

Visual Cortex Network Rule Set

The rule set used by our model to grow the visual cortex network is shown below (see, Martin C. & Reggia J., Self-Assembly of Neural Networks Viewed as Swarm Intelligence, *TBA*, 2009, in preparation). The rules are placed in an ASCII text file and are read into the simulator at runtime. The simulator then parses the rule set and displays warnings if there are any syntax errors. After parsing, the rules are compiled into the simulator's internal representation, which is a tree structure. The parser treats all characters on a line following a % symbol as comments. In the file each rule is terminated by a colon.

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%File containing the rules used to grow the visual cortex network.
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%=====
%           BEGIN: Inhibitory Layer (Top)
%=====
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(Cell;IS;{B0};{0.1}) => <DivCell;[180,90]; <GenCell;IS;{B0};#>; <GenCell;IS;{D01};1>>:
(Cell;IS;{D0};{0.1}) => <DivCell;[0,90]; <GenCell;IS;{D0};#>; <GenCell;IS;{D01};1>>:
(Cell;IS;{D01};{0.1}) => <DivCell;[90,90]; <GenCell;IS;{D1};8>; <GenCell;IS;{D02};1>>:
(Cell;IS;{D02};{0.1}) => <DivCell;[270,90]; <GenCell;IS;{D2};8>; <GenCell;I;{D03};0>>:
(Cell;IS;{D1};{0.1}) => <DivCell;[90,90]; <GenCell;IS;{D1};#>; <GenCell;I;{D1};0>>:
(Cell;IS;{D2};{0.1}) => <DivCell;[270,90]; <GenCell;IS;{D2};#>; <GenCell;I;{D2};0>>:
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%=====
%           END: Inhibitory Layer (Top)
%=====
```

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%=====
%           BEGIN: Excitatory Layer (Middle)
%=====
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(Cell;ES;{A0};{0.1}) => <DivCell;[180,90]; <GenCell;ES;{A0};#>; <GenCell;ES;{C01};[0,0,0];1>>:
(Cell;ES;{C0};{0.1}) => <DivCell;[0,90]; <GenCell;ES;{C0};#>; <GenCell;ES;{C01};1>>:
(Cell;ES;{C01};{0.1}) => <DivCell;[90,90]; <GenCell;ES;{C1};8>; <GenCell;ES;{C02};1>>:
(Cell;ES;{C02};{0.1}) => <DivCell;[270,90]; <GenCell;ES;{C2};8>; <GenCell;E;{C03};0>>:
(Cell;ES;{C1};{0.1}) => <DivCell;[90,90]; <GenCell;ES;{C1};#>; <GenCell;E;{C1};0>>:
(Cell;ES;{C2};{0.1}) => <DivCell;[270,90]; <GenCell;ES;{C2};#>; <GenCell;E;{C2};0>>:
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%=====
%           END: Excitatory Layer (Middle)
%=====
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%=====
%           BEGIN: Afferent Layer (Bottom)
%=====

(Cell;AS;{G0};{0.1}) => <DivCell;[0,90]; <GenCell;AS;{G1};#>; <GenCell;AS;{G1};#>>:
(Cell;AS;{G1};{0.1}) => <DivCell;[90,90]; <GenCell;AS;{G0};#>; <GenCell;AS;{G0};#>>:
(Cell;AS;{G0,G1};{0.2}) => <SetCellType; A>:

%=====
%           END: Afferent Layer (Bottom)
%=====

%=====
% BEGIN: Axon Emissions from Inhibitory Layer (Top) to Excitatory Layer (Middle)
%=====

%After a specified period of time inhibitory cells are
%selected at random on regular intervals and given an "F50" tag.
