Retrieving stimulus hidden structure from spike data through context tree modeling

Postdoctoral project
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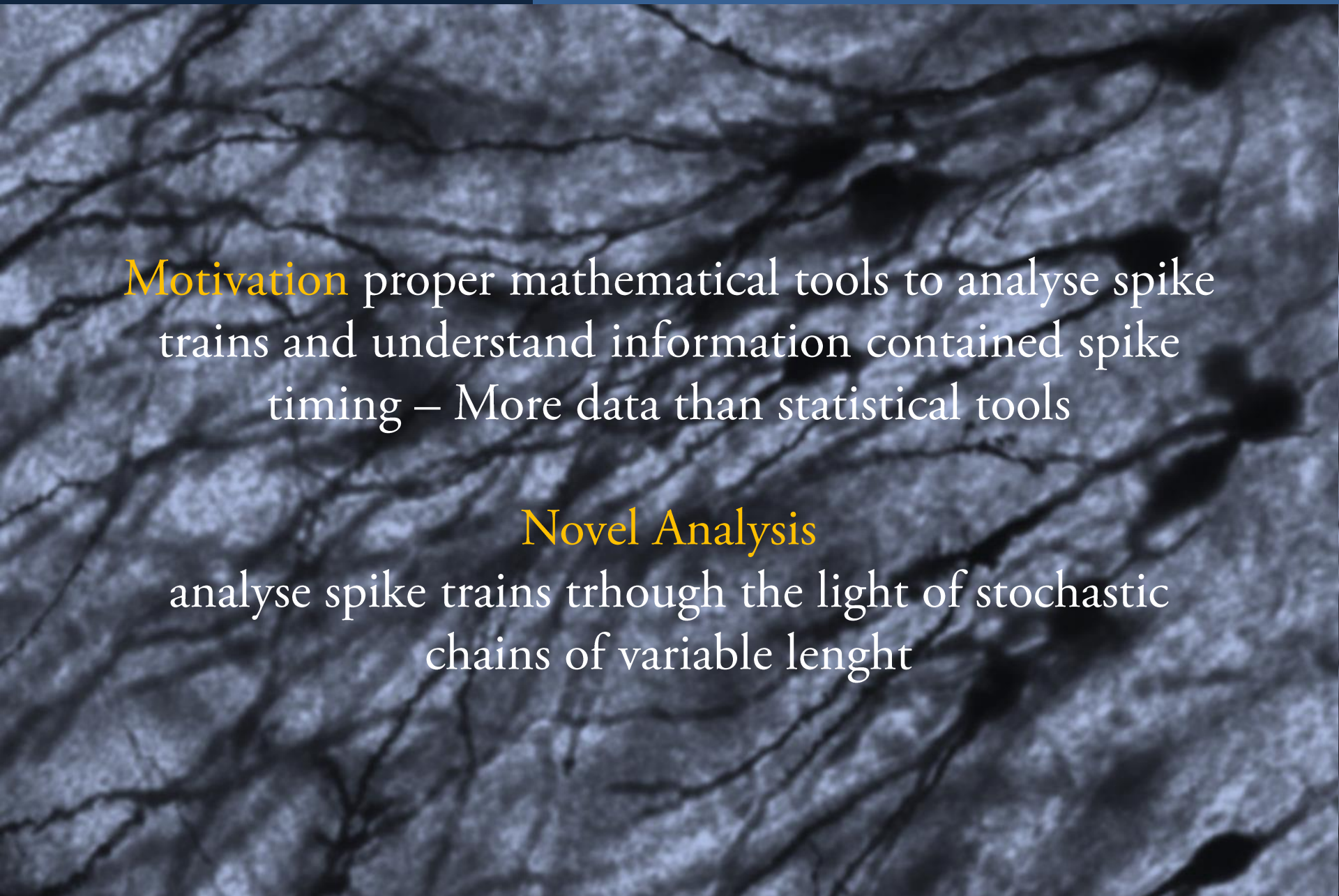
NEUROMAT
Research, Innovation and Dissemination Center for Neuromathematics

