Short Course on

Mathematical Models in Neuroscience and their Applications

Lecture 1 (24/10) : From the discovery of neuron to artificial neural networks

1.1 Structure of brain

1.1 Discovery of neuron

1.2 Structre of neuron

1.3 Synapses

1.4 Natural neural networks

1.5 Artificial neural networks

1.6 - Statistical learning theory

1.7- Algorithms for neural network learning

First Problems Class (25/10)

Problems on artificial neural networks

Lecture 2 (28/10) : Frrom Hodgkin-Huxley Equations to topological methods in Neuroscience

2.1 Hodkin-Huxley Equations

2.2 Fitzhugh-Nagumo Equations

2.3 Integrate and Fire Models

2.4 Neural Fields

2.5 Representing neuronal connections by graphs

2.6- Directed graphs as a tool for analysing information flux in brain

2.7 - From a simplex to a cavity

2.8 - Using topological methods to evaluate the complexity of neuronal connections

Second Problems Class (28/10)

Problems on represnation of neural networks by graphs.

Lecture 3 (2/11) : Modelling nerve conduction by Fitzhugh-Nagumo Equations

3.1 - Propagation of nervous signals in mielinated axons

3.2 - Pure saltatory model

3.3 - Analogy between axons and electric circuits

3.4 -Discrete Fitzhugh - Nagumo equations (FNE)

3.5 -Numerical solution of FNE

3.6 - Stochastic FN equation

Third Problems Class (2/11)

Problems on Fitzhugh-Nagumo equations

Lecture 4 (4/11) : Numerical Methods for Neural Fields (deterministic case)

4.1 Statement of problem(without delay)

4.2 Statement of problem (delay case)

4.3 Existence and uniqueness of solution

4.4 Time discretization

4.5 Space Discretization

4.6 Rank Reduction

4.7 Numerical Results

Fourth Problems Class (4/11)

Problems on Neural Field Equations

Lecture 5 (23/11) : Applications of Neural Fields to Robotics

5.1 -Introdution: neural fields approach to robotics

5.2- working memory - 1D and 2D neural fields

5.3- generation of self-sustained neural activity

5.4 - Examples with simultaneous events

5.5 -Examples with a sequence of events at different times

Fifth Problems Class (23/11)

Problems on Neural Fields and Working Memory

Lecture 6 (25/11) : Numerical Methods for Neural Fields (stochastic case)

6.1- Introduction: sources of noise in neural activity

6.2 -Stochastic Neural Field Equation

6.3- Computational Methods

6.4 - Numerical Results

Sixth Problems Class (25/11)

Problems on stochastic neural field equations

Seventh Problems Class (29/11)

Preparation for the test

Test- 30/11 – during the class