(Cell;I;{F50};*) => <SetTags;{F51,D1}>:

(Cell;I;{F50};*) => <EmitAxon;[0,155]; <GenCone;{B1}>>:
(Cone;{B1};{0.035}) => <SetLocalForce;[0,157,25];0.5>:
(Cone;{B1};{0.5}) => <SetLocalForce;[0,180,25];3.0>:
(Cone;{B1};{1.0}) => <DivCone;[90,90]; <GenCone;{B11}>>:
(Cone;{B1};{1.0}) => <DivCone;[270,90]; <GenCone;{B12}>>:
(Cone;{B1};{2.0}) => <DivCone;[100,90]; <GenCone;{B13}>>:
(Cone;{B1};{2.0}) => <DivCone;[280,90]; <GenCone;{B14}>>:
(Cone;{B11};{0.05}) => <SetLocalForce;[90,180,25];3.0>:
(Cone;{B12};{0.05}) => <SetLocalForce;[270,180,25];3.0>:
(Cone;{B13};{0.05}) => <SetLocalForce;[100,180,25];2.5>:
(Cone;{B14};{0.05}) => <SetLocalForce;[280,180,25];2.5>:

(Cell;I;{F50};*) => <EmitAxon;[60,155]; <GenCone;{B2}>>:
(Cone;{B2};{0.035}) => <SetLocalForce;[60,157,25];0.5>:
(Cone;{B2};{0.5}) => <SetLocalForce;[60,180,25];3.0>:
(Cone;{B2};{1.0}) => <DivCone;[150,90]; <GenCone;{B21}>>:
(Cone;{B2};{1.0}) => <DivCone;[330,90]; <GenCone;{B22}>>:
(Cone;{B2};{2.0}) => <DivCone;[160,90]; <GenCone;{B23}>>:
(Cone;{B2};{2.0}) => <DivCone;[340,90]; <GenCone;{B24}>>:
(Cone;{B21};{0.05}) => <SetLocalForce;[150,180,25];3.0>:
(Cone;{B22};{0.05}) => <SetLocalForce;[330,180,25];3.0>:
(Cone;{B23};{0.05}) => <SetLocalForce;[160,180,25];2.5>:
(Cone;{B24};{0.05}) => <SetLocalForce;[340,180,25];2.5>:

(Cell;I;{F50};*) => <EmitAxon;[120,155]; <GenCone;{B3}>>:
(Cone;{B3};{0.035}) => <SetLocalForce;[120,157,25];0.5>:
(Cone;{B3};{0.5}) => <SetLocalForce;[120,180,25];3.0>:
(Cone;{B3};{1.0}) => <DivCone;[210,90]; <GenCone;{B31}>>:

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(Cone;{B3};{1.0}) => <DivCone;[30,90]; <GenCone;{B32}>>:
(Cone;{B3};{2.0}) => <DivCone;[220,90]; <GenCone;{B33}>>:
(Cone;{B3};{2.0}) => <DivCone;[40,90]; <GenCone;{B34}>>:
(Cone;{B31};{0.05}) => <SetLocalForce;[210,180,25];3.0>:
(Cone;{B32};{0.05}) => <SetLocalForce;[30,180,25];3.0>:
(Cone;{B33};{0.05}) => <SetLocalForce;[220,180,25];2.5>:
(Cone;{B34};{0.05}) => <SetLocalForce;[40,180,25];2.5>:

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(Cell;I;{F50};*) => <EmitAxon;[180,155]; <GenCone;{B4}>>:
(Cone;{B4};{0.035}) => <SetLocalForce;[180,157,25];0.5>:
(Cone;{B4};{0.5}) => <SetLocalForce;[180,180,25];3.0>:
(Cone;{B4};{1.0}) => <DivCone;[270,90]; <GenCone;{B41}>>:
(Cone;{B4};{1.0}) => <DivCone;[90,90]; <GenCone;{B42}>>:
(Cone;{B4};{2.0}) => <DivCone;[280,90]; <GenCone;{B43}>>:
(Cone;{B4};{2.0}) => <DivCone;[100,90]; <GenCone;{B44}>>:
(Cone;{B41};{0.05}) => <SetLocalForce;[270,180,25];3.0>:
(Cone;{B42};{0.05}) => <SetLocalForce;[90,180,25];3.0>:
(Cone;{B43};{0.05}) => <SetLocalForce;[280,180,25];2.5>:
(Cone;{B44};{0.05}) => <SetLocalForce;[100,180,25];2.5>:

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(Cell;I;{F50};*) => <EmitAxon;[240,155]; <GenCone;{B5}>>:
(Cone;{B5};{0.035}) => <SetLocalForce;[240,157,25];0.5>:
(Cone;{B5};{0.5}) => <SetLocalForce;[240,180,25];3.0>:
(Cone;{B5};{1.0}) => <DivCone;[150,90]; <GenCone;{B51}>>:
(Cone;{B5};{1.0}) => <DivCone;[330,90]; <GenCone;{B52}>>:
(Cone;{B5};{2.0}) => <DivCone;[160,90]; <GenCone;{B53}>>:
(Cone;{B5};{2.0}) => <DivCone;[340,90]; <GenCone;{B54}>>:
(Cone;{B51};{0.05}) => <SetLocalForce;[150,180,25];3.0>:
(Cone;{B52};{0.05}) => <SetLocalForce;[330,180,25];3.0>:
(Cone;{B53};{0.05}) => <SetLocalForce;[160,180,25];2.5>:
(Cone;{B54};{0.05}) => <SetLocalForce;[340,180,25];2.5>:

