OpenWorm

Building a digital organism

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OCNS 2015 - Prague

OpenWorm's Goal

Long term

Full scale **simulation** of **C. elegans**

Medium term

Accurately predict **WormBehavior** database using data-driven, cell-by-cell **3D neuromechanical model**

Szigeti et al, - Front. Comp. Neuro., 2014

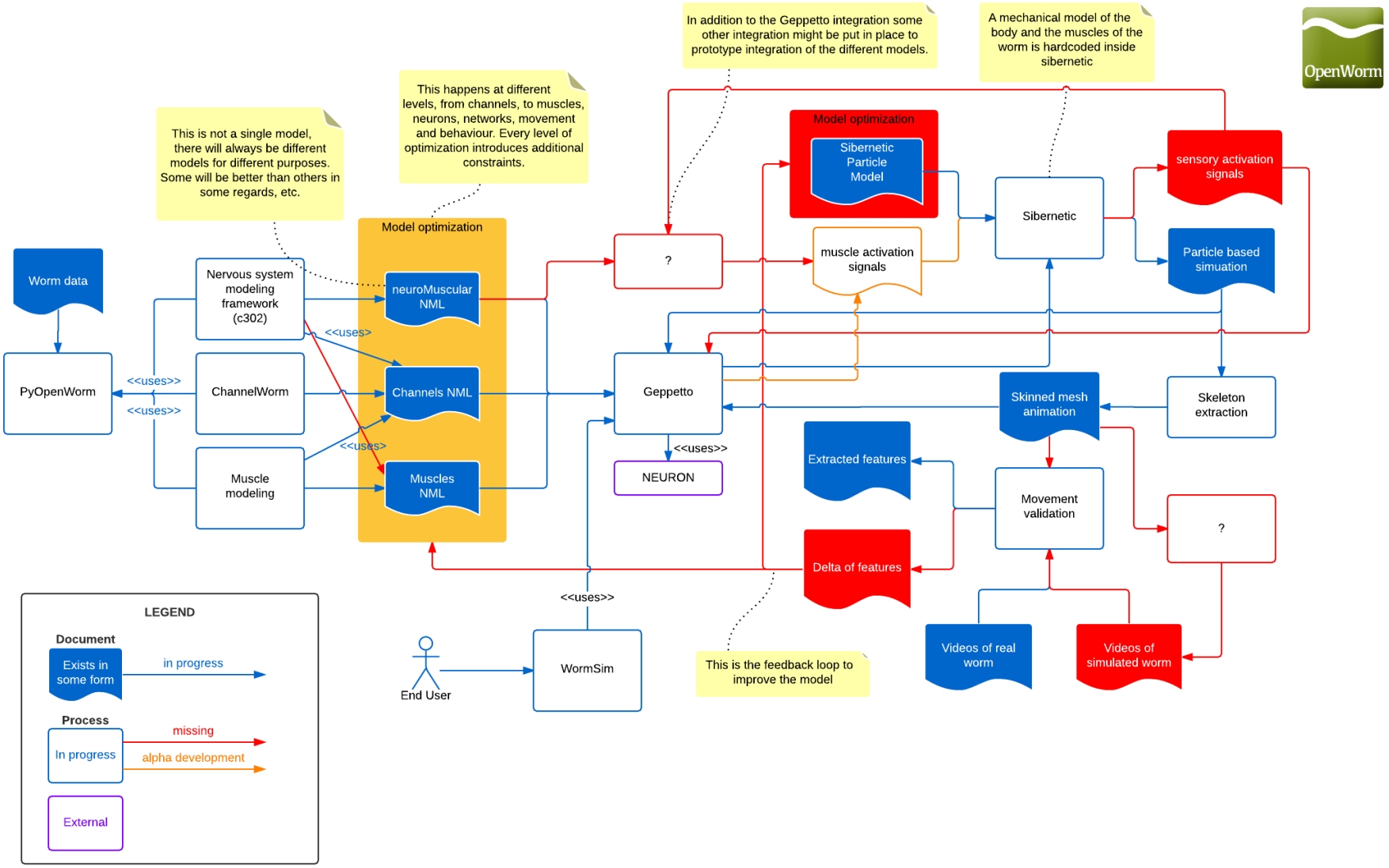
Why the C. elegans?

- Wide range of behaviours
  - Locomotion, feeding, reproduction
  - Learning, mating, social behaviours
- How does it do it?
  - 1mm long
  - 302 neurons
  - 956 cells in total
- The first organism to have its genome **fully sequenced**
  - 100 million base pairs
    - 3 billion in mouse and humans

OpenWorm open science community

- Independent international **open science** community
  - 9 **core** members
  - 20 **active members** & 40 **additional contributors** across 14 **countries**
- Networked science
  - >35 **Git repositories**
  - ~350 **mailing list** members
  - Streamed 40+ online meetings last year on YouTube
- Collaborative open source construction
  - Every line of code committed to GitHub

Where are we?