Motivations



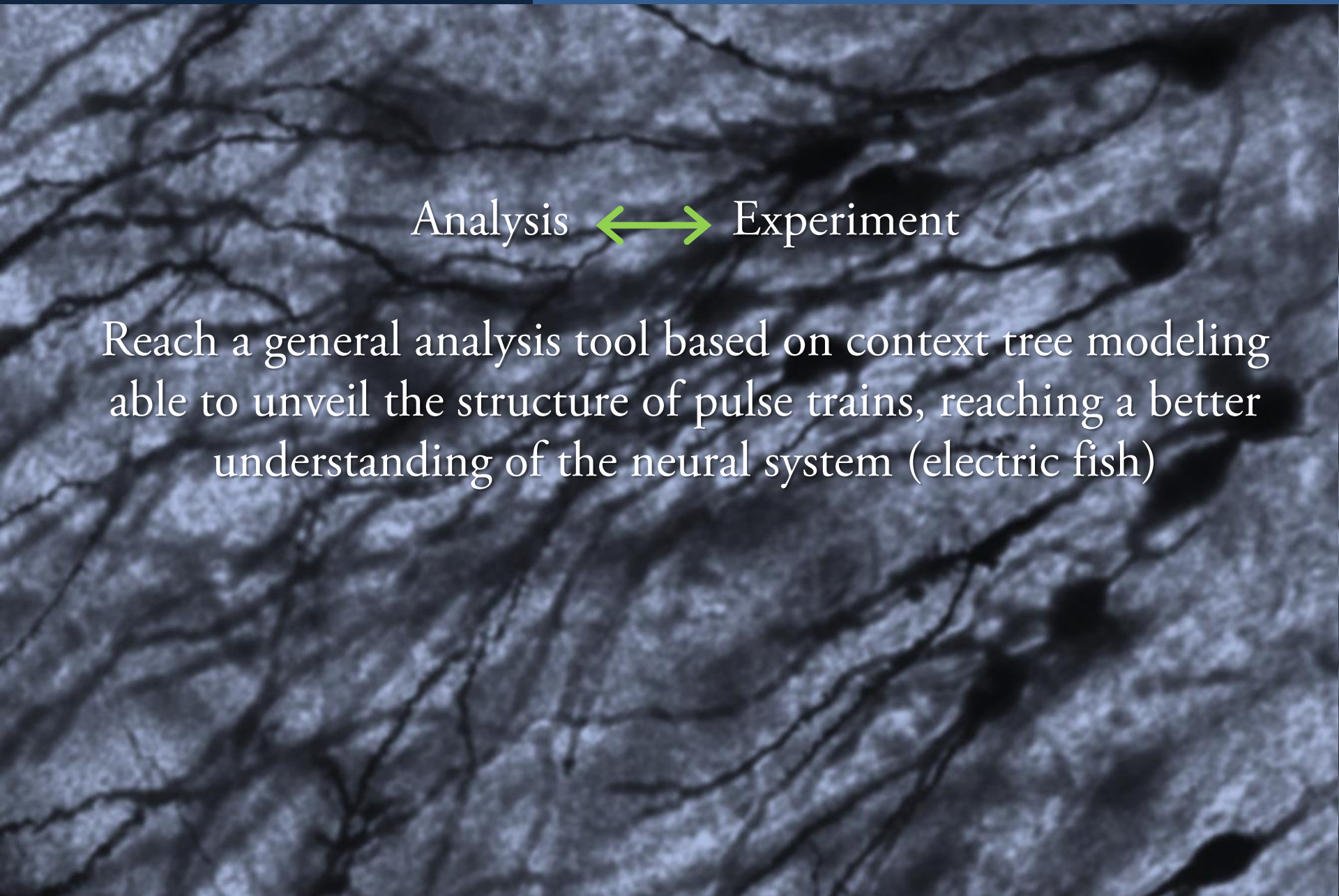
Motivation proper mathematical tools to analyse spike trains and understand information contained spike timing – More data than statistical tools

Novel Analysis

analyse spike trains trhough the light of stochastic chains of variable lenght

Pos Doc Project

Proposition and Goals



Analysis ⟷ Experiment

Reach a general analysis tool based on context tree modeling able to unveil the structure of pulse trains, reaching a better understanding of the neural system (electric fish)

Pos Doc Project

Proposition and Goals

- Obtain experimental recordings of pulse trains of weakly electric fish
- Infer signal structure using statistical selection of models in the class of stochastic chains of variable length – methods developed by NEUROMAT
- Design experimental protocol to investigate if the animal respond to a similar kind os structure - artificial stimuli

Modelling

Novel Approach

- Descriptive statistic analysis: overlook information in subtle structure of the spike train
- Previous attempts: stochastic processes - Markov Chains (Escola et al.,2011)

Modelling

Novel Approach

Markov Chain: is a random process with finite number of possible states where the probability of occurrence of a state is given by the transition probabilities from one state to the next state. (Low order VS High order)

Smart solution: Stochastic Chains of Variable Length (Rissanen,1983)

probability to observe a certain state depends on a sequence of past states but, unlike a Markov chain, the length of this sequence is variable and dependent on the process history.