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(Cell;I;{F50};*) => <EmitAxon;[300,155]; <GenCone;{B6}>>:
(Cone;{B6};{0.035}) => <SetLocalForce;[300,157,25];0.5>:
(Cone;{B6};{0.5}) => <SetLocalForce;[300,180,25];3.0>:
(Cone;{B6};{1.0}) => <DivCone;[210,90]; <GenCone;{B61}>>:
(Cone;{B6};{1.0}) => <DivCone;[30,90]; <GenCone;{B62}>>:
(Cone;{B6};{2.0}) => <DivCone;[220,90]; <GenCone;{B63}>>:
(Cone;{B6};{2.0}) => <DivCone;[40,90]; <GenCone;{B64}>>:
(Cone;{B61};{0.05}) => <SetLocalForce;[210,180,25];3.0>:
(Cone;{B62};{0.05}) => <SetLocalForce;[30,180,25];3.0>:
(Cone;{B63};{0.05}) => <SetLocalForce;[220,180,25];2.5>:
(Cone;{B64};{0.05}) => <SetLocalForce;[40,180,25];2.5>:

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%=====
% END: Axon Emissions from Inhibitory Layer (Top) to Excitatory Layer (Middle)
%=====

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%=====
% BEGIN: Axon Emissions from Excitatory Layer (Middle) to Inhibitory Layer (Top)
%=====

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%After a specified period of time excitatory cells are
%selected at random on regular intervals and given an "E50" tag.
(Cell;E;{E50};*) => <SetTags;{H50,C1}>:

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(Cell;E;{E50};*) => <EmitAxon;[0,0]; <GenCone;{A1}>>:
(Cone;{A1};{0.035}) => <SetLocalForce;[0,0,25];2.0>:

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(Cone;{A1};{0.5}) => <DivCone;[0,90]; <GenCone;{A11}>>:
(Cone;{A11};{0.05}) => <DivCone;[90,90]; <GenCone;{A111}>>:
(Cone;{A11};{0.05}) => <DivCone;[270,90]; <GenCone;{A112}>>:
(Cone;{A11};{0.05}) => <SetLocalForce;[180,0,25];2.0>:
(Cone;{A111};{0.05}) => <SetLocalForce;[180,0,25];2.0>:
(Cone;{A112};{0.05}) => <SetLocalForce;[180,0,25];2.0>:

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(Cone;{A1};{0.5}) => <DivCone;[90,90]; <GenCone;{A12}>>:
(Cone;{A12};{0.05}) => <DivCone;[180,90]; <GenCone;{A121}>>:
(Cone;{A12};{0.05}) => <DivCone;[0,90]; <GenCone;{A122}>>:
(Cone;{A12};{0.05}) => <SetLocalForce;[270,0,25];2.0>:
(Cone;{A121};{0.05}) => <SetLocalForce;[270,0,25];2.0>:
(Cone;{A122};{0.05}) => <SetLocalForce;[270,0,25];2.0>:

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(Cone;{A1};{0.5}) => <DivCone;[180,90]; <GenCone;{A13}>>:
(Cone;{A13};{0.05}) => <DivCone;[90,90]; <GenCone;{A131}>>:
(Cone;{A13};{0.05}) => <DivCone;[270,90]; <GenCone;{A132}>>:
(Cone;{A13};{0.05}) => <SetLocalForce;[0,0,25];2.0>:
(Cone;{A131};{0.05}) => <SetLocalForce;[0,0,25];2.0>:
(Cone;{A132};{0.05}) => <SetLocalForce;[0,0,25];2.0>:

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(Cone;{A1};{0.5}) => <DivCone;[270,90]; <GenCone;{A14}>>:
(Cone;{A14};{0.05}) => <DivCone;[180,90]; <GenCone;{A141}>>:
(Cone;{A14};{0.05}) => <DivCone;[0,90]; <GenCone;{A142}>>:
(Cone;{A14};{0.05}) => <SetLocalForce;[90,0,25];2.0>:
(Cone;{A141};{0.05}) => <SetLocalForce;[90,0,25];2.0>:
(Cone;{A142};{0.05}) => <SetLocalForce;[90,0,25];2.0>:

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```

%=====
% END: Axon Emissions from Excitatory Layer (Middle) to Inhibitory Layer (Top)
%=====

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```

%=====
% BEGIN: Axon Emissions from Excitatory Layer (Middle) to Excitatory Layer (Middle)
%=====

```

```

%After a specified period of time excitatory cells are
%selected at random on regular intervals and given an "H50" tag.

