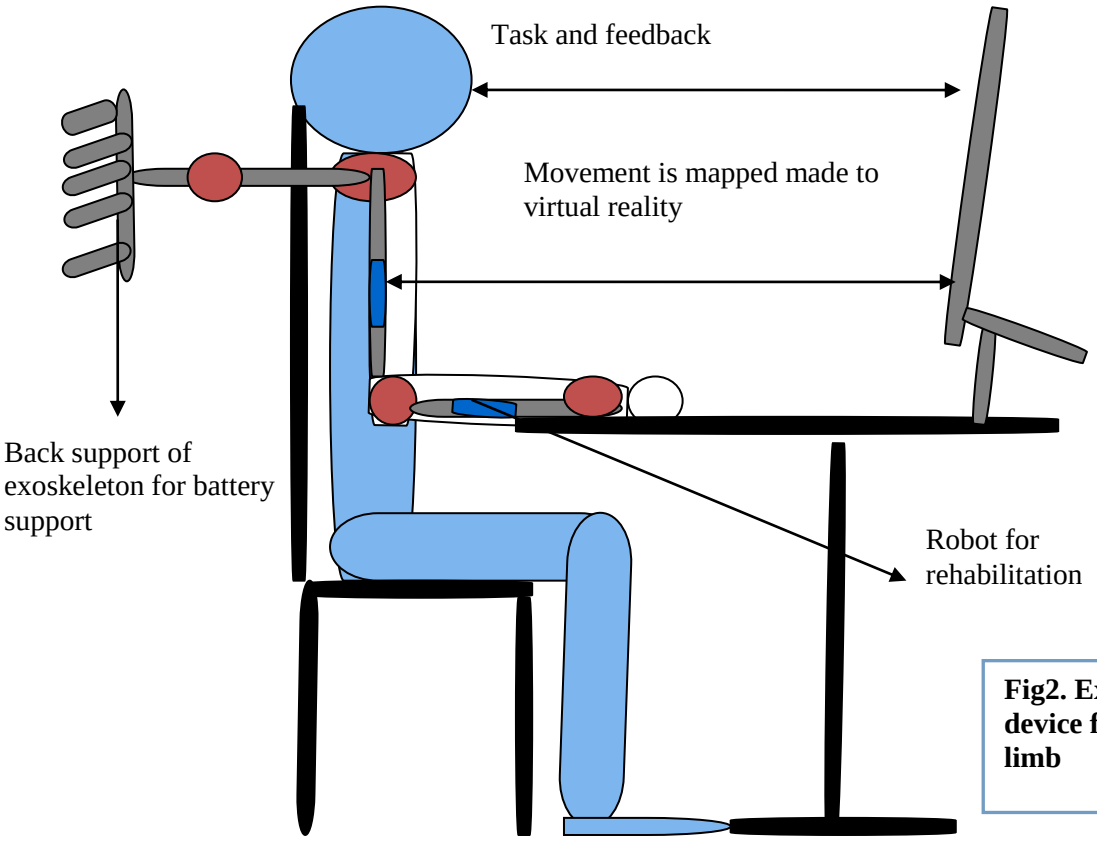
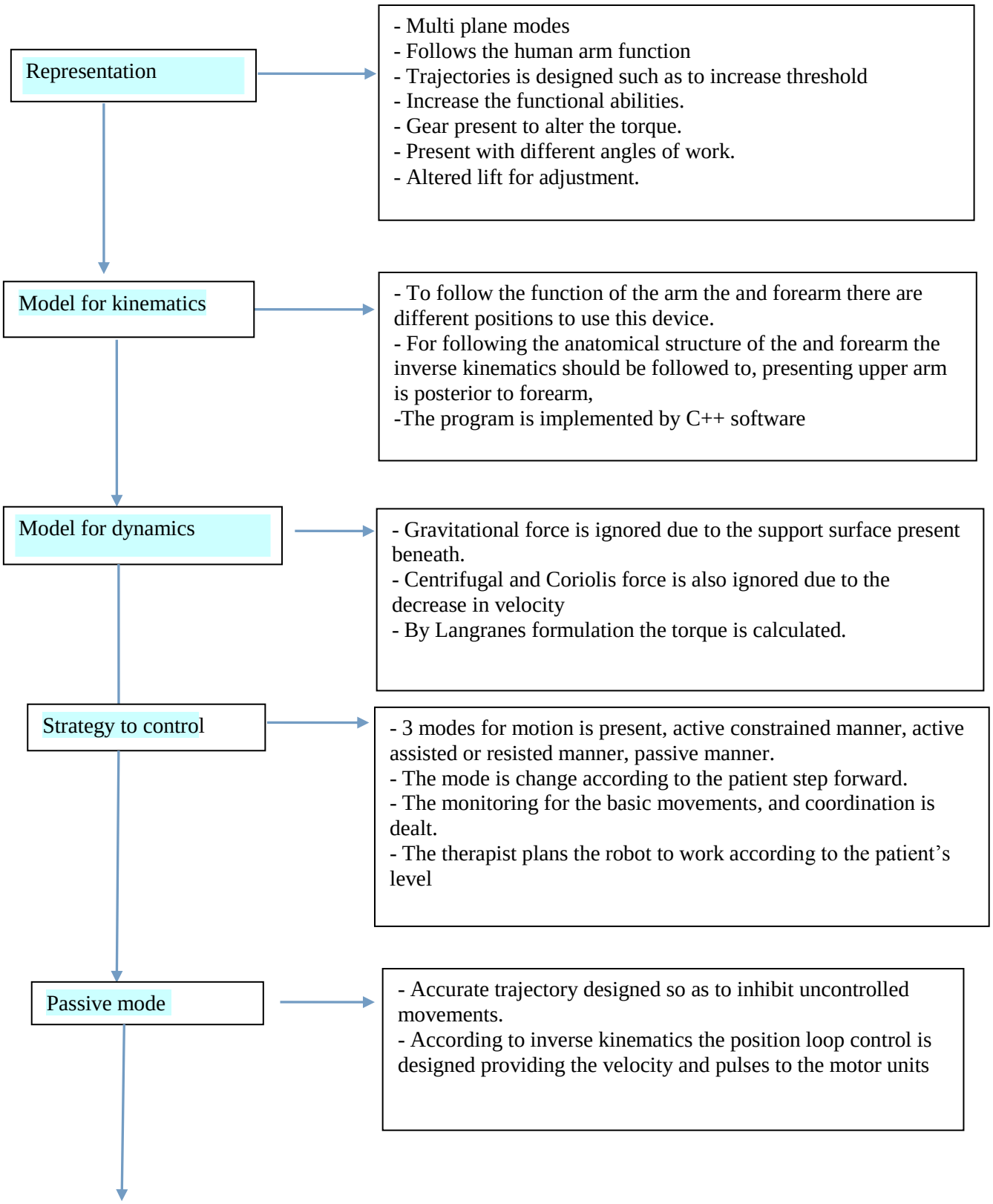