OpenWorm
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A mechanical model of the body and the muscles of the worm is hardcoded inside sibernetic
This is not a single model, there will always be different models for different purposes. Some will be better than others in some regards, etc.
This happens at different levels, from channels, to muscles, neurons, networks, movement and behaviour. Every level of optimization introduces additional constraints.
Model optimization
Sibernetic Particle Model
Model optimization
Worm data
Nervous system modeling framework (c302)
neuroMuscular NML
?
muscle activation signals
Sibernetic
sensory activation signals
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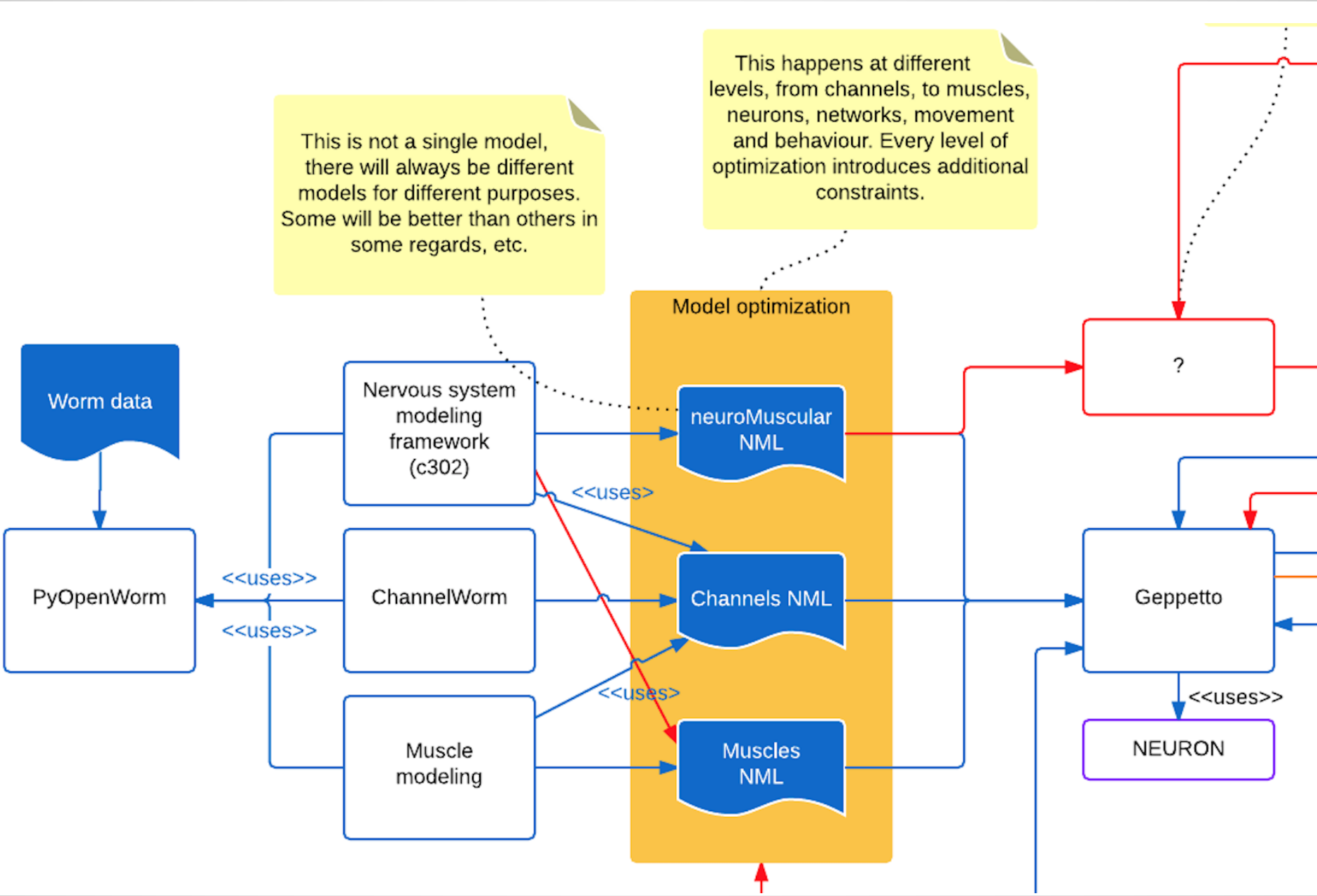
Modelling the channels and the cells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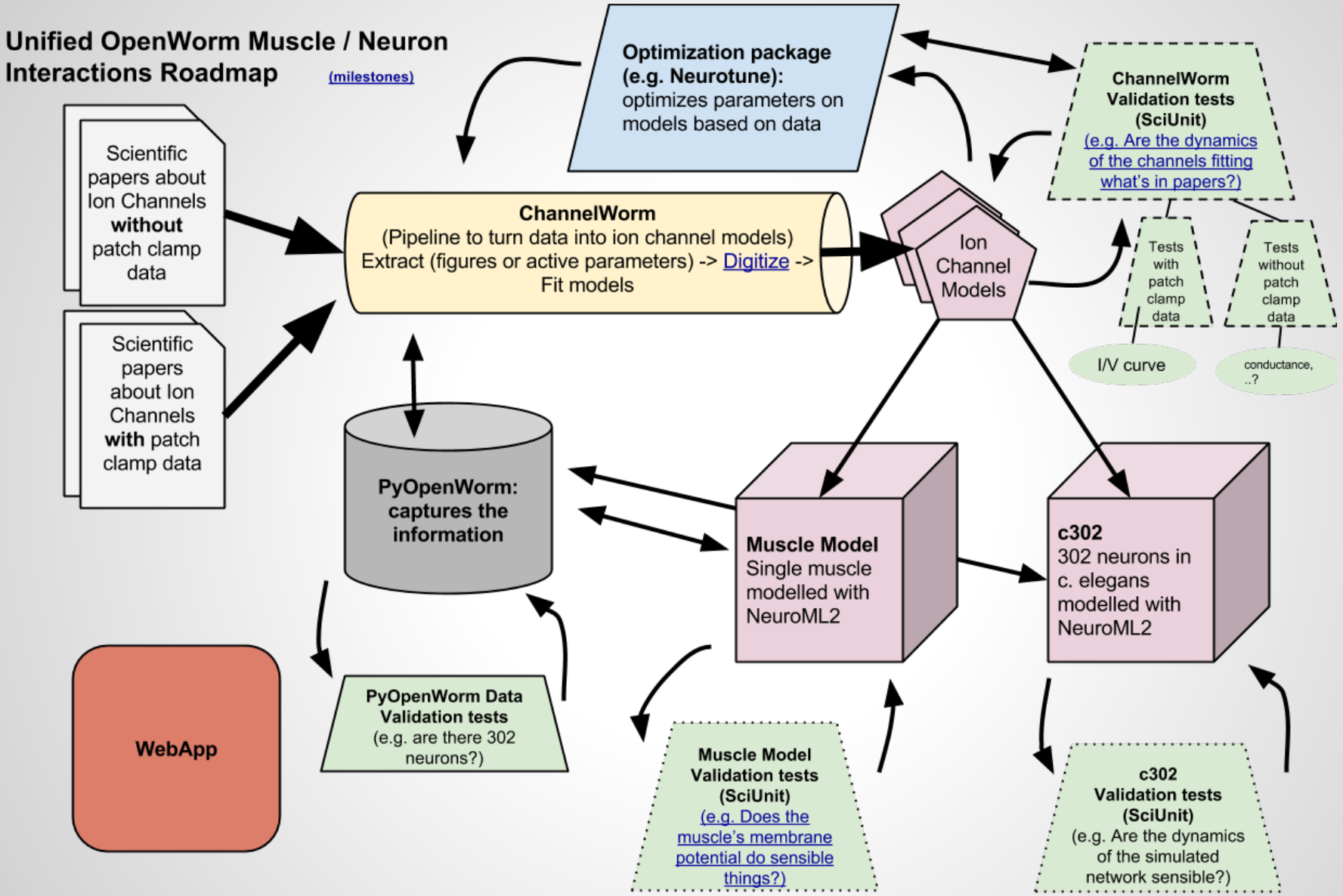
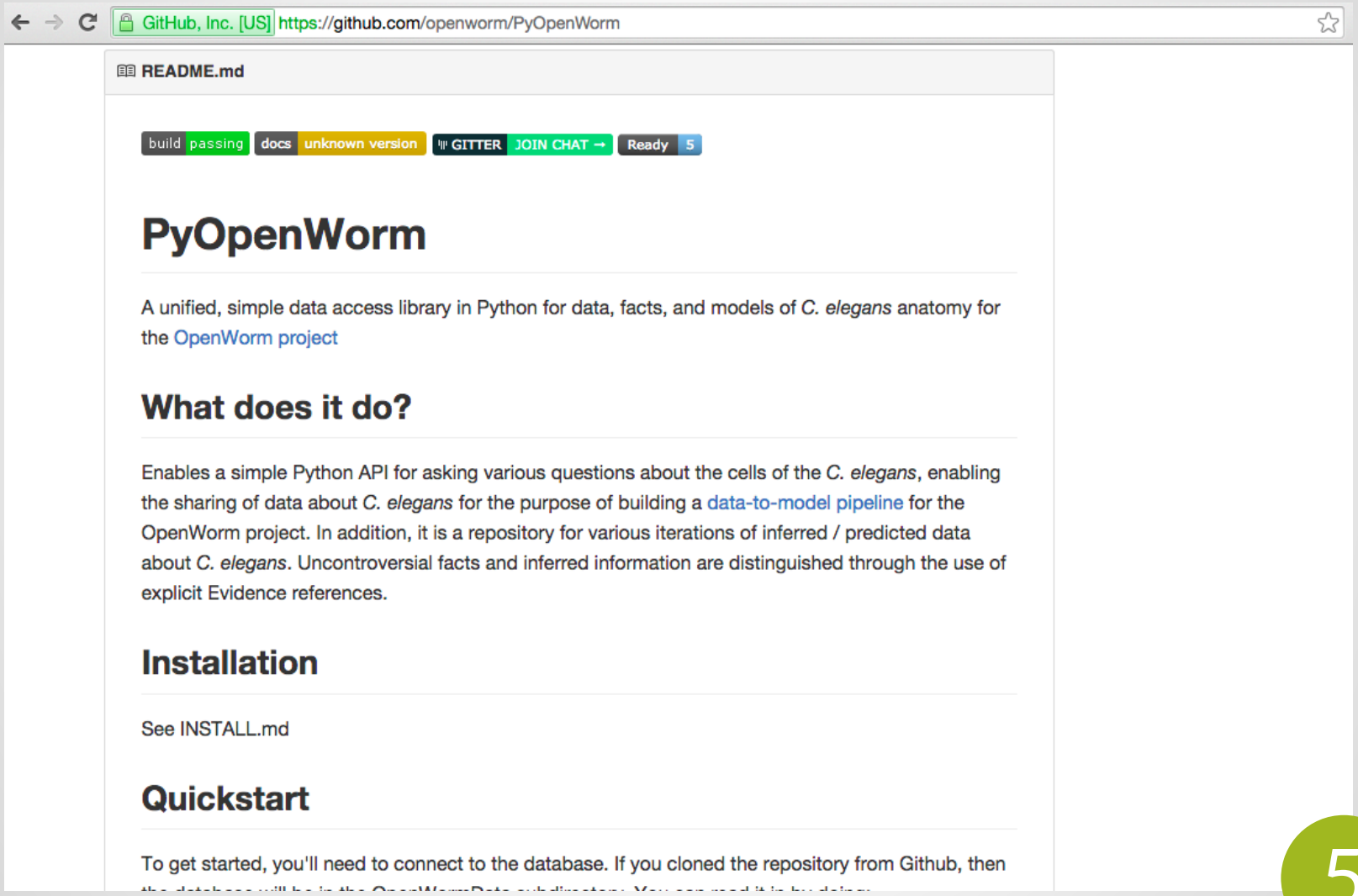


