First Name

Last Name

Identification Number

NEUROENGINEERING [2]

Available time: 30 min

1. NEUROENGINEERING FOR BIOLOGY
   1.1. Suggest an optical method to record *in vitro* neuronal activity and describe the working principle of this technique.
   1.2. What are the major technological elements (devices) to run an experiment with the above selected solution
   1.3. Highlight advantages and disadvantages with respect to other available technologies for recording in vitro neuronal activity.

2. Complete the following table

Goal of the experiment	Experimental technique	Possible model to describe collected data	Limits/comments
Study and model the ionic channels in the axon initial segment			
Study and model the neural mechanisms underpinning learning behaviour in primates			
Study and model plasticity between two neural populations			

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NEUROENGINEERING [2]

Available time: 30 min

1. NEUROPROSTHESES (NP)
   1.1. Define a sensorial NP and a motor NP; present the main components to build each of them, using a block diagram.
   1.2. Describe the context of application of sensorial NP (target population, goal, end use).
   1.3. Why do we address the issue of implanted neuroprostheses more for sensorial ones than for motor ones?

2. REHABILITATION ROBOTICS
   2.1. Consider an exoskeleton for the upper limb, adopted to promote motor relearning. Select the context of application (target population and treatment).
   2.2. Define the best control strategy to be implemented.
   2.3. Discuss the advantages of the proposed solution with respect to conventional physical therapy.

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Step-by-step: available time is 30 min. You have to answer questions 1 and 2 for step-by-step 1, questions 3 and 4 for step-by-step 2.

Full exam: available time is 45 min. You have to answer 3 out of the 4 questions.

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1. CEREBELLUM
   1.1. List the main neural populations in the cerebellum, describing their role in the circuit.
   1.2. The E-GLIF neuron model: report basic equations, pointing out which parameters need to be defined and optimized. Suppose to use this model to represent cerebellar neurons: list advantages and disadvantages of the approach.
   1.3. Present one cerebellum-driven protocol which can be used to test cerebellar properties. Is the model in 1.2 suitable to test the protocol?

2. IN VITRO NEUROENGINEERING
   2.1. Describe the working principle of Multi-Electrode Arrays (MEAs).
   2.2. List the advantages and disadvantages of MEAs for recording in vitro neuronal activity with respect to the other available technologies (patch clamp and voltage-sensitive dyes).
   2.3. Describe the main components of a setup for MEA recordings using a block diagram and explaining the function of each block.

3. NEUROPROSTHESES (NP):
   3.1. EMG-controlled NP: what are the main problems you need to face when designing EMG-controlled NP? Propose a control algorithm to solve them.
   3.2. What are the reasons for applying EMG-controlled NP?
   3.3. Describe a situation (patients, diagnosis and conditions) where the use of EMG-controlled NP is not applicable and a situation where it is for sure.

4. REHABILITATION ROBOTICS
   4.1. Consider a robot for assistive walking in a complete SCI patient (Spinal Cord Injury patient with complete lesion at level C7). How the robot can be used? Describe a possible control strategy.
   4.2. Propose a solution to compute the desired trajectory.
   4.3. Which are the target application scenarios of the designed robotic platform?

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Full exam: available time is 45 min.

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1. MOTOR CONTROL
   1.1. Define reflexes and voluntary movements; list and explain the laws of voluntary movements.
   1.2. Represent the main brain areas involved in motor control through a block diagram, highlighting motor and sensory signal flow among them.
   1.3. Identify and describe the brain area involved in voluntary movement control. What happens if an external perturbation occurs during execution of a voluntary movement?

2. BIOMIMETIC CONTROLLERS:
   2.1. Define biomimetic controllers
   2.2. Design a biomimetic controller, describing how you define the best control strategy.
   2.3. Suggest a clinical trial to test the designed solutions (patients, protocol, etc).

3. ROBOTICS
   3.1. Explain the difference between rehabilitation robots and ortheses.
   3.2. Provide an example of a robot for rehabilitation of the lower limb and one for rehabilitation of the upper limb. What are the main differences in design and control of the device?
   3.3. Choose one of the robots in 3.2 and provide an example of application: patients, task, rehabilitation plan.