Fig2. Exoskeleton device for upper limb

2. End effector for upper limb:



Modes for training

- *Passive* - in this the patient is monitored through trajectory and rehabilitated with the help of robot's limb so as to achieve passive strength
- *Active*- In this when the patient present with the volunteer from the movement the robot automatically changes trajectory according to feedback.
-*Active assisted* - in this the robot assist the patient's limb to work when patient start to achieve then the signal is arrived where the robot tries to lower the assistance and make patient independent.
-*Active resisted*- In this the limb of the robot is moving opposite to patient's limb so as to make the exercise more useful

Gait detection

Limb sensing technology inclusive of the sensors based on BCI, angle sensors and electromyogram.
The planted sensing technology is for the forces applied by the man on the ground.
- Mixed sense technology in which the monitoring and identification is done of the limb by sensors.
- Nowadays the cHRI and pHRI are used as the detection method in which the brain motility and muscle motility information is provided through the EMG, EEG and sEMG and in other the kinematics, force, torques is determined by pressure sensors, angle sensors

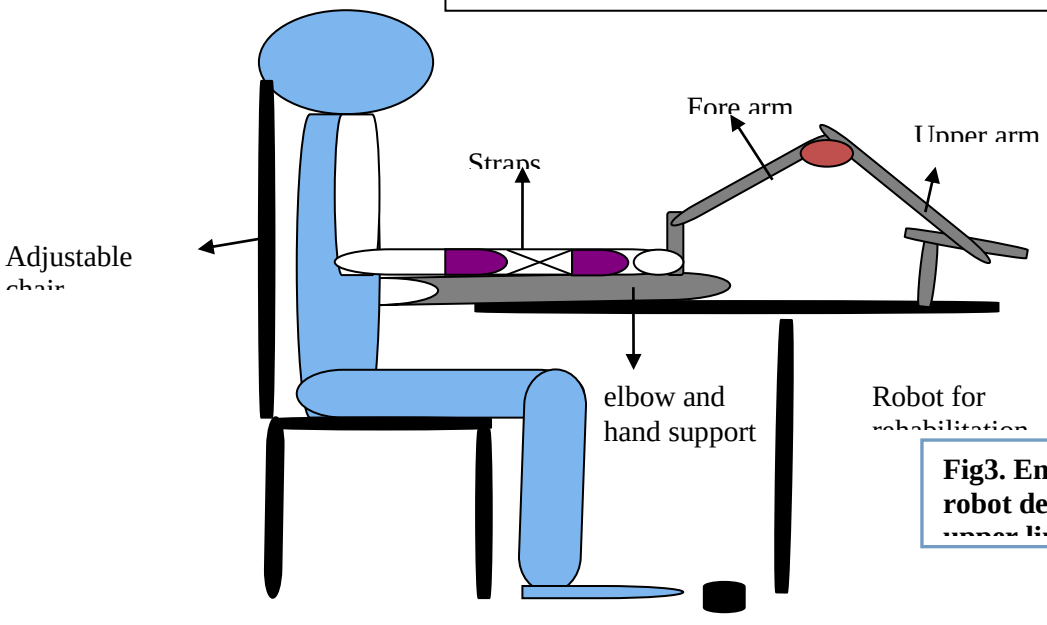
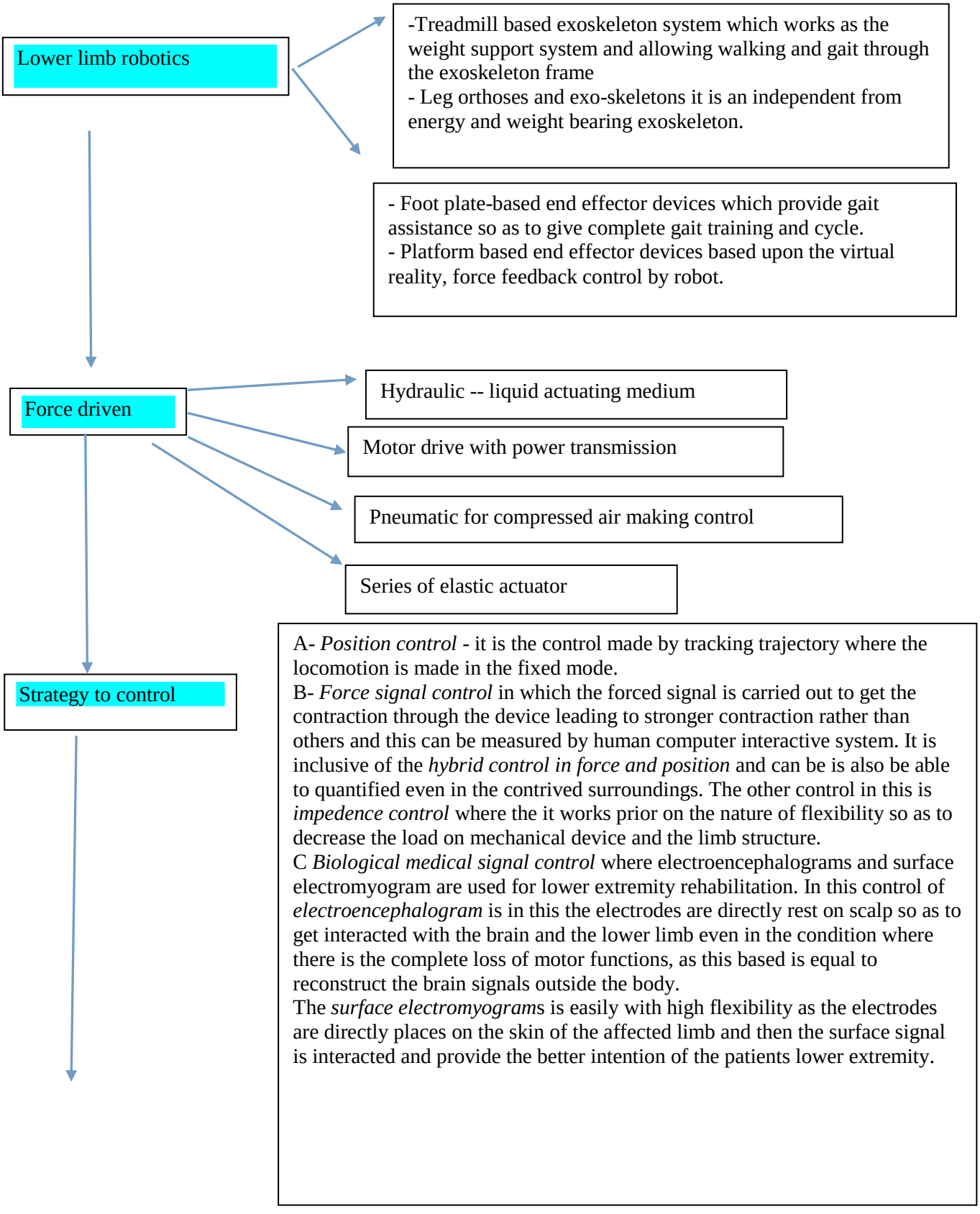