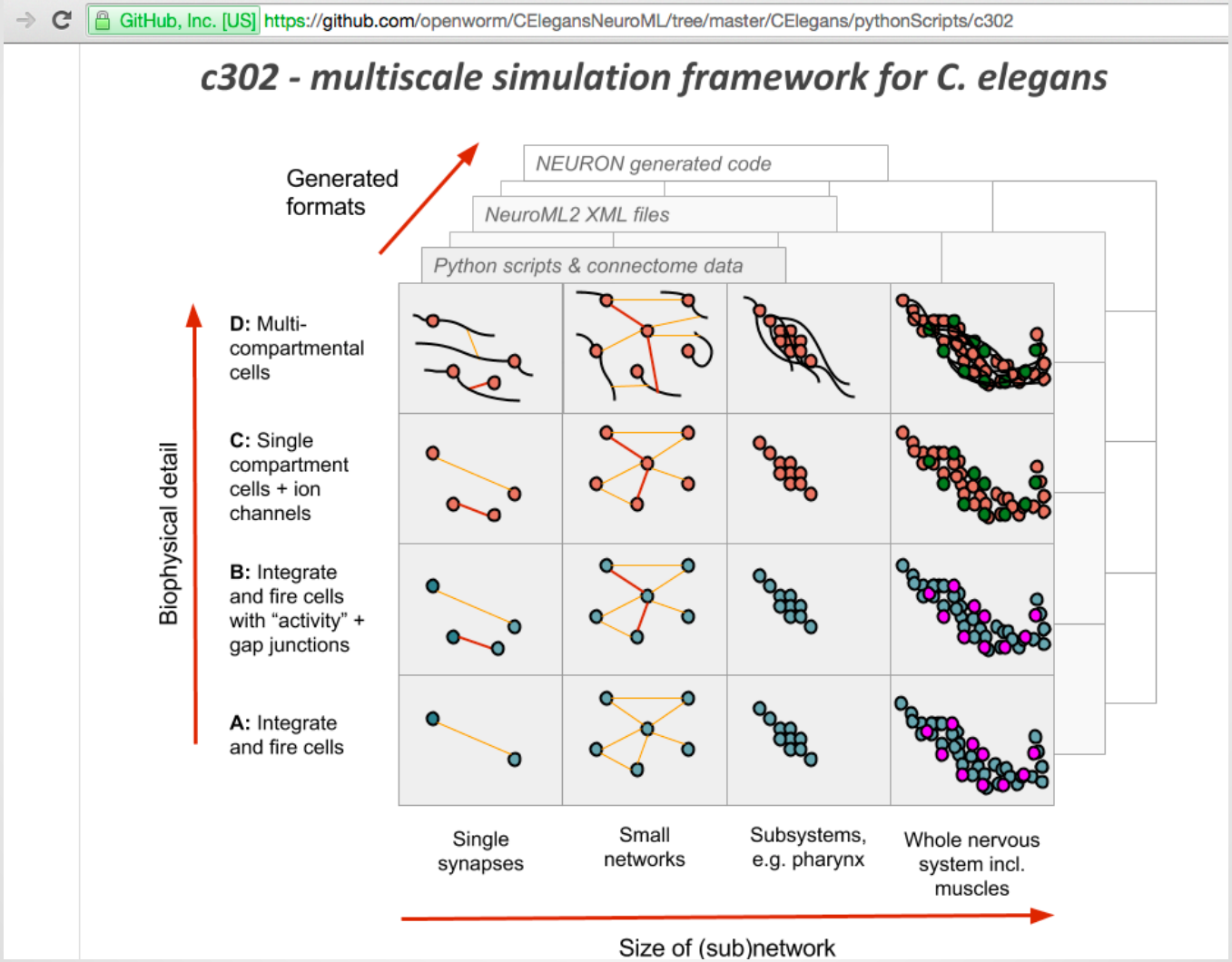
http://docs.openworm.org/en/latest/Projects/muscle-neuron-integration/

