Modelling the Population Level and Beyond

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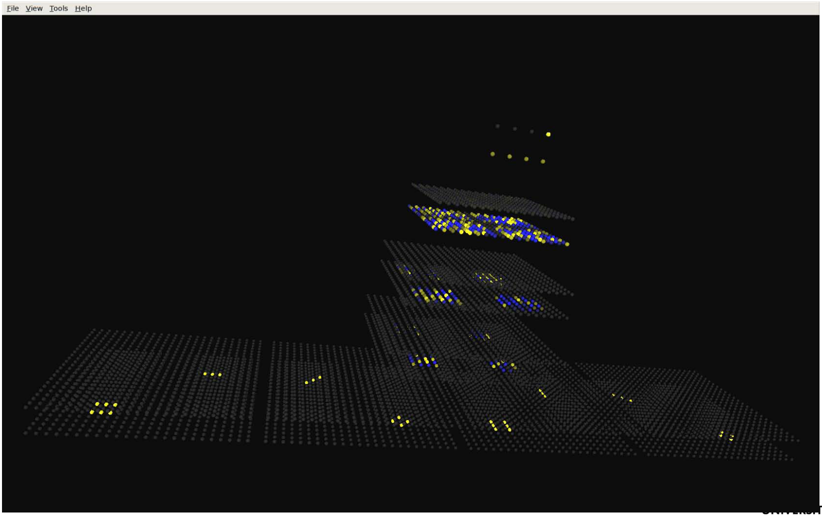
Funding for the Neurosciences

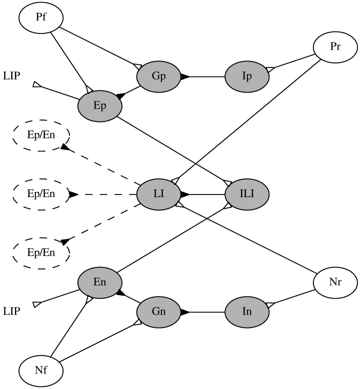
Three drivers:

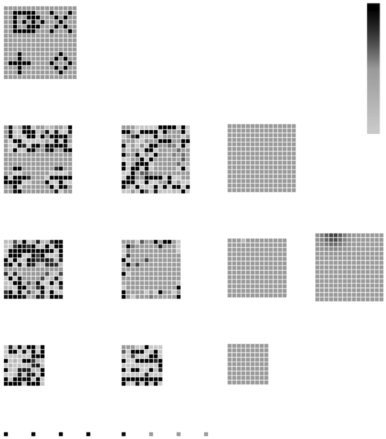
- Health related
- Brain-inspired technology
- Understanding brain/mi(i)nd

Spatial Structure

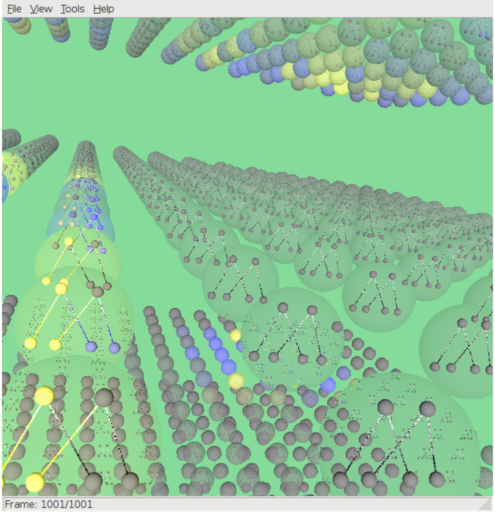


Local Circuit





Circuits



Outline

CLAMVis Top Level Elements

```
<CLAMVisProject name="XMLTest" xsi:noNamespaceSchemaLocation="CLAMVisProject.xsd">
  <ProjectDescription> Description of Project </ProjectDescription>
+<LayerDescriptions></LayerDescriptions>
+<Networks></Networks>
+<CircuitDescriptions></CircuitDescriptions>
+<DynamicNetworks></DynamicNetworks>
+<Mappers></Mappers>
+<Simulations></Simulations>
</CLAMVisProject>
```