Fig3. End effector robot device for upper limb

END EFFECTOR ROBOT FOR UPPER LIMB

3. Robotics for lower limb:



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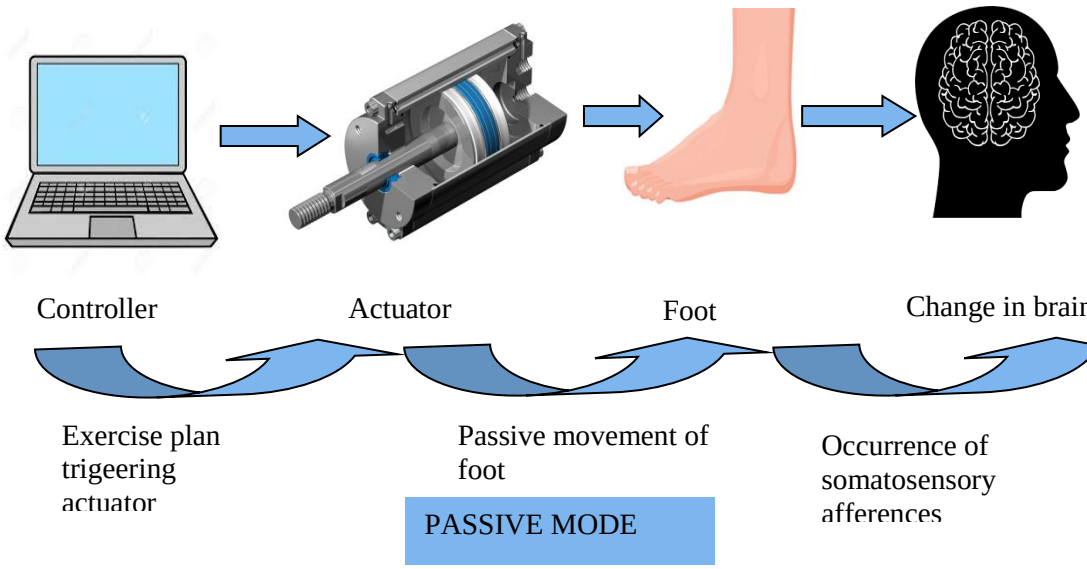