PyOpenWorm



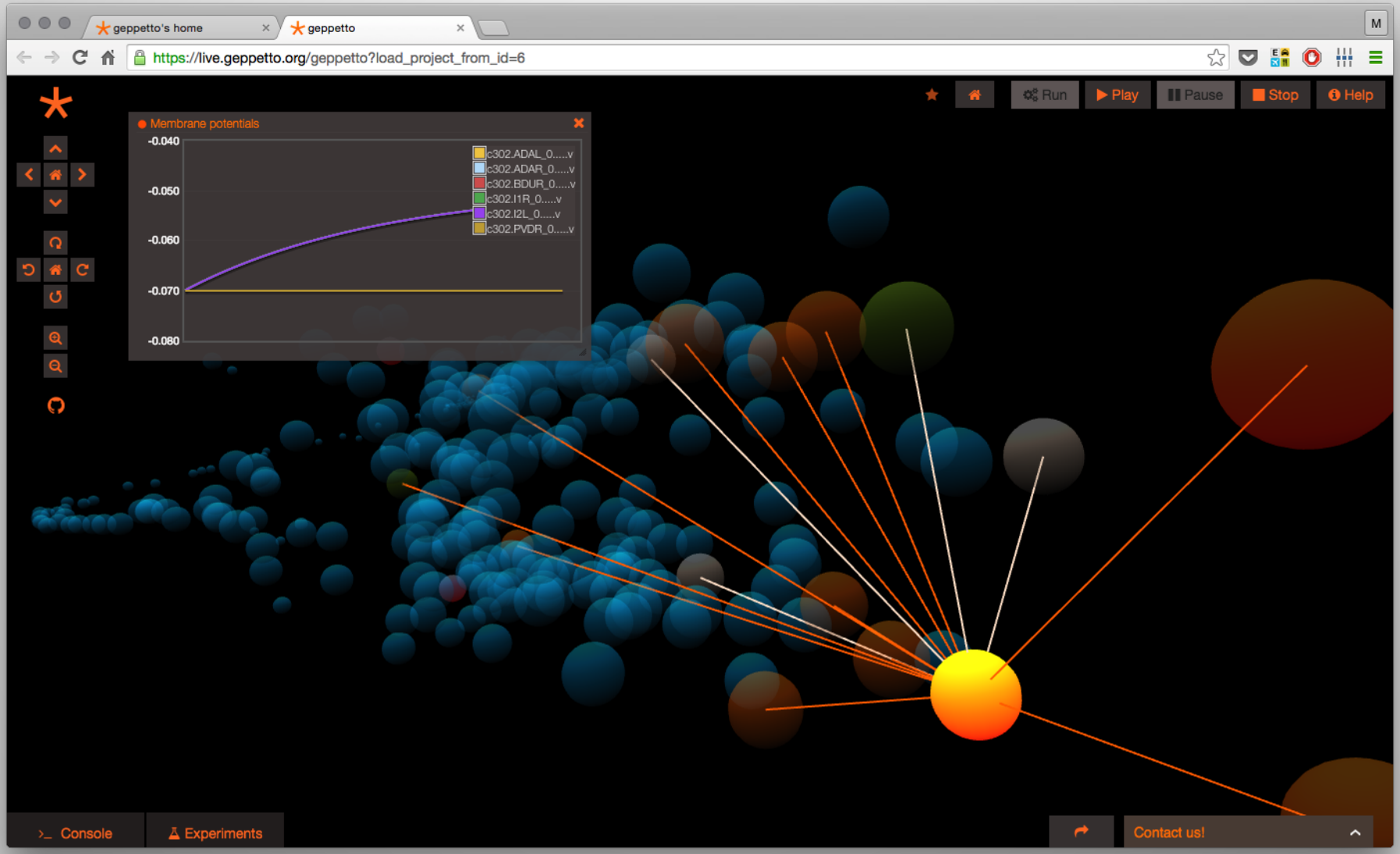
http://github.com/openworm/pyopenworm

c302 model generation framework



https://github.com/openworm/CElegansNeuroML/tree/master/CElegans/pythonScripts/c302

c302 generated network



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Model of a C. elegans muscle

GitHub, Inc. [US] https://github.com/openworm/muscle_model

build passing

Open Worm muscle model

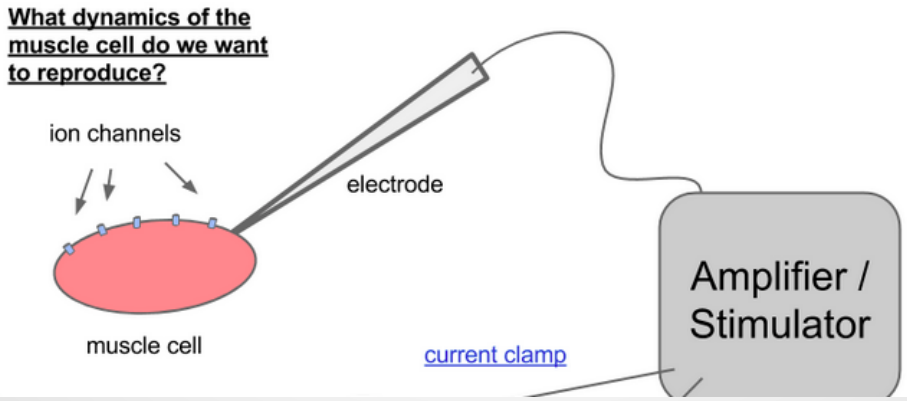
GITTER JOIN CHAT →

Authors: Mike Vella, Alex Dibert, Padraig Gleeson, Rayner Lucas email:mv333@cam.ac.uk

If you contribute to the project please add your name to the Authors field

Introduction

This repository contains several different subprojects all related to the construction of a biophysically-detailed model of the dynamic properties of electrical excitation of the body wall muscle of the c. elegans.



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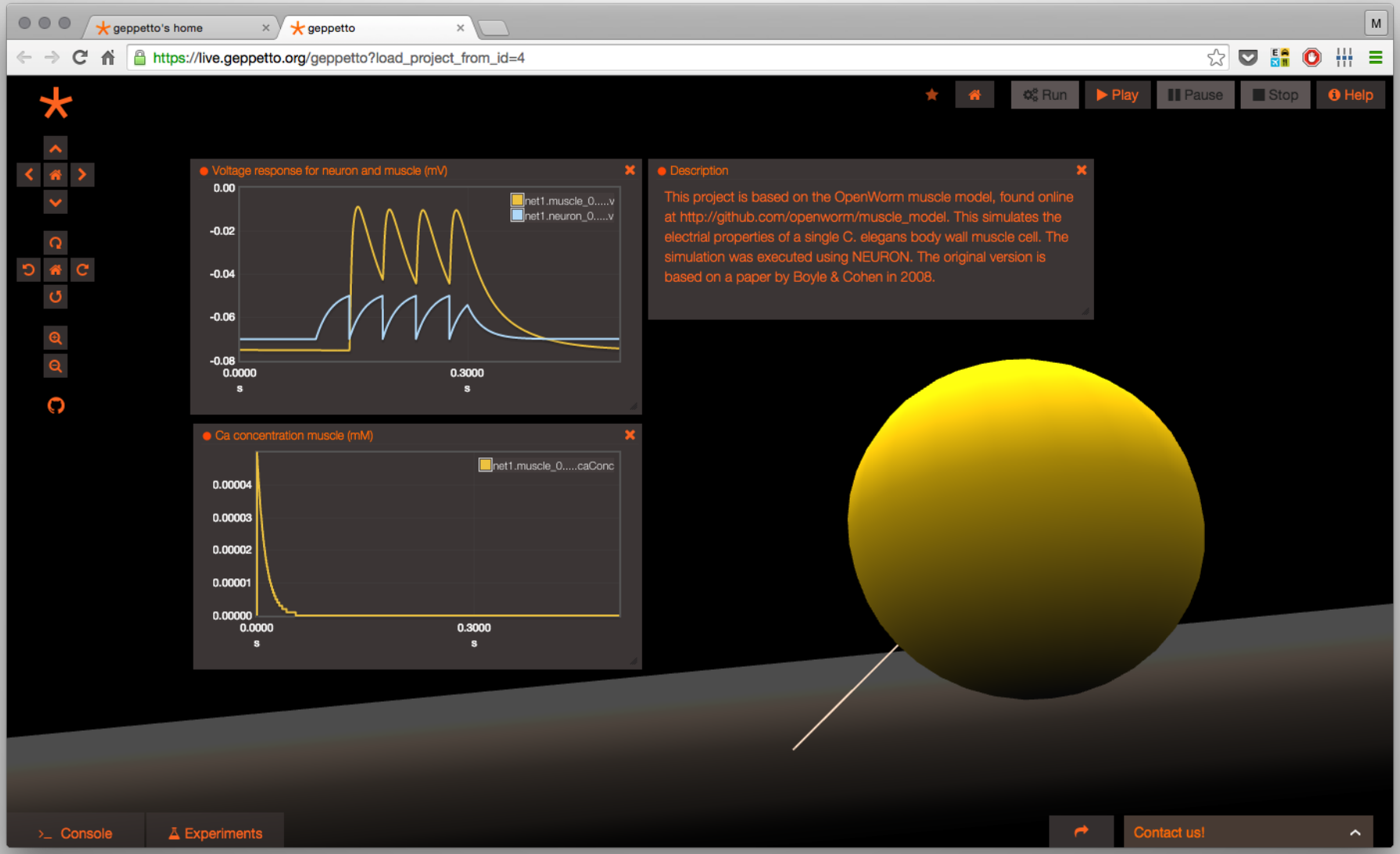

