# Motifs and higher-order patterns

The purpose of this document is to collect (biologically inspired) motifs and patterns.

# Design Operators

Diagram

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# Higher order motifs

## Inhibition related

**Inhibition**: this connection always persists

A picture containing text, clock

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**Second-order inhibition**: with an intermediate neuron [Mathias Lechner, (2017) Brain-inspired Neural Control (Master Thesis)]

Diagram

Description automatically generated

Extra condition: Intermediate neuron can be activated or inhibited

|  |  |
| --- | --- |
| A picture containing clock  Description automatically generated | Diagram  Description automatically generated |

## Activation related

**Second-order activation**: like inhibition

## Sequencing related

**Sequencing Design Operator**

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Description automatically generated

**Indirect sequencing** [Mathias Lechner, (2017) Brain-inspired Neural Control (Master Thesis)]

Diagram

Description automatically generated

Extra condition: Intermediate neurons can be activated or inhibited

A picture containing text, clock, sign

Description automatically generated

# Generalization of Dos [Mathias Lechner, (2017) Brain-inspired Neural Control (Master Thesis)]

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Self-activation

Conservation

General conservation (Connections should be all-to-all)

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Self-inhibition

Selection: Mutual exclusion/„Winner-takes-all“ topology/flip-flop circuit

General selection

# Selection in animals

## Mutual exclusion/flip-flop in *C. elegans*

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[Z. Li, Y. Li, Y. Yi, W. Huang, S. Yang, W. Niu, L. Zhang, Z. Xu, A. Qu, Z. Wu, and T. Xu. (2012). Dissecting a central flip-flop circuit that integrates contradictory sensory cues in *C. elegans* feeding regulation]

## In birds’ midbrain

Diagram

Description automatically generatedComputational model:

Lateral inhibitory circuit

- with long-range projections from the inhibitory units (red ovals) to the excitatory output units (black circles).

Channel (1): target stimulus

Channel (2): a competitor stimulus (there can be many)

Reciprocal feedback inhibition: between inhibitory units, solid red lines

[Goddard CA et al. (2014) Spatially reciprocal inhibition of inhibition within a stimulus selection network in the avian midbrain]

Diagram

Description automatically generatedSchematic of midbrain selection network

Neurons in layer 10 of the OT (white circles, grey dendrites) send topographic projections to Imc neurons (red ovals)

Imc neurons send widespread GABAergic projections to neurons in the intermediate/deep layers of the OT (black circles).

Putative reciprocal inhibition between spatial channels is depicted with dashed lines.

OT: optic tectum

Imc: isthmi pars magnocellularis

flexible selection of the strongest stimulus observed in the OT

* Interesting architecture: selection happens in a different region and its result is projected back to deeper layers (layer 13)

[Goddard CA et al. (2014) Spatially reciprocal inhibition of inhibition within a stimulus selection network in the avian midbrain]

# Other motifs

## Convergence and divergence

Diagram

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Convergence: receiving input from many neurons

Divergence: communicate with many neurons

Microcircuits: few interconnected neurons

Macrocircuits: multiple microcircuits, higher brain functions

[John H. Byrne, Ph.D., Department of Neurobiology and Anatomy, McGovern Medical School, Introduction to Neurons and Neuronal Networks]