Fig4. Passive mode for lower limb

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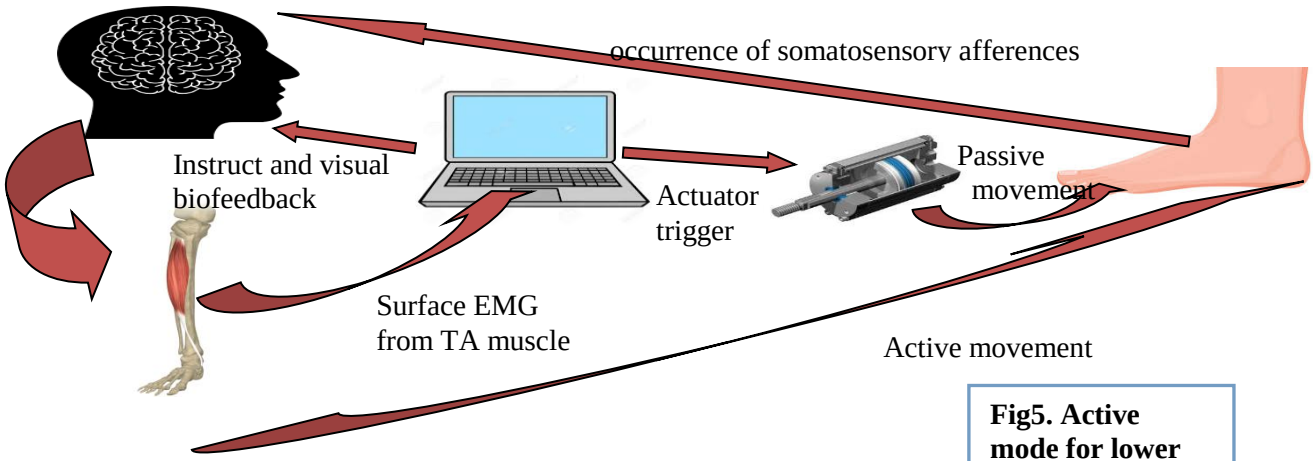

Fig5. Active mode for lower limb

Need For Robotic:

Rehabilitation

According to the facts by the WHO statistically drawn out with 70 percent of neurological problems are reported that are progressive and chronic and higher in elder population, whereas the remaining are with amputation, musculo-skeletal disability, pain, traumatic injury, learning disabilities.

The requirement of the automated technology is present with atypical requirements by gathering the alternative mechanism which can restore the function of the disability, and deal with compensation dealt with that disability, the procedure can be followed with wearable technology such as orthosis or even with the electromechanical approach. , problems are reported that are progressive and chronic and higher in elder population, whereas the remaining are with amputation, musculo-skeletal disability, pain, traumatic injury, learning disabilities.

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According to the studies, drawn that robot-based rehabilitation supports clinicians , for better results in short span of time, these studies are from global perspective , which studies the role of robots in rehabilitation and consider rehabilitation system as the integrated approach . Various studies suggested that nowadays there are various classification of the automated technology in health care, working on various control strategies , and user interface such as EMG and EEG , , basis and focuses on better feedback.

Robotic technology as the brain is dynamic and the property named as plasticity is the fundamental, the plasticity occurs after being aided by the therapy leading to relearning the and make the therapy in more functional . The robotic therapy aids and enhances the plasticity . Due to interaction with the robotic device the therapist is able to interact both with the physical and mental parameters for patients.

Robotics in Health Care:

Robot institute of America in 1979 framed the termed for robotics as a reconfigurable, versatile, operator which is drafted to mobilize the segments, materials, tools and other particularize task given and configured accordingly.

Medical robots have been specified according to the domain such as surgical, medical and rehabilitation and following the basic science such as tele surgery, ergonomics, DOF, kinematics of motion with different kinds of robots behind. , , , ,

IN SURGERY:

1. Neurological:

Neuro-surgery is a very delicate surgery involving precision and accuracy at every step, this can be done under fine medical images, , , it began with computed tomography and stereotactic frame, the biopsy was done by the trajectory of the robot and the probe was placed accordingly. Nowadays the integrated surgical systems involving the image guide positioning, there is the addition of deep brain stimulation and intra cranial stimulation, radio surgery, neuroendoscopy, providing the accuracy for the results where, as the robots are guide the instruments and, somewhere the robot is so small that it can easily be invasive and be useful for review as well as deformity correction, 3D verification can be done easily with ongoing surgery and biopsy. , . Presently the evidence was resulting in better benefits in percutaneous implants in spine assistance.