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ChannelWorm

ChannelWorm

docs latest | GITTER JOIN CHAT → | Ready 5 | build passing

The aim of the **ChannelWorm** is to integrate information and tools related to modeling ion channels in C. elegans for the OpenWorm Project.

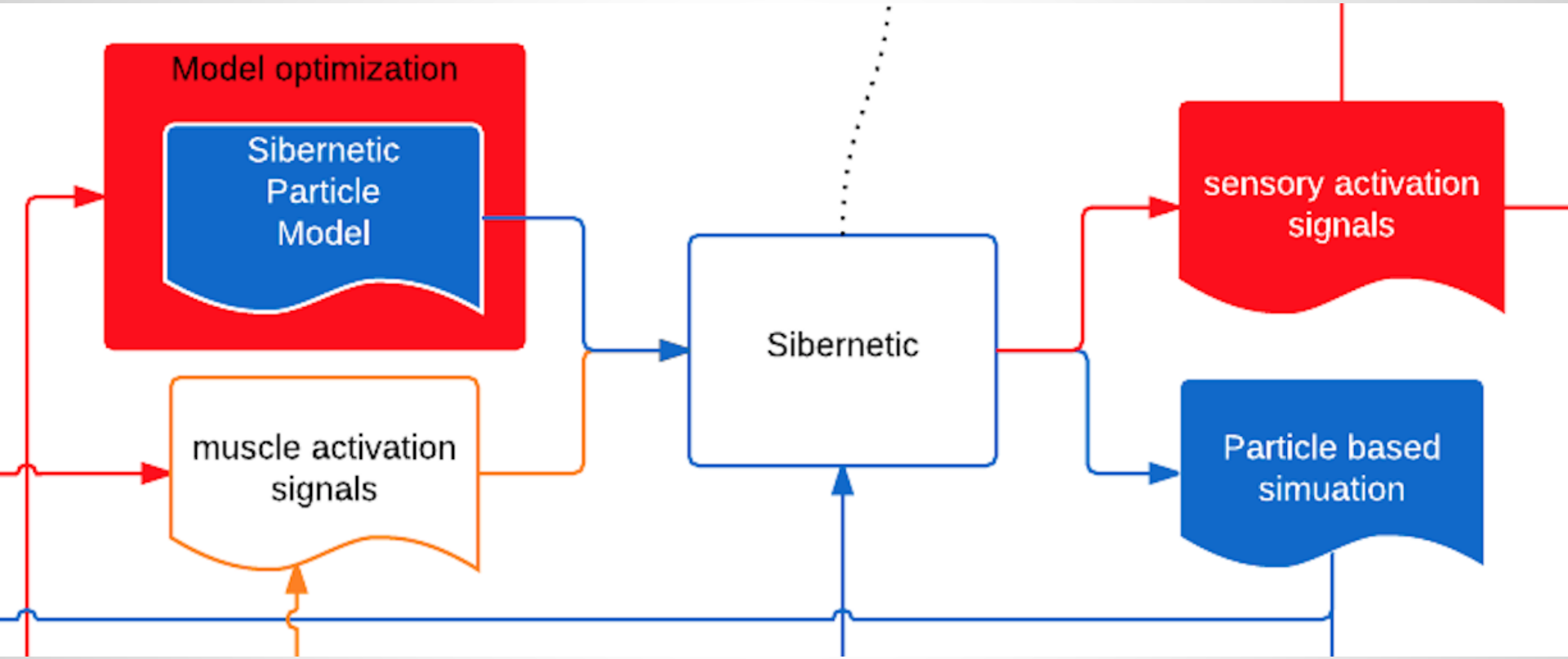
Objectives

- **Information Management**
  - Integrate and structure data related to ion channels in C. elegans, from genotype to phenotype
  - Develop APIs for accessing data
  - Keep data up-to-date
- **Ion channel modeling**
  - Build Hodgkin-Huxley models for ion channels based on experimental patch clamp studies
  - Estimate kinetics and build models for ion channels with no patch clamp data available (based on homologous channel types)
  - Create verification & validation tests to prove matching of the models with experimental data
- **Setting up a simulation environment**
  - Simulate the computational analysis phase of a patch clamp experiment
  - Simulate and run customized versions of ion channel(s) in cell(s)
  - Check if the simulation fits the biological boundaries

