NUTS NARS and Speech

NUTS: raNdom dimensionality redUction non axiomaTic reasoning few Shot learner for perception

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Code & Supplementary Material: https://github.com/dwanev/NUTS.git

Motivation

- Can Open Non Axiomatic Reasoning for Applications (ONA) be used for perception?
- Children learn new words with just a few examples -
- Can it be made sample efficient?

Assumed Knowledge

- That the audience knows about Open NARS for Applications (ONA)
  - If not see https://github.com/opennars/OpenNARS-for-Applications
  - ONA was built on top of the assumption that it will be operating with insufficient knowledge and resources (AIKR).

- The the audience knows a little Narsese
  - If not see https://cis.temple.edu/~pwang/NARS-Intro.html

Dataset

List of words in the Speech Commands dataset v2:

’bed’, ’cat’, ’down’, ’five’, ’forward’, ’go’, ’house’, ’left’, ’marvin’, ’no’, ’on’, ’seven’, ’six’, ’tree’, ’up’, ’visual’, ’yes’, ’backward’, ’bird’, ’dog’, ’eight’, ’follow’, ’four’, ’happy’, ’learn’, ’nine’, ’off’, ’one’, ’right’, ’sheila’, ’stop’, ’three’, ’two’, ’wow’, ’zero’

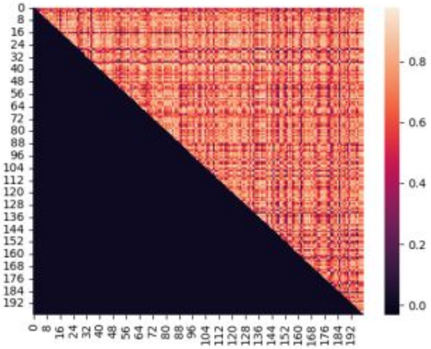
Consists of 105,829 utterances of 35 words, of between 1500 and 4000 utterance each, multiple speakers.

Warden, P.: Speech commands: A dataset for limited-vocabulary speech recognition. arXiv preprint arXiv:1804.03209 (2018) https://doi.org/10.48550/arXiv.1804.03209

Dataset

Correlation of many utterance of “One” from

the Speech Commands dataset v2.



Low Correlation

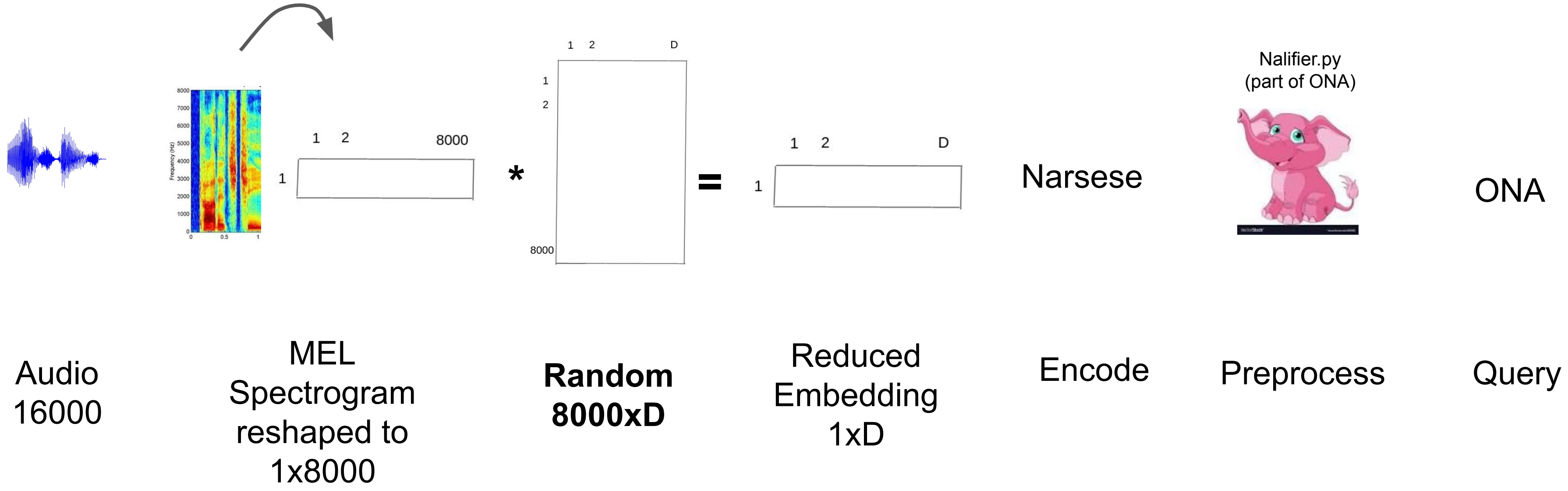
NUTS - High Level Process

Build background knowledge inside ONA, *n* examples of each class.