2. Orthopaedics:

Robotic technology is highly beneficial in the surgery for total hip and knee replacements since 1996 , , The root has the accuracy to cut down the bones and re-sect in the clean manner and place the implant with great accuracy and leading to functional outcomes. According to the study the "Orthodoc" was given the name for surgical planner for milling in the bone and plant the implant at that place. The robot in this technology is present with the sensors for safety monitoring covering all the axes and provide better orientation and position . There were many examples such as CASPAR, iblock, Navio PFS, Stanmore sculpture. , ,

3. Laparoscopy:

Robotic technology in the laparoscopy is the surgery for incisions in the abdomen, as there is the placement of visceral organs and decrease visibility at the surgical site the camera used to be inserted as the small modifications in 1980s, this procedure is very difficult as due to less exposure the bigger the incision used to be done as the upcoming technology decreased it further with the help of accuracy and confinement. , ,

Da-vinci a surgical robot for laparoscopy which is installed with multiple functions in it, present with 2 degrees of freedom of wrist, with ease in suturing, surgical mapping, better surgeon ergonomics. The da vinci is installed in four models till now in worldwide as standard, S, Si, S-ie , . These models were enhanced year by year with better vision, easy working, better outcome, besides Sie, Si have the ability to practice surgery in virtual environment.

The other robots were like free hand, Tele- AP, and SOFAR. With different accessibility, endoscopic view and other different parameters such as assistance, manipulators and sensors .

4. Percutaneous:

This involves use of needles and suture, drainage, destruction of tumor, delivery of drug, biopsy . The intra operating imaging was used for the surgery with 3-dimensional view, involving MRI compatibility with the joint sensation. The robotic arm is designed and operated with CT scan MRI. , ,

5. Catheters:

Catherterization is useful as the diagnostic tool in case of vascular injury and its diagnosis in the blood vessels that are obstructed and fluoroscopy is done for the guidance. The steered catheters are the provision to decrease the risk of physician towards radiation. , ,

Sensei the robot for steered catheter which handled by the doctor by 3D joystick with the mechanism of pulleys , the sensations are gathered by the vibration at surgeon's hand.

Niobe a robot came with the magnetic technology using the magnets guides catheter for the movement , surgeon can orient the magnetic power fro retraction and the movement inside with change in the magnetic field as required.

In Rehabilitation:

1. Prosthetics and orthotics

These are controlled with the help of exoskeletons, end effector device which are actually a micro-processor device adjusting the dynamics of the device according to the available kinematics in the limb. Examples such as C leg used for the dynamics of the gait training, they deal with the better functional outcome as powered control on every digit, as the power is made by the remaining limb present by myoelectric signals. , Re walk is the dynamic wheel chair allowing the patient to walk and the stand on their own.

2. Assistive mobility devices;

These are the devices which focuses on the whole-body system so as to complete the task for the activities of daily living . Example MIT MANUS a device used for re-educate the patient in all aspect,

have different function to access, to make patient independent. The signals are produced that provide the feedback to the therapist and the patient. This system records the velocity and the force of motion. The other robot is the Master II which is inclusive of manual, external powered or the pre synchronized motions.

3. Robots for communication;

There are robots present specially for the interaction with social environment and improve the psychological aspects, improving the communication skills specially in case of children. In this the feedback is gathered from patient's movement for understanding such as head nodding, the interaction is meant to be in different languages so as to create barrier free environment. These robots are followed in home and hospital settings from mental rehabilitation. These are humanoid robots followed post-surgery or the children in the sterile room such as in case of immuno- compromised condition these robots help them to interact and talk. The examples are: Nao humanoid robot. ,

4. Motivational robot:

The researches have been done eliciting that for better rehabilitation one must have better quality of life, hence there are motivational robots deal with your mental state and react optimistically and permits some intellectual tasks such as memory, and other motivational lectures to improvise the QOL.

Advancement within robotic health care

There are currently many researches going on present with decrease complexity and increased accuracy in various departments that is surgery, medicine, and rehabilitation and many more.