Some use cases

https://github.com/VahidGh/ChannelWorm/

Modelling the body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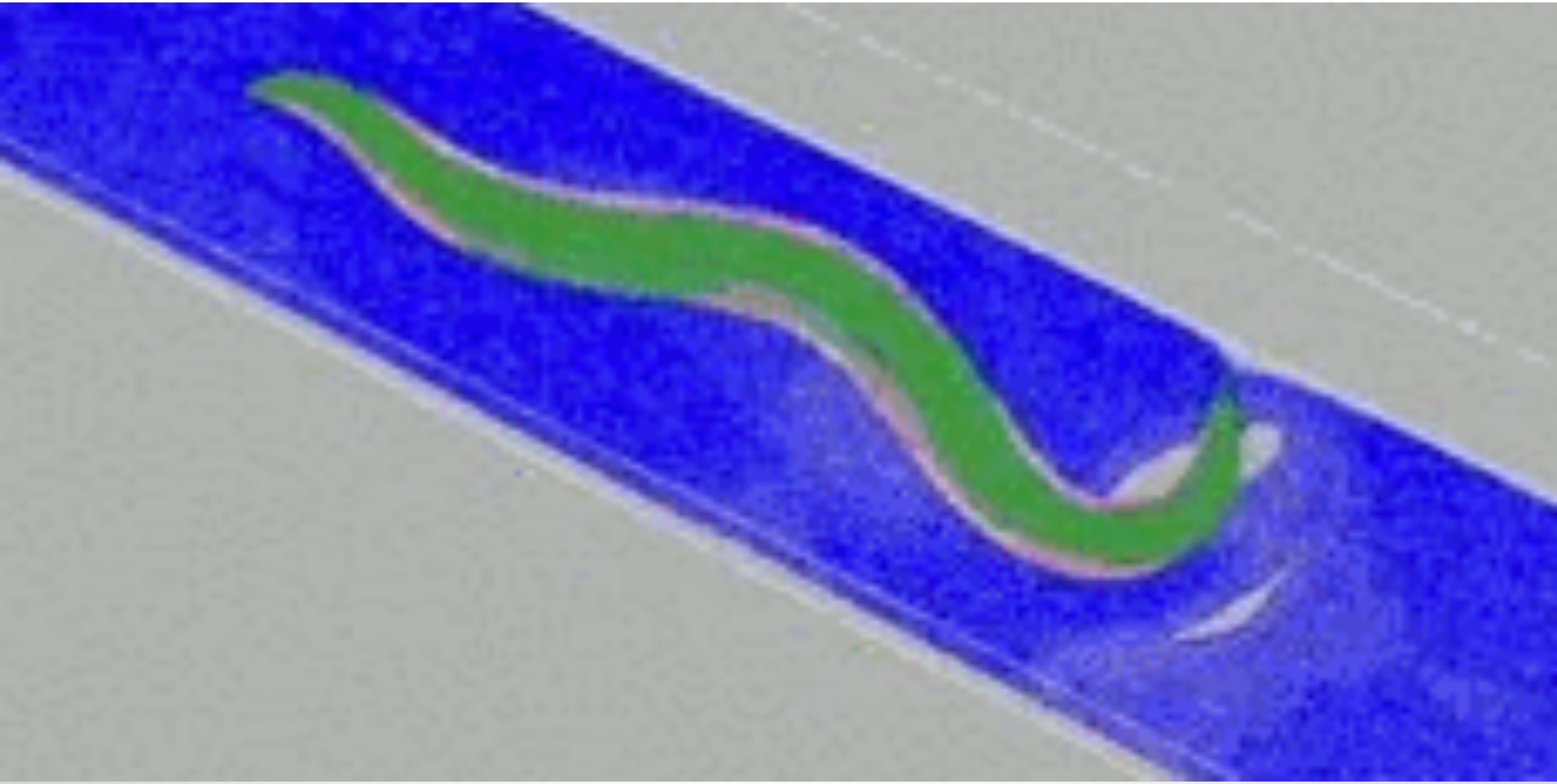
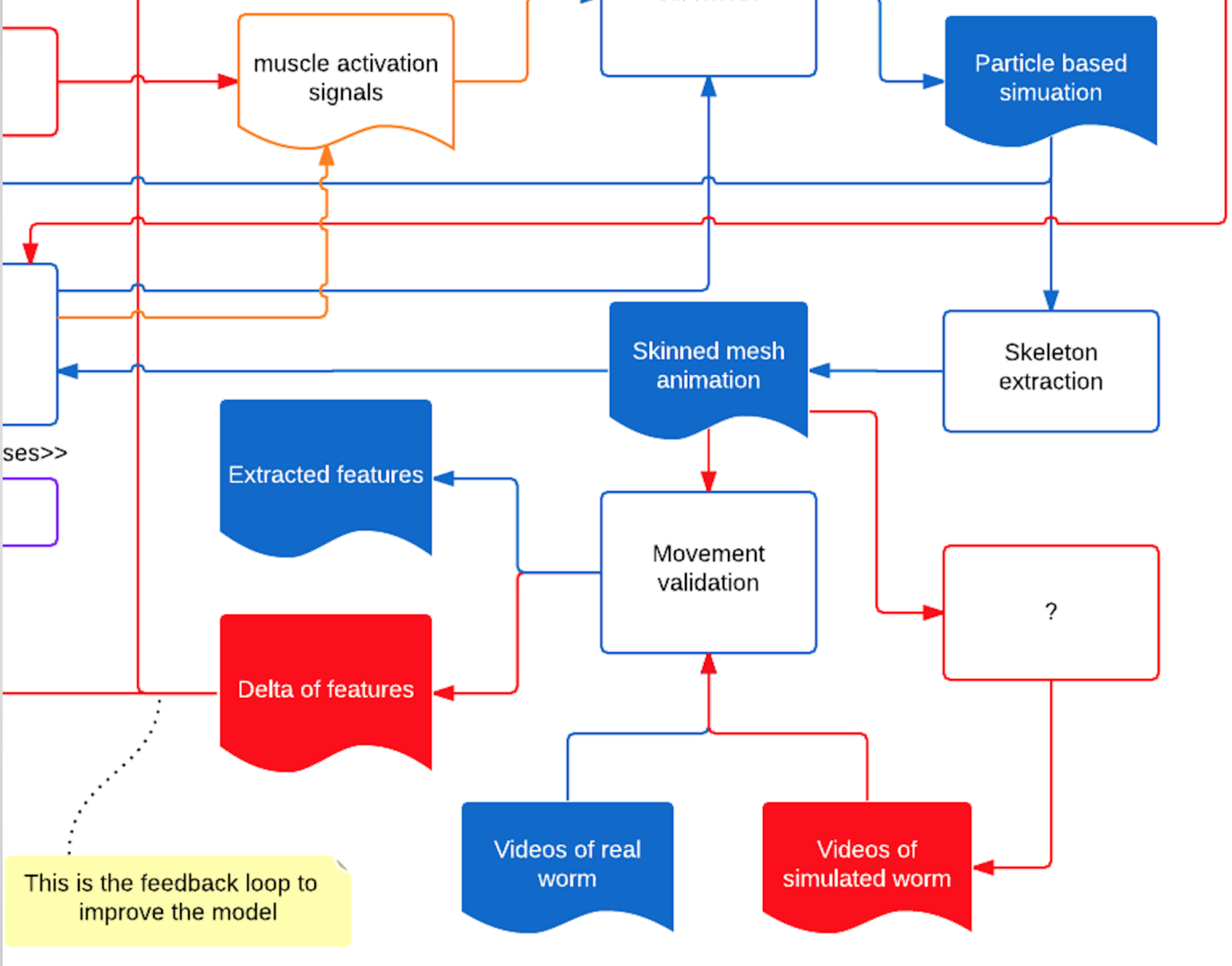


http://github.com/openworm/sibernetic

Palyanov et al., 2015, - In Revision

OpenWorm

Movement Validation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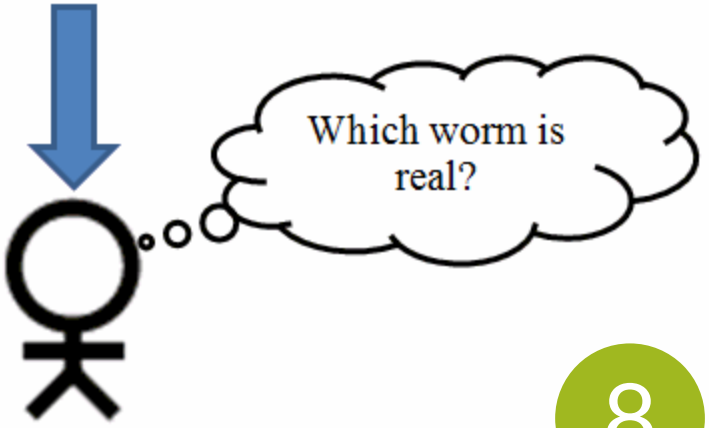
Movement validation