Present ONA with a new unlabeled instance

Query ONA as to what the unlabeled instance is

NUTS - End to End Process



NUTS - Pseudo Code

```
Generate a random 8000xD matrix R

For u in Class List C:

    Pick a random unlabeled instance ui

    For w in class list C:

    Pick n random samples from the class w

    Convert the n samples into Narsese by

        Load waveform, convert into Mel Spectrogram S            # dimension [8000,1]

        Reduced Dimension Matrix E = S * R                       # dimension [D,1]

        E = normalised(E)                                        # normalises all values to between 0.0 and 1.0

        Convert E -> Narsese Statements                          # shown on next slide

        Add Instance Label Narsese statement (“isa”) for all the labeled samples

        Pass the Narsese Statements - > Nalifier -> Filtered Narsese Statements -> ONA

    Query ONA with < {U} -> Label_1>?
```

NUTS - Encoding into Narsese

< {Word_One_Utterance_A} -> [p1]>. %0.9%

< {Word_One_Utterance_A} -> [p2]>. %0.51%

< {Word_One_Utterance_A} -> [NOTp3]>. %0.8%

1 Narsese statement for each property p1, p2 … p**D**

……

< {Word_One_Utterance_A} -> Label_ONE >.

State what A is

……

(repeat for all other instance and unlabeled instance)

……

< {Unlabbeld_Utterance_X} -> Label_1>?

Query What C is similar to (for every class)

Consider correct if highest > 0.5 and is the correct class

For Narsese see https://cis.temple.edu/~pwang/NARS-Intro.html

Is this? not What is this?

In a 35 class example, we asked ONAs

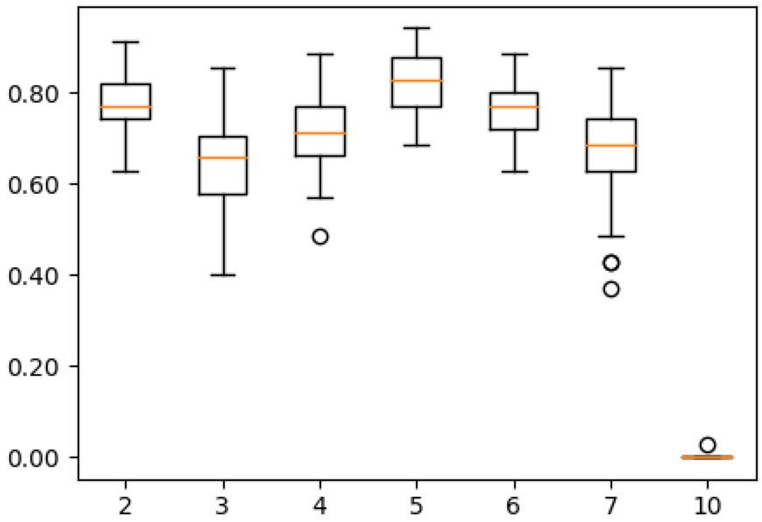
“is this a One?”, “is this a Two?”, …

Rather than

“what is this?”

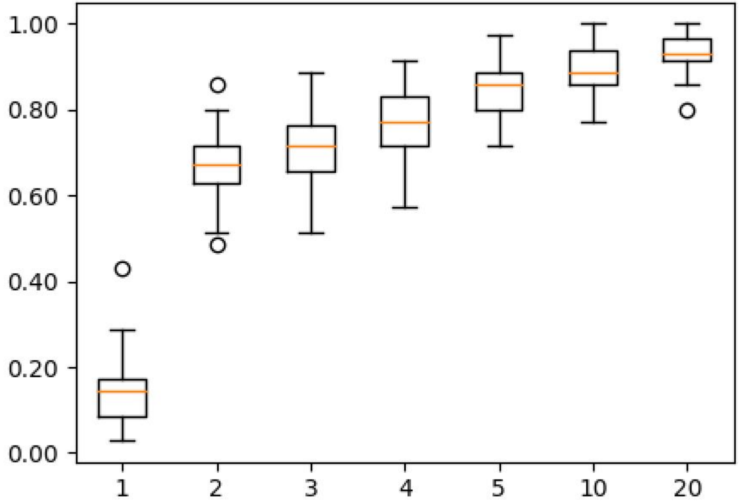
I.e. we needed to know what the target label was.
Need to ask for every class, and take highest if > 0.5