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```

(Cell;E;{H50};*) => <SetTags;{H51,C1}>:

(Cell;E;{H50};*) => <EmitAxon;[0,60]; <GenCone;{C1}>>:
(Cone;{C1};{0.02}) => <SetLocalForce;[0,140,5];1>:

(Cell;E;{H50};*) => <EmitAxon;[60,60]; <GenCone;{C2}>>:
(Cone;{C2};{0.02}) => <SetLocalForce;[60,140,5];1>:

(Cell;E;{H50};*) => <EmitAxon;[120,60]; <GenCone;{C3}>>:
(Cone;{C3};{0.02}) => <SetLocalForce;[120,140,5];1>:

(Cell;E;{H50};*) => <EmitAxon;[180,60]; <GenCone;{C4}>>:
(Cone;{C4};{0.02}) => <SetLocalForce;[180,140,5];1>:

(Cell;E;{H50};*) => <EmitAxon;[240,60]; <GenCone;{C5}>>:
(Cone;{C5};{0.02}) => <SetLocalForce;[240,140,5];1>:

(Cell;E;{H50};*) => <EmitAxon;[300,60]; <GenCone;{C6}>>:
(Cone;{C6};{0.02}) => <SetLocalForce;[300,140,5];1>:

%=====
% END: Axon Emissions from Excitatory Layer (Middle) to Excitatory Layer (Middle)
%=====

%=====
% BEGIN: Axon Emissions from Afferent Layer (Bottom) to Excitatory Layer (Middle)
%=====

%After a specified period of time afferent cells are
%selected at random on regular intervals and given a "G50" tag.
(Cell;A;{G50};*) => <SetTags;{G51}>:

(Cell;A;{G50};*) => <EmitAxon;[0,35]; <GenCone;{G1}>>:
(Cone;{G1};{0.3}) => <DivCone;[90,90]; <GenCone;{G11}>>:
(Cone;{G1};{0.3}) => <DivCone;[270,90]; <GenCone;{G12}>>:
(Cone;{G1};{0.05}) => <SetLocalForce;[0,60,25];5.0>:
(Cone;{G11};{0.05}) => <SetLocalForce;[30,60,25];5.0>:
(Cone;{G12};{0.05}) => <SetLocalForce;[330,60,25];5.0>:

(Cell;A;{G50};*) => <EmitAxon;[60,35]; <GenCone;{G2}>>:
(Cone;{G2};{0.3}) => <DivCone;[150,90]; <GenCone;{G21}>>:
(Cone;{G2};{0.3}) => <DivCone;[330,90]; <GenCone;{G22}>>:
(Cone;{G2};{0.05}) => <SetLocalForce;[60,60,25];5.0>:
(Cone;{G21};{0.05}) => <SetLocalForce;[90,60,25];5.0>:
(Cone;{G22};{0.05}) => <SetLocalForce;[30,60,25];5.0>:

(Cell;A;{G50};*) => <EmitAxon;[120,35]; <GenCone;{G3}>>:
(Cone;{G3};{0.3}) => <DivCone;[210,90]; <GenCone;{G31}>>:
(Cone;{G3};{0.3}) => <DivCone;[30,90]; <GenCone;{G32}>>:
(Cone;{G3};{0.05}) => <SetLocalForce;[120,60,25];5.0>:

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(Cone;{G31};{0.05}) => <SetLocalForce;[150,60,25];5.0>:
(Cone;{G32};{0.05}) => <SetLocalForce;[90,60,25];5.0>:

(Cell;A;{G50};*) => <EmitAxon;[180,35]; <GenCone;{G4}>>:
(Cone;{G4};{0.3}) => <DivCone;[270,90]; <GenCone;{G41}>>:
(Cone;{G4};{0.3}) => <DivCone;[90,90]; <GenCone;{G42}>>:
(Cone;{G4};{0.05}) => <SetLocalForce;[180,60,25];5.0>:
