

Learning Topology and Geometry

Automated Grammar Induction

Linas Vepstas

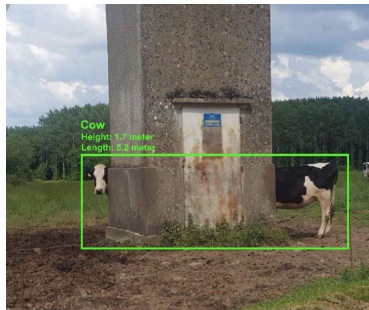
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A Lack of Topological and Geometric Awareness

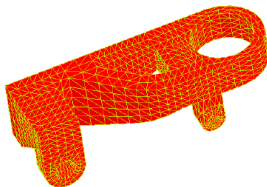
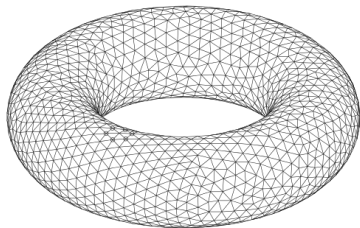
Critiques of DL/NN recently circulating on social media



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Conventional Simplicial, Cellular Homology

Triangulations, cycles, cocycles, universal covering groups, metrics

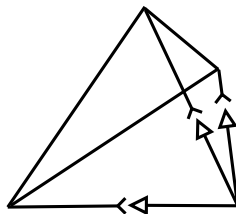
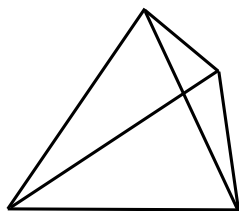


Deep and broad mathematical foundations to draw on.

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Reframe: Edge Lists \rightarrow Jigsaws with Connectors

Jigsaws, plus “global” constraints such as must-form-a-cycle

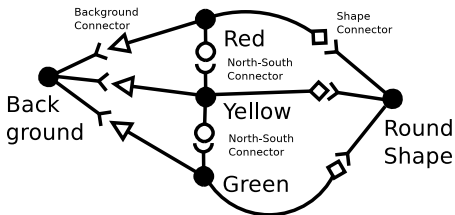


Not quite graph theory.
Not quite relational algebra.
... but almost so.

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Connectors Indicate Symbolic Relationships

Image segmentation as labelled geometric relationships

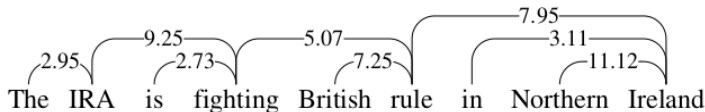
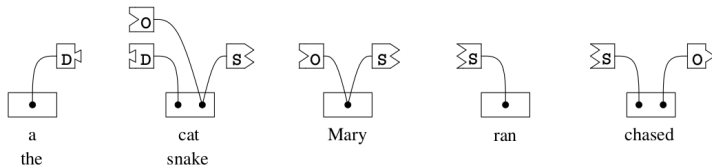


Geometric syntax encodes part-whole relationships!

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Jigsaw Paradigm Established in Linguistics

Syntax in Link Grammar (1991) and earlier (Marcus, 1967)

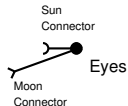
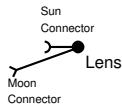
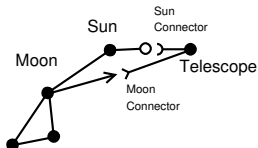
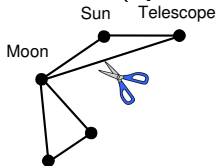


Maximum Spanning Tree parse from Word-Pair MI (1998)

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Provides Semantics for Symbolic AI

Abstract (Symbolic AI) “Things that can be seen”



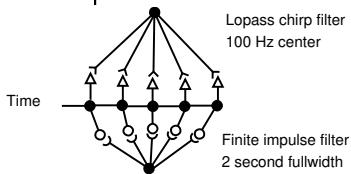
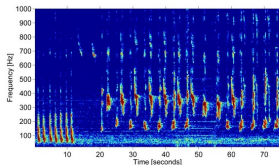
Syntax extending into shallow semantics

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Not Just 1D, 2D, 3D, but also Abstract Sensory Domains

Audio: frequency, intensity, time, envelope, chirp modulation

More generally: wavelet-style decomposition

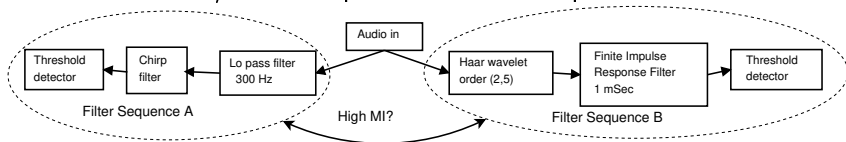


Syntax and structure of a whale song

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Segmentation and Tokenization as (evolutionary, ML) Program Learning

Conventional ML/AI can explore DSP filter sequences



Can DL/NN be used to generate these?

Possibly ... probably. Not been done.

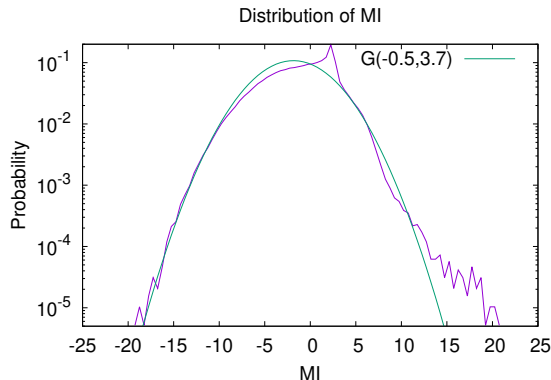
Recursive... (model->syntax->model->syntax...)

... and deep ("cheap").

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Experimental results

Gaussian Orthogonal Ensemble (Spin Glass)

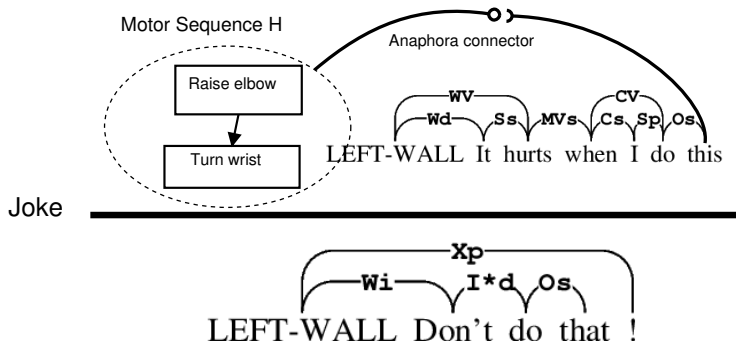


Uniform distribution of English word similarities in high dimensions.
Conventional (information-theoretical) metrics apply.

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Common Sense as Inference over Symbolic Domains

- ▶ Enactive AI founded on unsupervised symbolic relationships.
- ▶ “Common Sense” can be learned recursively i.e. “deeply”.



- ▶ GOFAL failed because it depended on human-curated datasets.
- ▶ This proposal doesn't, but it remains (mostly) symbolic.
- ▶ GOFAL was shallow. Shallow==hard-to-learn.