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Layer Descriptions and Networks

```
<LayerDescriptions>
  <LayerDescription name="XML_V1" x_pixels="32" y_pixels="32" features="4"/>
  <LayerDescription name="XML_V2" x_pixels="30" y_pixels="30" x_field="3" y_field="3"/>
  <LayerDescription name="XML_V4" x_pixels="28" y_pixels="28" x_field="3" y_field="3"/>
  <LayerDescription name="XML_PIT" x_pixels="26" y_pixels="26" x_field="3" y_field="3"/>
  <LayerDescription name="XML_AIT" x_pixels="1" y_pixels="1" features="6" x_field="26"
 y_field="26"/>
  <LayerDescription name="LIP" x_pixels="32" y_pixels="32"/>
</LayerDescriptions>
<Networks>
-<Network name="ANN_FWD" filename="xml_all_fwd.net">
  -<Layers>
     <Layer>XML_V1</Layer>
     <Layer>XML_V2</Layer>
     <Layer>XML_V4</Layer>
     <Layer>XML_PIT</Layer>
     <Layer>XML_AIT</Layer>
   </Layers>
   <LinkRelation>DenseOverlapLinkRelation</LinkRelation>
   <TrainingParameters bias="0.01" momentum="0.0" sigma="0.25" stepsize="0.2"
   train_threshold="false" train_threshold_value="1e-5" init="true"
   training_set="xml_all.trainingset" noise_level="0.005" noise_strength="0.5"/>
  </Network>
+<Network name="ANN_REV" filename="xml_all_rev.net" reverse="ANN_FWD" type="Hebbian">
  </Network>
</Networks>
```

Circuit Descriptions

```
<CircuitDescriptions>
-<CircuitDescription name="perceptron" external="e_p" number_of_nodes="6">
   <CircuitNodeRole name="e_p" type="exc" x_pos="3.0" y_pos="0.0" z_pos="-2.0"/>
   <CircuitNodeRole name="i_p" type="inh" x_pos="-3.0" y_pos="0.0" z_pos="-2.0"/>
   <CircuitNodeRole name="e_n" type="exc" x_pos="1.0" y_pos="0.0" z_pos="-2.0"/>
   <CircuitNodeRole name="i_n" type="inh" x_pos="-1.0" y_pos="0.0" z_pos="-2.0"/>
   <CircuitNodeRole name="P_OUT" type="exc" x_pos="2.5" y_pos="0.0" z_pos="2.0"
   isOutput="true"/>
   <CircuitNodeRole name="N_OUT" type="exc" x_pos="-2.5" y_pos="0.0" z_pos="2.0"
   isOutput="true" isNegative="true"/>
   <Connection from="i_p" to="N_OUT" weight="-2.0"/>
   <Connection from="e_p" to="P_OUT" weight="2.0"/>
   <Connection from="i_n" to="P_OUT" weight="-2.0"/>
   <Connection from="e_n" to="N_OUT" weight="2.0"/>
  </CircuitDescription>
-<CircuitDescription name="lip_circuit" external="lipNode" number_of_nodes="1">
   <CircuitNodeRole name="lipNode" type="exc" x_pos="0.0" y_pos="0.0" z_pos="0.0"
   isOutput="true"/>
  </CircuitDescription>
</CircuitDescriptions>
```

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Dynamic Networks

```
<DynamicNetworks>
-<Parameters>
   <WilsonCowanParameter name="exc" time_membrane="20e-3" rate_maximum="1.0"
   noise="1.0"/>
   <WilsonCowanParameter name="inh" inhibitory="true" time_membrane="10e-3"
   rate_maximum="1.0" noise="1.0"/>
 </Parameters>
-<DynamicNetwork name="fwd" ANN="ANN_FWD" exc_param="exc" inh_param="inh">
   <CircuitCreator type="Perceptron" circuitDescription="perceptron"/>
  -<Layers>
     <Layer>XML_V1</Layer>
     <Layer>XML_V2</Layer>
     <Layer>XML_V4</Layer>
     <Layer>XML_PIT</Layer>
     <Layer>XML_AIT</Layer>
   </Layers>
 </DynamicNetwork>
</DynamicNetworks>
<Mappers>
-<Mapper type="GaussianLayerNodeMapper" from_network="fwd" to_network="disinhibition"
 from_layer="1" to_layer="0" sigma="0.1" strength="1.0">
   <Mapping from_id="P_OUT" to_id="i_gat_p" from_feature="0" to_feature="0"/>
   <Mapping from_id="P_OUT" to_id="e_dis_p" from_feature="0" to_feature="0"/>
   <Mapping from_id="N_OUT" to_id="i_gat_n" from_feature="0" to_feature="0"/>
   <Mapping from_id="N_OUT" to_id="e_dis_n" from_feature="0" to_feature="0"/>
 </Mapper>
</Mappers>
```

