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1. Concept of a rehabilitation robot based on hand held support. Indicate three types of therapy modes.

With the MIME robotic system, for example, the following therapy modes are possible:

- Passive: the robot moves the patient's limb towards target.
- Active-assisted: the patient initiates the movement and is assisted by the robot.
- Active-constrained: the robot provides low resistance in the direction of desired movement and springlike restoring forces in the other directions.

2. Principle of an assistant robot for tremor compensation.

The sensors in the robot estimate the tremor movement and interaction force between the robot and arm/hand. The robot discriminates between a tremor movement and voluntary movement. Then, the actuators generate a movement in the opposite directions of the tremor movements to effectively suppress the tremors.

3. Explain the sensors used to acquire neurological signals in rehabilitation

There are usually 2 types of sensors used:

- Electroencephalogram (EEG): record the electrical activity of the brain.
- Electromyography (EMG): detects and records the electrical activity of the muscles.

4. Indicate the role of virtual reality in the process of training for the use of a prosthesis

Virtual Reality helps patients learn faster to control their movements with the prosthesis. It also helps them reprogram their reflexes and build a psychological feeling of the prosthesis as if it were their own natural limb.

5. Perception system proposed for an assistant robot with a mobile base for personal assistance at home. Relate the mentioned sensors and perception systems to concrete tasks.

The robot can for example learn how the human separates groceries into different groups and place them at different locations in the kitchen. The perception part is that the robot can later on recognize the activity which is the human is starting to arrange the groceries or maybe just putting them at an initial location and then the robot interacts and help in arranging the groceries.

6. What's the reason to provide a wheelchair with articulated wheels?

It enables producing wheelchairs that can climb stairs.

7. Justify the slower progress of medical robotics with respect to industrial robots?

Laws and regulations are stricter for medical robotics. It is also a more complex and difficult domain that requires more consideration than industrial robotics. In contrast with the industrial setting where the environment is known and structured, medical robotics interact in a natural, unknown environment where there is higher concern for the safety of patients and the medical personnel.

8. What are the main requirements of a robot for implanting electrodes in the brain?

For implanting electrodes in the brain, the robot contributes in following 3D trajectories, handling high precision movements and minimizing damage. The technical requirements for such robot are:

- Very high positioning precision
- Very high trajectory precision
- High dexterity
- Small space accessibility requirements
- Low haptics requirements

9. When you would suggest use teleoperation versus programmed robots in surgery?

In intracavity type of surgery where the ability is not programmable and there is need for manual guidance.

10. Explain the concept of virtual fixtures and its use in surgery.

Virtual fixtures are computer-generated virtual overlays that simulates physical constraints and fields in a virtual scene to assist the surgeon while performing real physical surgery. During surgery, virtual fixtures limits the surgical tool's motions to appropriate area close to the site of contact with the patient. This helps in reducing precision requirements on the surgeon and the number of degrees of freedom that must be controlled.

11. Make a list of the kind of assistance a teleoperated robot can provide in surgery with a short justification

Teleoperated surgical robots help improve the accuracy (e.g. exact site point of operation), dexterity (e.g. tremor suppression) and visualization (e.g. magnification) of the surgeon. With virtual fixtures, the robot can limit the movements requested by the surgeon as measure of safety and accuracy. With haptic technology enabled on the robotic system, the

surgeon has a feel of the manipulation of the surgical instruments as if, to some extent, it is done by his own hands. Also, some teleoperated robotic systems can allow surgical procedures to be conducted from remote locations.