Real Worm → Raw video → Contour → Features

Simulated Worm → Generated video → Contour → Features

Statistical Comparison



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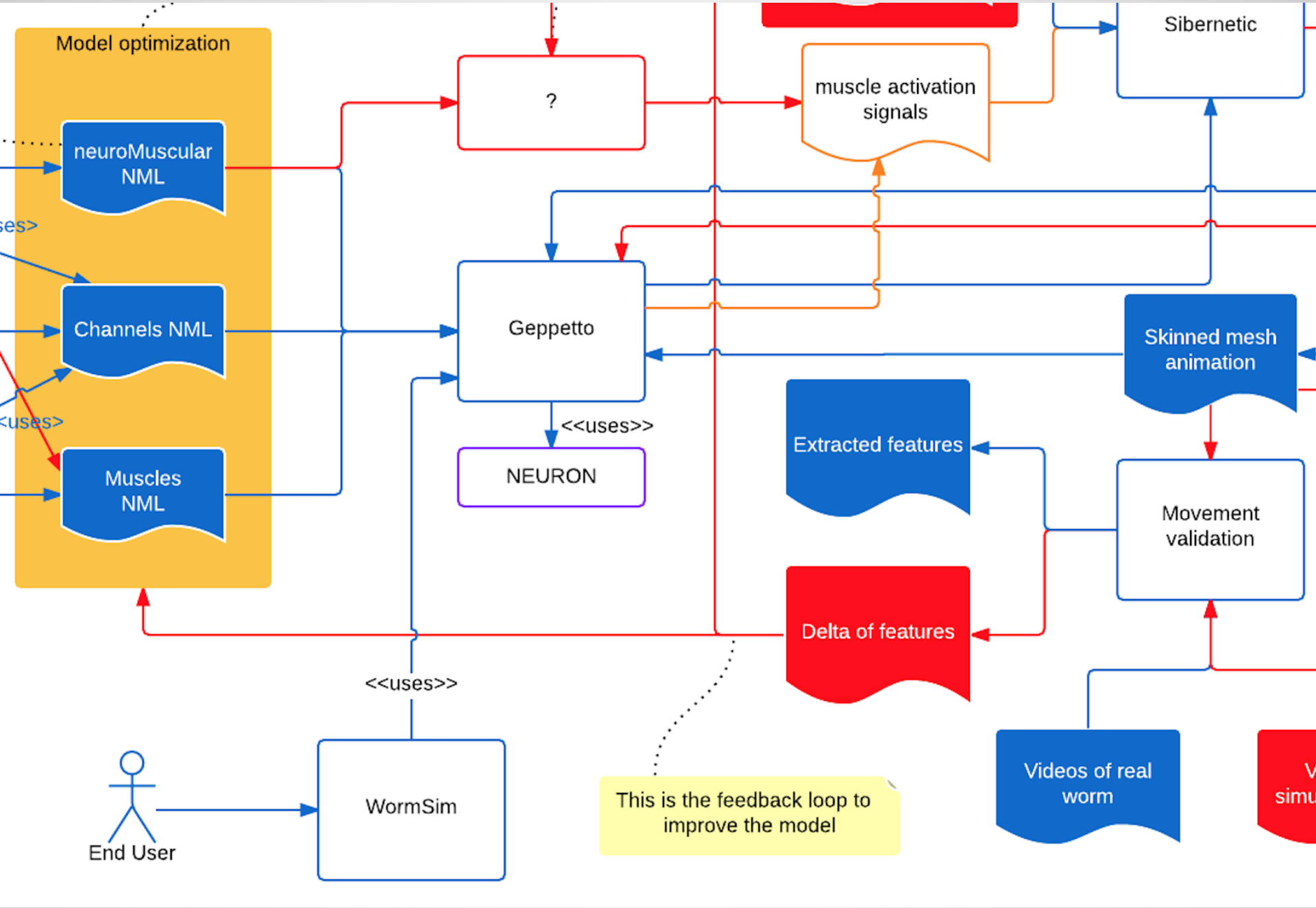
Model integration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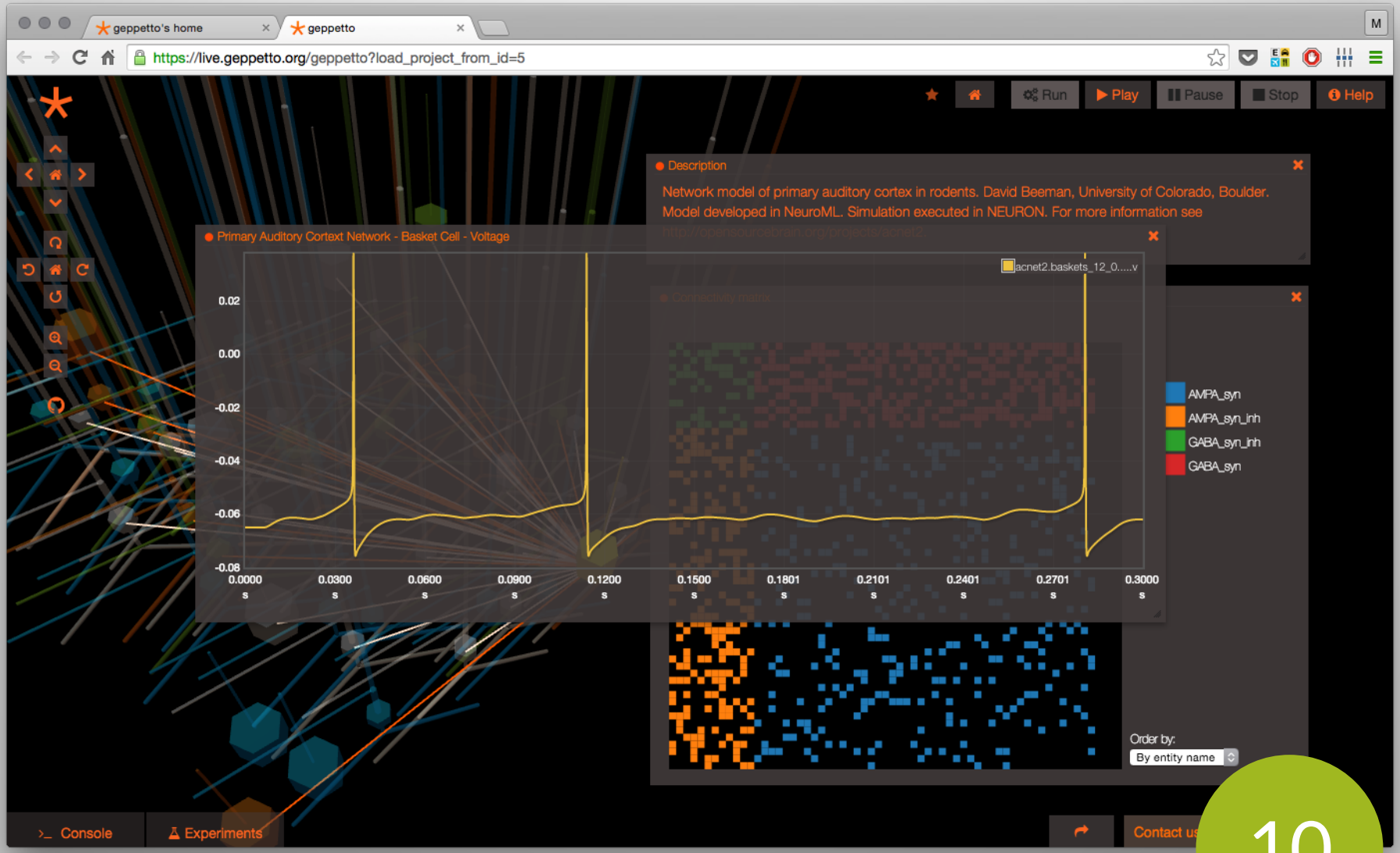