Context is the part of the past that is relevant to predict the next state in the sequence

Context Tree is the set of all contexts along with their associated conditional probabilities of predicting the next state given a context in the set

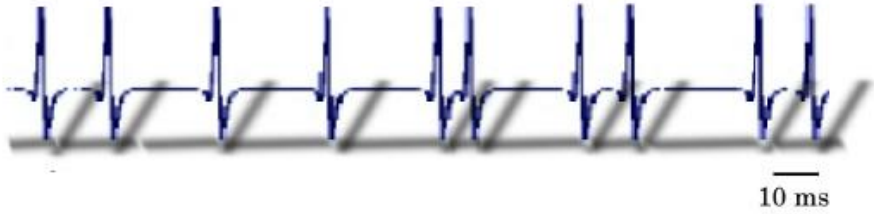
Context tree modeling

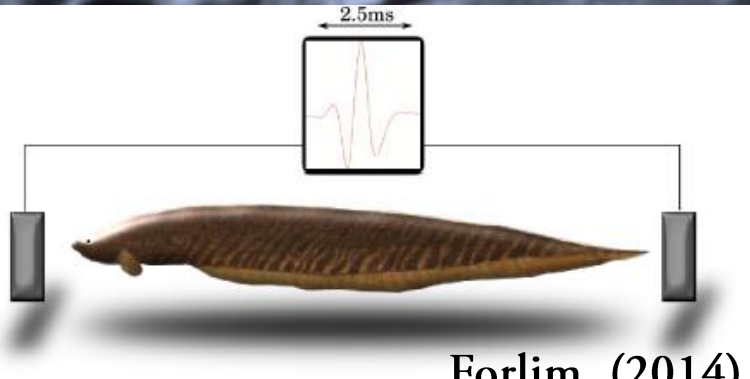
- Spike train: transformed in a sequence of bits
- Statistical model selection: best probabilistic context tree that models the data sample (Rissanen,1983; Galves and Leonardi, 2008;Galves et al. 2008, Galves and Löcherbach, 2013)

Project

Animal Model

Weakly electric fish : Electric Organ Discharge – EODs
mesured by electrodes in the water
Electrocomunication and Electrolocation
Gyminotus carapo – Pulse fish





Forlim (2014)

Pulse train = Spike train => same analysis

Colaboration: prof. Reynaldo Pinto – IFSC- USP

Electric Fish

Animal Model

Novel Analysis Method - Traditional Neurobiological Method

Central nervous system

Stimuli

Behavior/
Phisiology

Image: Gymnotus sp. by Clinton and Robertson, 2011

Electric Fish

Animal Model

Novel Analysis Method - Traditional Neurobiological Method

Central nervous system

Stimuli

Behavior/ Phisiology

Automated and artificially controlled

Paper: Forlim & Pinto (2014)

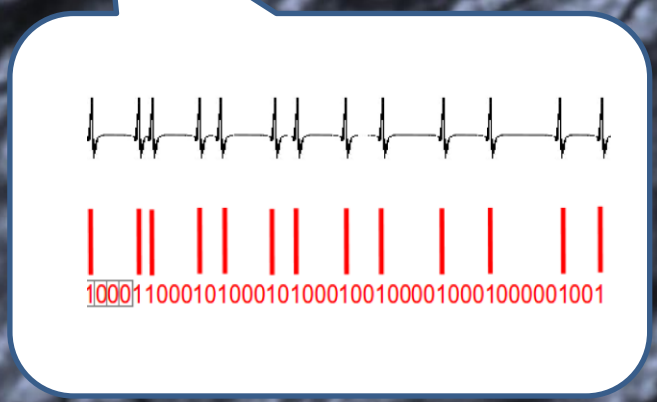
EOD recordings – neural output and behavior