(Cone;{G41};{0.05}) => <SetLocalForce;[210,60,25];5.0>:
(Cone;{G42};{0.05}) => <SetLocalForce;[150,60,25];5.0>:

(Cell;A;{G50};*) => <EmitAxon;[240,35]; <GenCone;{G5}>>:
(Cone;{G5};{0.3}) => <DivCone;[330,90]; <GenCone;{G51}>>:
(Cone;{G5};{0.3}) => <DivCone;[150,90]; <GenCone;{G52}>>:
(Cone;{G5};{0.05}) => <SetLocalForce;[240,60,25];5.0>:
(Cone;{G51};{0.05}) => <SetLocalForce;[270,60,25];5.0>:
(Cone;{G52};{0.05}) => <SetLocalForce;[210,60,25];5.0>:

(Cell;A;{G50};*) => <EmitAxon;[300,35]; <GenCone;{G6}>>:
(Cone;{G6};{0.3}) => <DivCone;[30,90]; <GenCone;{G61}>>:
(Cone;{G6};{0.3}) => <DivCone;[210,90]; <GenCone;{G62}>>:
(Cone;{G6};{0.05}) => <SetLocalForce;[300,60,25];5.0>:
(Cone;{G61};{0.05}) => <SetLocalForce;[330,60,25];5.0>:
(Cone;{G62};{0.05}) => <SetLocalForce;[270,60,25];5.0>:

%Set rule-based force of growth cones towards excitatory layer (middle).
(Cone;{T0};{0.05}) => <SetLocalForce;[0,30,25];10>:
(Cone;{T1};{0.05}) => <SetLocalForce;[90,30,25];10>:
(Cone;{T2};{0.05}) => <SetLocalForce;[180,30,25];10>:
(Cone;{T3};{0.05}) => <SetLocalForce;[270,30,25];10>:
(Cone;{T4};{0.05}) => <SetLocalForce;[0,30,25];10>:
(Cone;{T5};{0.05}) => <SetLocalForce;[0,30,25];10>:
(Cone;{T6};{0.05}) => <SetLocalForce;[0,30,25];10>:
(Cone;{T7};{0.05}) => <SetLocalForce;[0,30,25];10>:

(Cone;{G1,G2,G3,G4,G5,G6,G11,G12,G21,G22,G31,G32,G41,G42,G51,G52,G61,G62};
{0.3,0.8,1.2,1.4}) => <DivCone;[0,0]; <GenCone;{L1,D1,T0}>>:

(Cone;AND{L1,D1,T0};{0.02}) => <SetLocalForce;[0,0,25];10>:

%Pattern of growth cone divisions. "+" gives tag T(#+1)
(Cone;AND{L1,D1};{0.2}) => <DivCone;[90,90]; <GenCone;{L1,D2,+}>>:
(Cone;AND{L1,D1};{0.2}) => <DivCone;[270,90]; <GenCone;{L1,D2,+}>>:

(Cone;AND{L1,D2};{0.2}) => <DivCone;[0,90]; <GenCone;{L1,D1,+}>>:
(Cone;AND{L1,D2};{0.2}) => <DivCone;[180,90]; <GenCone;{L1,D1,+}>>:

%No more divisions for this growth cone.
(Cone;{L1};{0.2}) => <SetTags;{L0}>:

%Halt divisions at T4.
(Cone;{T4};{0.02}) => <SetTags;{L0}>:

```

```
%=====
%  END: Axon Emissions from Afferent Layer (Bottom) to Excitatory Layer (Middle)
%=====
```

```
%=====
%BEGIN: LGF rules
%=====
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```
%Duration of 10000 means LGF (Local Growth Force) lasts throughout simulation.
(Cell;I;{D03,D1,D2};{0.05}) => <SetLGF;-;10;10000>:
(Cell;E;{C03,C1,C2};{0.05}) => <SetLGF;-;10;10000>:
```

```
%=====
%END: LGF rules
%=====
```