NUTS - Accuracy



Reduced dimension embedding size

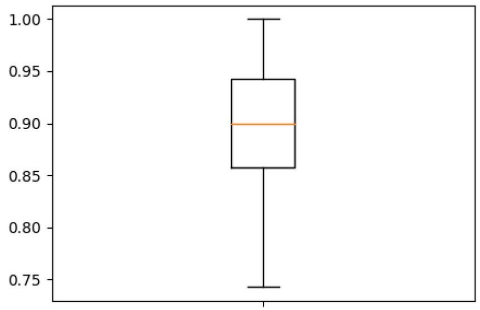
NUTS - Accuracy

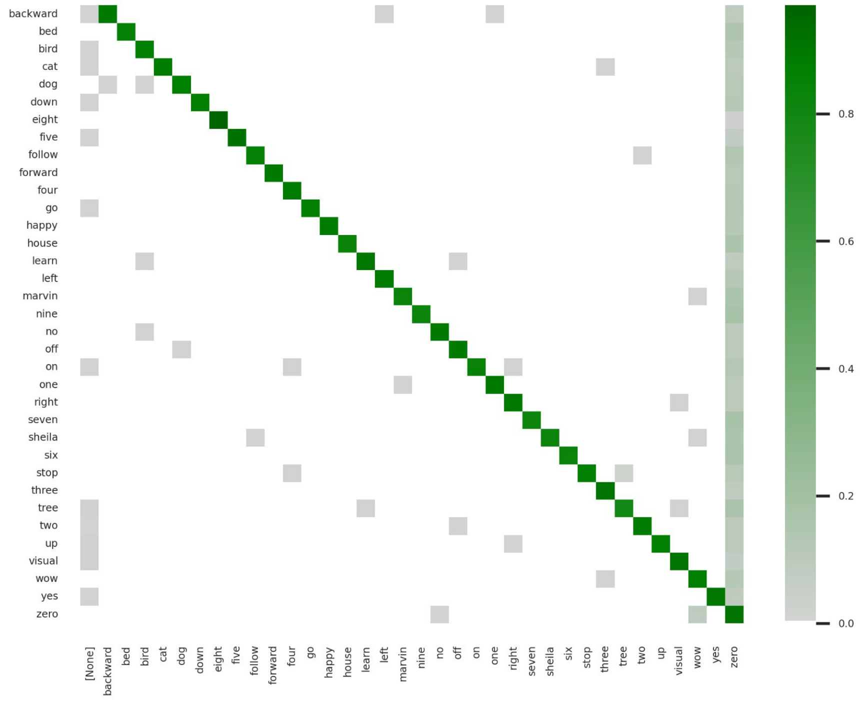


Number of examples

Note: 100 examples accuracy = ~0.28

NUTS - Confusion Matrix





Comparison with state-of-the-art

	Accuracy	
ANAN State of the Art	94%	de Andrade, D.C., Leo, S., Viana, M., Bernkopf, C.: A neural attention model for speech command recognition. ArXiv abs/1808.08929 (2018) **1000s** of examples
NUTS	89%	5 dimensions, **20** examples, AIKR limit 100
NUTS	64%	5 dimensions, **2** examples, AIKR limit 100

Open Questions

- Is there a magic ‘best’ matrix?
- Can it be found in a computationally efficient way?

NUTS - Summary

It’s NUTS that **random** dimensionality reduction,

in combination with NARS,

works as well as it does.

Afterthought

Where is the intelligence?

Is it driven from the desire that ”there must be an easier way than this”?