1. Trauma pod it is the semiautonomous telerobotic system for surgery, this system allows the surgery with all the care that is nursing, anesthetics, dressing, monitoring, closing, shunt placement without a single person in theater.
2. In vivo robots are based on da vinci rules of robots and established further where there is a nerbekas laparoscopic surgery system where the arms of the robot are present with 6 degrees of freedom providing the better accuracy with minimum incision.
3. Swallowable capsules and its further evolution developed, that is to be swallowed and it has the sensors controlled by magnetic field fives the imaging without battery, induces electrical peristalsis, provides the help for the ultrasound imaging and biopsy, pH regulator, bowel movements monitoring, gastric secretions monitoring and more.
4. Heart lander, it is the robot system specially to suction the removal from heart wall, epicardium, pericardium and drug delivery and other cardiac procedures with minimum incision.
5. MrBot and Neuro arm: Mrbot is the device with pneumatic steeper motors to reduce the MR interference which provides a access to prostate gland and with horizontal linkage arm for magnetic resonance imaging entrance. The neuro arm works with 3 DOF with micrometers and sensors for optics working with MRI access with piezoelectric motors.
6. Microsurgery and RAVEN: RAVEN A device for teleoperated laparoscopic surgery present with 7 degrees of freedom each in both arms which works on kinematic spherical mechanism with adjustable length and angles of arms for function in the arm. The device is less expensive a light in weight. Whereas the Microsurgery is for endoscopic surgery, providing highly versatile functions with different domain of surgery.
7. Amaedeus: a laparoscopic surgery device for complete of intutive design of da vinci robotic system, this robot provides high level of flexibility and as present with snake arms. from long distance surgery as tele operative.

Discussion:

The robotic technology for the health care system is wide based system which provides a wide featured are inclusive of all the facilities, where the technology plays the role in increase of assistance for the procedures that are difficult to procure, but this does not lead to any removal of health care workers.

Robotic based rehabilitation is very useful for faster and accurate results in part of rehabilitation where the routine management can be done with accurate monitoring after every session and feedback is provided both to therapist and patient, commercially available robots are high on demand and are present in out-patient rehabilitation and deals with number of patients.

In robotics in rehabilitation patient is prescribed with the accurate regimen prescribed by therapist ,to be followed under the supervision of therapist, this provides the better outcome and increased

amount of gratification. ,

Most commonly with the patients with low level of motivations tends not to comply with the intervention hence the robot is induced with addition of motivation as supplement with the intervention to improve the outcome. This was induced with the help of gaming with exercise and for getting engaged the children with concentration and better amount of the results. , ,

In earlier rehabilitation with robotics were with decrease amount of interaction which now been improved in all senses such as feedback sensors, visual auditory, haptic and performance cues, motivation and virtual reality for better interaction.

After lots of research the robotic mechanism developed with the comfortable chair attached with the controller of computer that is managed by therapist and the patient is attached with orthosis and haptic device which is suspended and are moved according to the result required and the visual and haptic feedback is obtained and the treatment effect is quantified. ,

The great challenge was to introduce gaming in the rehabilitation process to made to process faster and interactive with entertainment specially in case of sensory deficits. The gaming provide the level of difficulty same throughout the rehabilitation. The gaming is structured according to the steps which provides feedback of the patient with desirable mood and undesirable mood and its movements and helps to encourage simultaneously. , , ,

There was new technology named ARMin exoskeleton rehabilitation robots provided the virtual games such as hockey, tennis and the mods can be changed according to patients mood and this therapy intensifies rehabilitation.

The senior and geriatric population is present with more amount of age-related disability, where the robotic technology helps by indulging social aspects, solving intellectual questions with lots of motivation beside which gathers the better amount of therapy and improvement. There are competitions assigned for cognitive skills and set according level of understanding and interest. The haptic joysticks play a role in cognitive development such as by planning virtual situation of polluted cities and to analyze the images and the data. There is one device Novint Falcon a low haptic device provides the force feedback and the position of end effector and able to differentiate between patients with disabilities and the patient under stroke intervention rehabilitation.

The rehabilitation exercises are very useful to recover, and also can be followed at home easily but the feedback, accuracy and intensity of exercise to be quantified, which is now possible with the help of home based rehabilitation robots, which are there in the market at low cost and affordable in case of Novint Falcon and java therapy but with a issue limited to small movements. Hence the Microsoft Kinect is new in technology where the motion is tracked with the help of camera allowing the estimation for all the sides of motions in 3 dimensions. This kinect is not only combined with the gaming but also with computer for its versatility making custom interface and better rehabilitation. , ,

Conclusion:

The robotic technology in the health care is a widely based system having the ability to transform the health care sector into new base with the accuracy in every department such as medicine, surgery, rehabilitation, and social. The robotic technology provides the long term rehabilitation and most accurate in cost effectiveness, time of recovery, feedback, this is guaranteed to be fulfilled. Due to this the robotic technology have come up with less time of surgery, fast recovery, less dependency, emergency care, nursing care, and rehabilitation which is easily accessible to the health care sectors and there team.

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