Specification of channel distribution in NeuroML v2.0

Padraig Gleeson

*Lab of **Prof. R. Angus Silver***
Department of Neuroscience, Physiology and Pharmacology
University College London

Overview

- <biophysics> element of NeuroML v1.x has been updated

- Channel conductance densities are not always uniform across cell

- Models incorporate conductance densities which change as a function of parameters along cell

```xml
<biophysicalProperties id="bio_cell">

    <membraneProperties>

        <channelPopulation id="naChansDend" ionChannel="NaConductance" segment="2" number="120000"/>

        <channelDensity id="pasChans" ionChannel="pas" condDensity="3.0 S_per_m2"/>

        <channelDensity id="naChansSoma" ionChannel="NaConductance" segmentGroup="soma_group"
                        condDensity="120.0 mS_per_cm2"/>

        <specificCapacitance segmentGroup="soma_group" value="1.0 uF_per_cm2"/>

        <specificCapacitance segmentGroup="dendrite_group" value="2.0 uF_per_cm2"/>

        <reversalPotential species="na" value="55mV"/>

    </membraneProperties>

    <intracellularProperties>

        <species id="ca" concentration="1e-5 mM"/>

        <resistivity value="0.1 kohm_cm"/>

    </intracellularProperties>

</biophysicalProperties>
```

```
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        <channelDensity id="pasChans" ionChannel="pas" condDensity="3.0 S_per_m2"/>

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        <specificCapacitance segmentGroup="dendrite_group" value="2.0 uF_per_cm2"/>

        <reversalPotential species="na" value="55mV"/>

    </membraneProperties>

    <intracellularProperties>

        <species id="ca" concentration="1e-5 mM"/>

        <resistivity value="0.1 kohm_cm"/>

    </intracellularProperties>

</biophysicalProperties>
```

Distinction between properties of membrane & intracellular space

```
<biophysicalProperties id="bio_cell">

    <membraneProperties>

        <channelPopulation id="naChansDend" ionChannel="NaConductance" segment="2" number="120000"/>

        <channelDensity id="pasChans" ionChannel="pas" condDensity="3.0 S_per_m2"/>

        <channelDensity id="naChansSoma" ionChannel="NaConductance" segmentGroup="soma_group"
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        <reversalPotential species="na" value="55mV"/>

    </membraneProperties>

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        <resistivity value="0.1 kohm_cm"/>

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</biophysicalProperties>
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Channel populations allowed

The UK
Neuroinformatics Node
www.neuroinformatics.org.uk

```
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        <channelDensity id="pasChans" ionChannel="pas" condDensity="3.0 S_per_m2"/>

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        <reversalPotential species="na" value="55mV"/>

    </membraneProperties>

    <intracellularProperties>

        <species id="ca" concentration="1e-5 mM"/>

        <resistivity value="0.1 kohm_cm"/>

    </intracellularProperties>

</biophysicalProperties>
```

Specifying biophysics per segment or segmentGroup

```xml
<biophysicalProperties id="bio_cell">

    <membraneProperties>

        <channelPopulation id="naChansDend" ionChannel="NaConductance" segment="2" number="120000"/>

        <channelDensity id="pasChans" ionChannel="pas" condDensity="3.0 S_per_m2"/>

        <channelDensity id="naChansSoma" ionChannel="NaConductance" segmentGroup="soma_group"
                        condDensity="120.0 mS_per_cm2"/>

        <specificCapacitance segmentGroup="soma_group" value="1.0 uF_per_cm2"/>

        <specificCapacitance segmentGroup="dendrite_group" value="2.0 uF_per_cm2"/>

        <reversalPotential species="na" value="55mV"/>

    </membraneProperties>

    <intracellularProperties>

        <species id="ca" concentration="1e-5 mM"/>

        <resistivity value="0.1 kohm_cm"/>

    </intracellularProperties>

</biophysicalProperties>
```

Specifying ion properties by reversal potential or concentration

Variable parameters

```xml
<segmentGroup id="dendrite_group" neuroLexId="sao1211023249">
    <member segment="1"/>
    <member segment="2"/>
    <member segment="3"/>

    <!-- A parameter whose value varies from 0 at the start of the group closest to the soma
         to 1 at the most distal point of the segments in the group.-->

    <inhomogeneousParam id="dendrite_group_x1" variable="p1" metric="Path Length from root">
        <proximal translationStart="0"/>
        <distal normalizationEnd="1"/>
    </inhomogeneousParam>