Appendix

Perceptual Reasoning (Nalifier)

- Keep up to K instances and concept nodes

New instance **{inst2}** arrives:

- Find closest known in terms of similarity **<{inst2} <-> {?1}>?** by considering overlap in all attributes

  <{inst2} <-> {inst1}>. (Comparison, value similarity)

- Increase useCount for best matched (forgetting based on useCount)
- Find biggest attribute differences to best matched to build

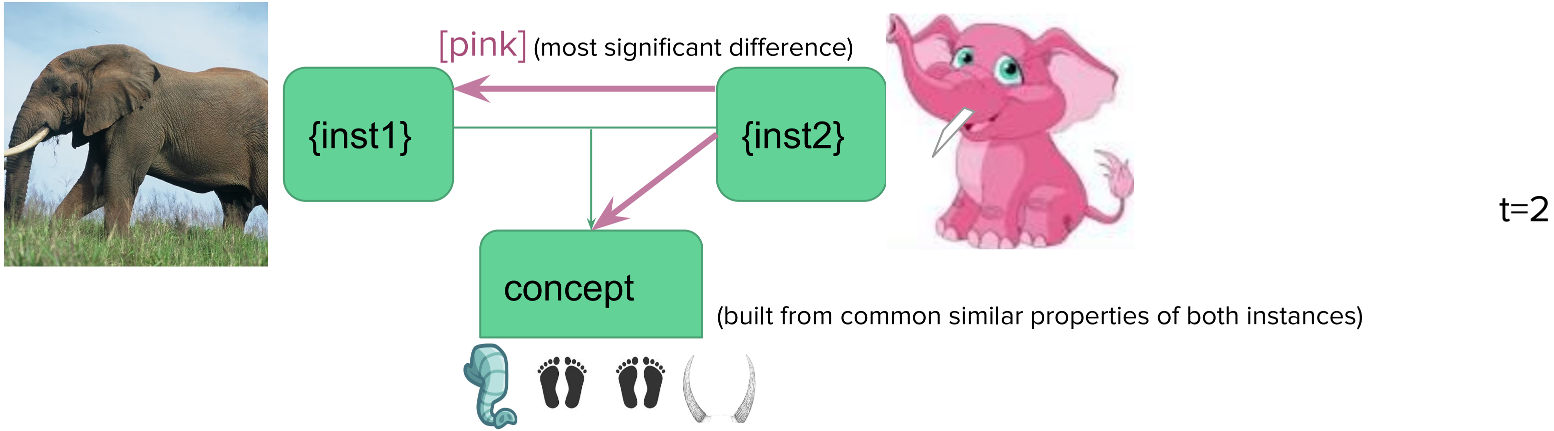
  <({inst1} * {inst2}) → [blue]> > (Difference, value differences)

- Find best matching concept node in terms of **<{inst1} → ?1>?** to build (again increasing useCount of answer)

  <{inst1} → concept> %f% (Abductions, value similarity + revisions)

- Use common closest attribute to form new concept nodes

Credit: Patrick Hammer Source: Perceptual reasoning: https://docs.google.com/presentation/d/1xi34co6rf27k4rodZyXiaar7AsC5_3JB1yj-doHY8qs/edit#slide=id.g166fbe6c77e_1_36



(from common properties, e.g. 4 legs, trunk, and horns)

Pink elephant example:

(describe/notice new instances in relation to their closest match and relative to their best concept belonging)