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Simulations


```
<Simulations>
-<Simulation name="Simulation">
  <SimulationDescription>Description of Simulation</SimulationDescription>
 -<SimulationPatterns>
   <SimulationPattern network="fwd">0 1 2 3</SimulationPattern>
   <SimulationPattern network="rev" time="0.5">3</SimulationPattern>
  </SimulationPatterns>
  <SimulationRunParameter max_iterations="100000000" start_time="0.0" end_time="1.0"
  report_time="1e-1" update_time="1e-2" network_step_time="1e-3" feedback_rate="0.35"
  feedback_time="0.5" progress_file_name="progress.txt"
  output_file_name="simulation_results.root"/>
 </Simulation>
</Simulations>
```


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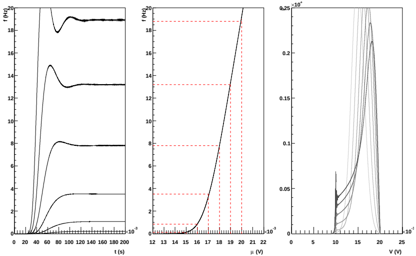
Is This Neuroscience?

Modelling Populations: MIIND

Sophisticated Population Dynamics

- Wilson-Cowan Dynamics
- Population Density method
    - Describes large populations of leaky-integrate-and-fire neurons
    - Fokker-Planck but better; no diffusion limit
    - $\rho(v)dv$: fraction of population with *membrane potential* in $[v, v + dv)$
    - Balance excitation-inhibition



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Short Demo

miind.xml - XML Copy Editor

File Edit View Insert XML Tools Help

miind.xml | omurtag.xml


```xml
<Simulation>
<WeightType>Pop</WeightType>
<Algorithms>
<Nodes>
<Node name="LIF E" type="EXCITATORY" algorithm="LIF_excitatory Algorithm"></Node>
<Node name="LIF I" type="INHIBITORY" algorithm="LIF_inhibitory Algorithm"></Node>
<Node name="Cortical Background" type="EXCITATORY" algorithm="Cortical Background Algorithm"></Node>
</Nodes>
<Connections>
<Connection In="LIF E" Out="LIF E">10000 0.000117647 0</Connection>
<Connection In="LIF I" Out="LIF I">2000 -0.00085531 0</Connection>
<Connection In="LIF E" Out="LIF I">10000 0.000285103 0</Connection>
<Connection In="LIF I" Out="LIF E">2000 -0.000352941 0</Connection>
<Connection In="Cortical Background" Out="LIF E">10000 0.000117647 0</Connection>
<Connection In="Cortical Background" Out="LIF I">10000 0.000285103 0</Connection>
</Connections>
<SimulationIO>
<SimulationName>two_pop</SimulationName>
<OnScreen>TRUE</OnScreen>
<WithState>TRUE</WithState>
<WriteNet>FALSE</WriteNet>
<CanvasParameter>
<T_min>0</T_min>
<T_max>0.05</T_max>
<State_min>0</State_min>
<State_max>0.02</State_max>
<F_max>10</F_max>
<Dense_max>250</Dense_max>
</CanvasParameter>
<CanvasNodes>Name="LIF E" Name="LIF I"</CanvasNodes>
</SimulationIO>
<SimulationRunParameter>
<max_iter>1000000</max_iter>
<t_begin>0</t_begin>
<t_end>0.05</t_end>
<t_report>1e-005</t_report>
<t_state_report>0.05</t_state_report>
<t_step>1e-005</t_step>
<t_update>1e-3</t_update>
<name_log>test/twopoptest.log</name_log>
```

Conclusions

- Many 'cognitive' models use stereotypic coding patterns which can easily be captured in XML
- The population is a natural bridge between 'basic' neuroscience and more higher level models
- The population level scales well, although it may not be appropriate in every situation
- Much replication effort can be avoided by extending the NeuroML, NineML domains
- Very much in the interest of the neurosciences, given the drivers for funding

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Status

- MIIND: public; XML available (slightly brittle). Documentation, patchy, but improving: `http://miind.sf.net`
- Soon: generic 1D neural model solver (not just LIF: QIF as well)
- Aim: Generic 2D population solver
  - Izhikevich
  - adaptive exponential
  - synapses
- Working on cloud implementation, web interface, tutorial
- ClamVis: Dave's project. Not really public but check out: `http://stacker.me.uk/~daveh/NetSimDocs/projectxmlformat.html`

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- Dave Harrison: modelling, XML stuff
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