    <!-- A parameter whose value varies from 0 at the start of the group closest to the soma (as it's
         attached to the soma) to 200 at the most distal point of the segments in the group.-->

    <inhomogeneousParam id="dendrite_group_x2" variable="p2" metric="Path Length from root"/>

</segmentGroup>
```

Variable parameters

```xml
<segmentGroup id="dendrite_group" neuroLexId="sao1211023249">
    <member segment="1"/>
    <member segment="2"/>
    <member segment="3"/>

    <!-- A parameter whose value varies from 0 at the start of the group closest to the soma
         to 1 at the most distal point of the segments in the group.-->

    <inhomogeneousParam id="dendrite_group_x1" variable="p1" metric="Path Length from root">
        <proximal translationStart="0"/>
        <distal normalizationEnd="1"/>
    </inhomogeneousParam>

    <!-- A parameter whose value varies from 0 at the start of the group closest to the soma (as it's
         attached to the soma) to 200 at the most distal point of the segments in the group.-->

    <inhomogeneousParam id="dendrite_group_x2" variable="p2" metric="Path Length from root"/>

</segmentGroup>
```
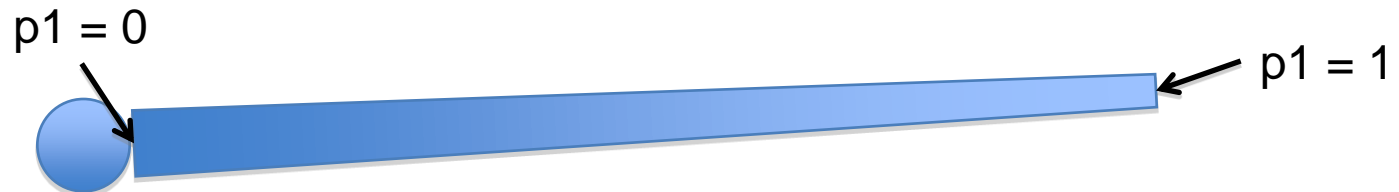
p1 = 0

p1 = 1

Variable parameters

```xml
<segmentGroup id="dendrite_group" neuroLexId="sao1211023249">
    <member segment="1"/>
    <member segment="2"/>
    <member segment="3"/>

    <!-- A parameter whose value varies from 0 at the start of the group closest to the soma
         to 1 at the most distal point of the segments in the group.-->

    <inhomogeneousParam id="dendrite_group_x1" variable="p1" metric="Path Length from root">
        <proximal translationStart="0"/>
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    </inhomogeneousParam>

    <!-- A parameter whose value varies from 0 at the start of the group closest to the soma (as it's
         attached to the soma) to 200 at the most distal point of the segments in the group.-->

    <inhomogeneousParam id="dendrite_group_x2" variable="p2" metric="Path Length from root"/>

</segmentGroup>
```
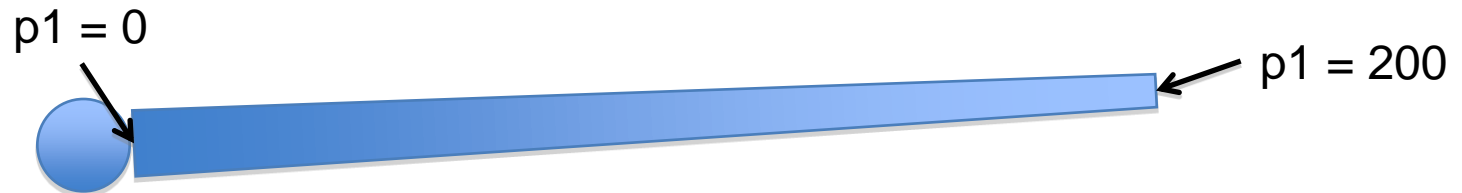
p1 = 0

p1 = 200

```
<channelDensity id="naChansSoma" ionChannel="NaConductance">

    <variableParameter parameter="condDensity" segmentGroup="dendrite_group">
        <!-- Will result in a condDensity of 0.2 at soma end, 0.1 at other end-->
        <inhomogeneousValue inhomogeneousParam="dendrite_group_x2" value="0.2 - 0.1(p2/200)"/>
    </variableParameter>

</channelDensity>
```

condDensity = 0.1

condDensity = 0.2