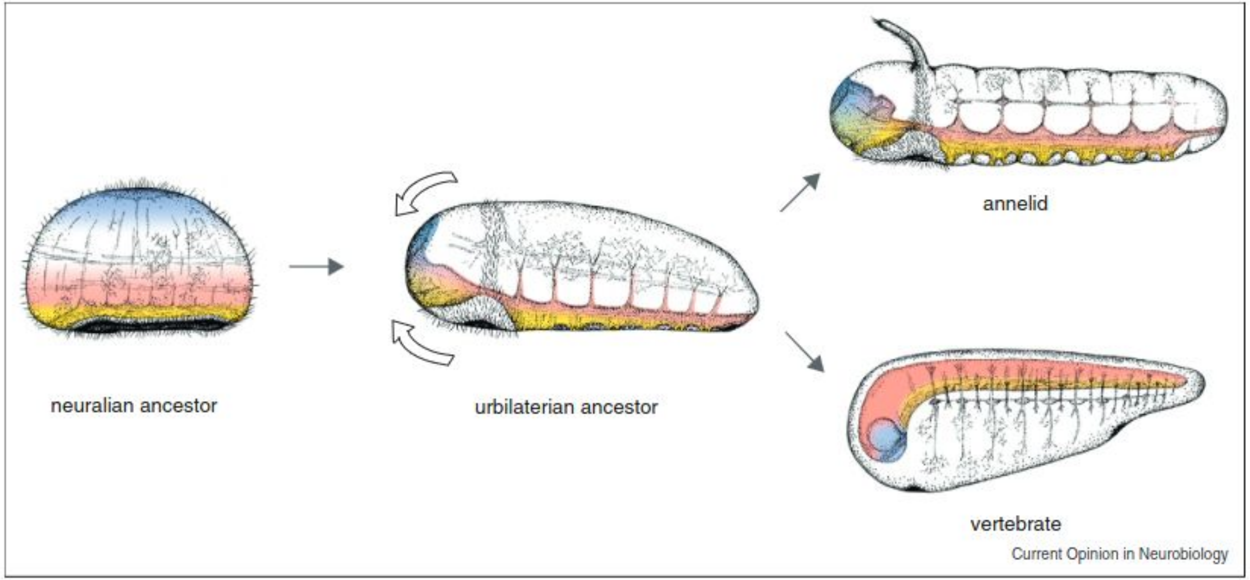
<{inst2} <-> {inst1}>. f1,c1

<{inst2} → elephant>. f2, c2

<({inst2} * {inst1}) → (+ pink)>. 1,c3

Credit: Patrick Hammer Source: Perceptual reasoning: https://docs.google.com/presentation/d/1xi34co6rf27k4rodZyXiaar7AsC5_3JB1yj-doHY8qs/edit#slide=id.g166fbe6c77e_1_36

Figure 3



The chimeric brain hypothesis. In the scheme, the apical nervous system is in blue, and the motor and the sensory-integrative components of the blastoporal nervous system are represented in yellow and red, respectively. In the last common ancestor of Cnidaria and Bilateria (neuralian ancestor) the two systems were separate, and concentrated respectively around the apical pole and the blastopore. With the transition to the urbilaterian (the ancestor of all Bilateria) the apical nervous system and anterior side of the blastoporal nervous system merged to form the forebrain, as found in extant annelids and vertebrates.

Source: Maria Antonietta Tosches, Detlev Arendt, The bilaterian forebrain: an evolutionary chimaera, Current Opinion in Neurobiology

Random Matrix

CS168: The Modern Algorithmic ToolboxLecture #4: Dimensionality Reduction

Peter from nPlan paper club suggested this: http://timroughgarden.org/s17/l/l4.pdf
Very good description on how multiplying by a random matrix can reduce dimensionality, yet keep (euclidean?) distance proportional within a desired epsilon https://dl.acm.org/doi/10.1145/1646353.1646379

Random Matrix

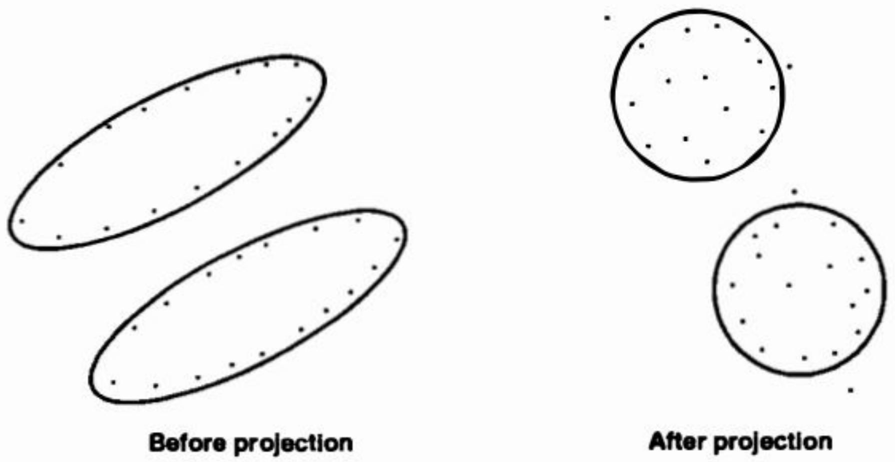
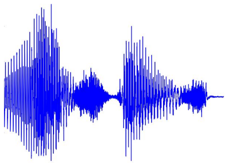


Figure 2: The effects of random projection: the dimension is drastically reduced while the clusters remain well-separated and become more spherical.

Credit: Sanjoy Dasgupta Source: https://arxiv.org/abs/1301.3849 : Experiments with Random Projection - UNCERTAINTY IN ARTIFICIAL INTELLIGENCE PROCEEDINGS 2000

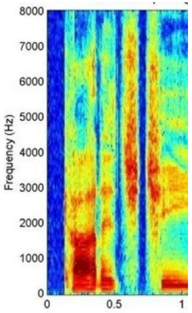
Sound Recap

Audio



16k
samples/sec

MEL
Spectrogram



8k
samples/sec
(industry standard)