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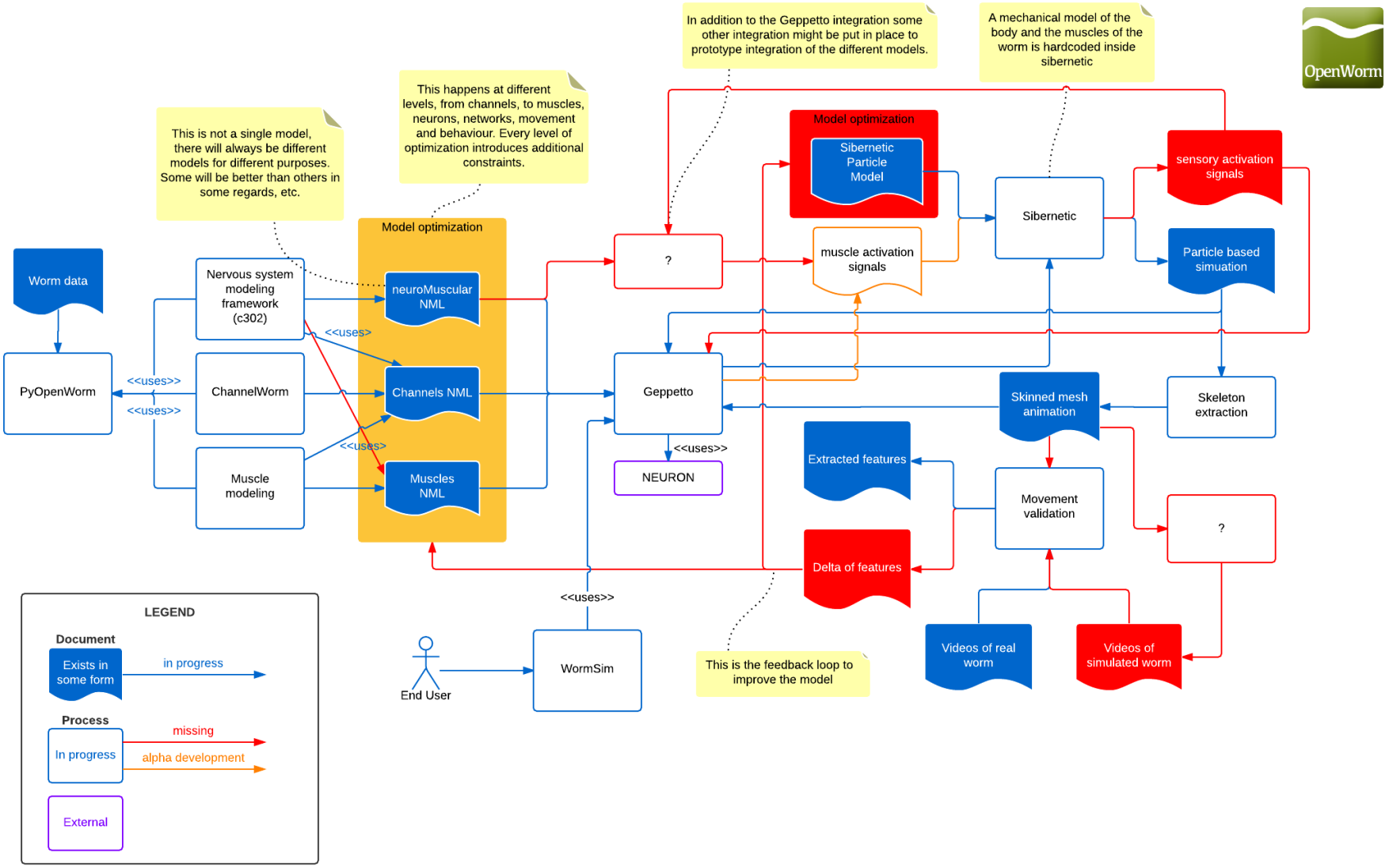
http://geppetto.org

Wormsim

funded with KICK STARTER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Recap

- OpenWorm is collaboratively building a c. elegans simulation in an open science manner
- The project is using a database of recorded worm behavior as its ground truth, in addition to reported cellular activity and observed anatomy
- Mechanical and neuronal simulations are currently used
- WormSim will let users interact with the different models and ultimately integrate them together

How can I contribute?

- Get in touch

info@openworm.org
http://openworm.org
@openworm

- Fork any of the repositories and issue a pull request
  - Join the conversations on GitHub

OpenWorm

wellcome trust

UCL

MRC Medical Research Council

funded with KICK STARTER

Caltech

Massachusetts Institute of Technology

Google Summer of Code 2014 Tenth Year

SALK INSTITUTE FOR BIOLOGICAL STUDIES

UC San Diego

UNIVERSITY OF LEEDS

Core team

Our Superheroes.

Andrey Palyanov, Balazs Szigeti, Giovanni Idili, Jim Hokanson, Matteo Cantarelli, Michael Currie, Padraig Gleeson, Sergey Khayrulin, Stephen Larson

Contributors

Helping us with amazing support. Thanks!

Abdullah Haroon, Adrian Quintana, Alexander Dibert, Alexander N, Allie Love, Andrew Leifer, Andrew Papadopoli, Ari Richman, Bóris Marin, Bradley Alicia, Charles Cooper, Christian Grove, Chris Jensen, Christina Lee, Christopher Perez, Credentiality, Crystin Slade, Dan Knudsen, Dan Kruchinin, David Dalrymple, Deanne Taylor, Dmitriy Shabanov, Dmitar Shterionov, Dominic Denicola, Domenico Luciani, Ellen McGowan, Eviatar Yemini, Gaston Gentile, Gleb Kuznetsov, Jay Coggan, Jesus Martinez, Joe Bowen, Johannes Rieke, John Hurliman, John White, Jordan Boyle, Jinze Yu, Marius Buibas, Mariusz Sasinski, Mark Watts, Martin Madaras, Matt Olson, Mike Vella, Mei Zhen, Nathan Daly, Netta Cohen, Pedro Tabacof, Peter McCluskey, Petr Baudis, Phil McElmurray, Rayner Lucas, Richard Gordon, Rich Stoner, Rick Gerkin, Steven Cook, Steve McGrew, Timothy Busbice, Travis Jacobs, Vanessa Adelmann, Vahid Ghayoomi

Thanks for the attention!

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