Experiments

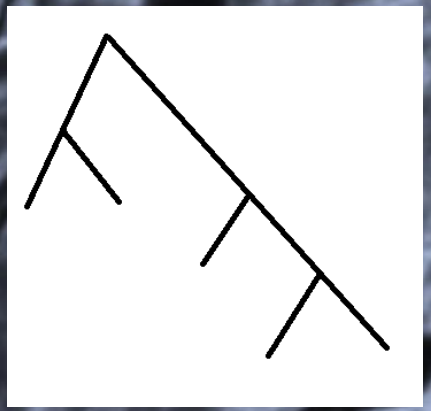
Design

Fish spontaneous activity

EOD recordings



Analisis: context tree model



Structure

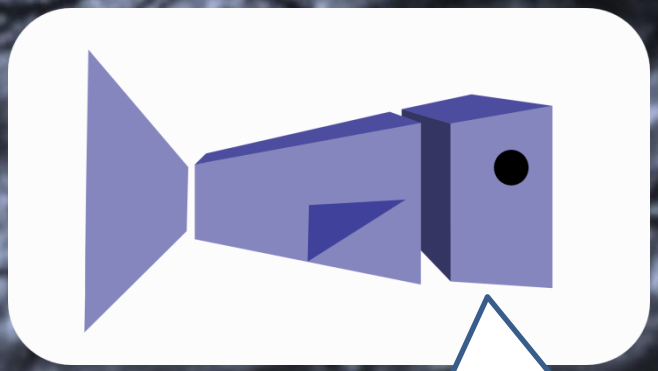
Experiments

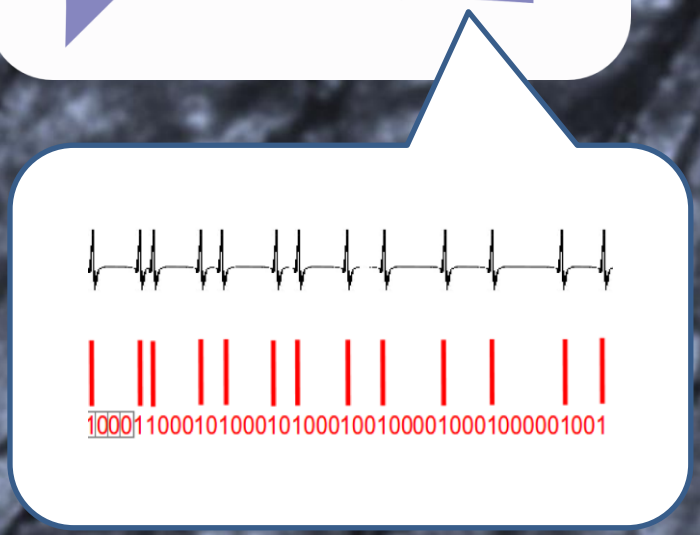
Design

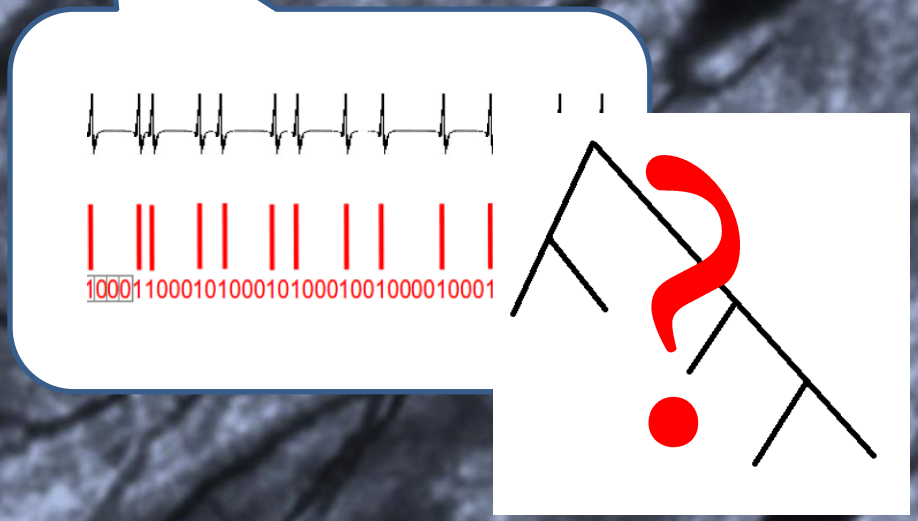
Artificial fish
with/without structure

stimuli

Real fish







Thanks!

To prof. A. Galves, all the Neuromat team
and collaborators at prof. Pinto's lab

USP

References

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background image: dentate gyrus source: wikipedia