PREDICTING OCEAN HEALTH
CLASSIFICATION OF PLANKTON

Harsh Parikh, Sahil Loomba

"The world is everything that is the case."
Ludwig Wittgenstein

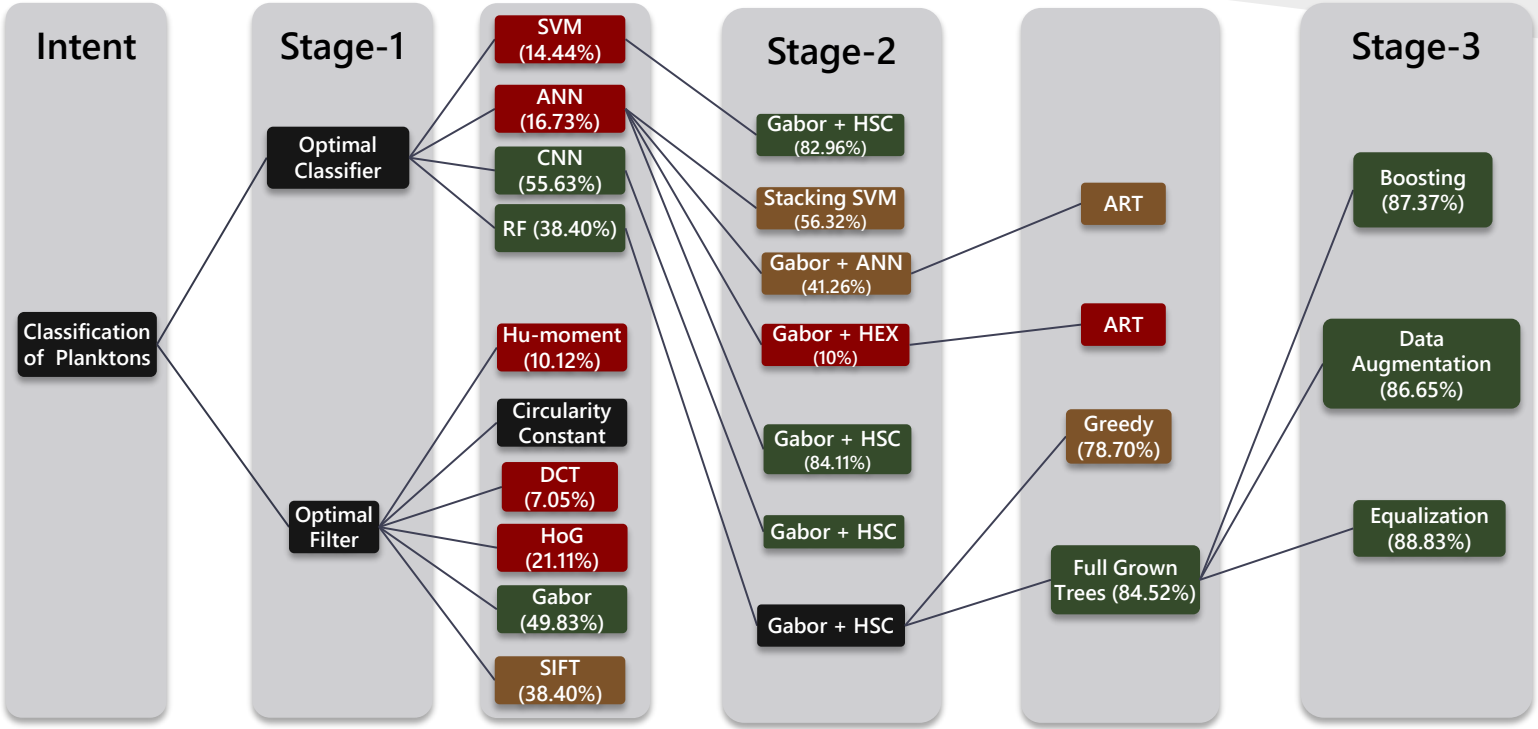
To be or not to be, that is

The Question

Classifying plankton images by underwater imagery sensor, using computational techniques.

- → 144 Classes of Plankton
- → Hierarchical Structure
- → 121 Leaf Classes
- → Skewed Data Distribution

The Odyssey

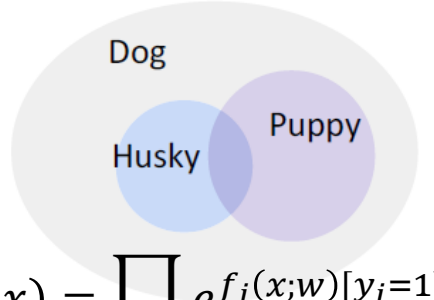


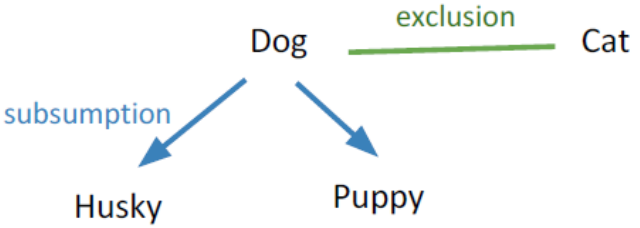
SVM– support vector machine, ANN- Artificial Neural Network, CNN- Convolutional Neural Network, RF- Random Forest, SIFT- Scale Invariant Feature Transform, HEX- Hierarchy and Exclusion Graphs, ART- Adaptive Rates Learning, HSC- Hierarchically Stacked Classifiers

Hierarchy and Exclusion Graphs

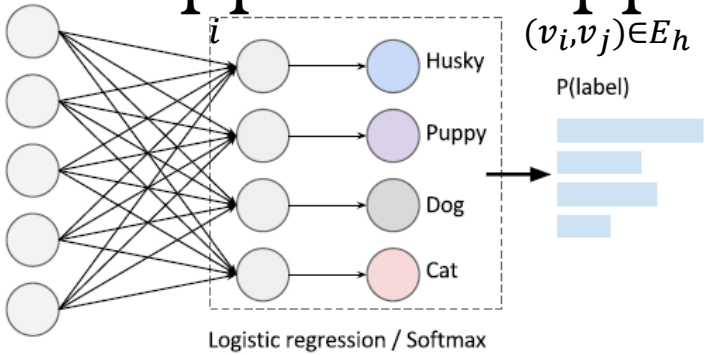
Jia Deng et al., *Large-Scale Object Classification using Label Relation Graphs*, University of Michigan and Google Inc.

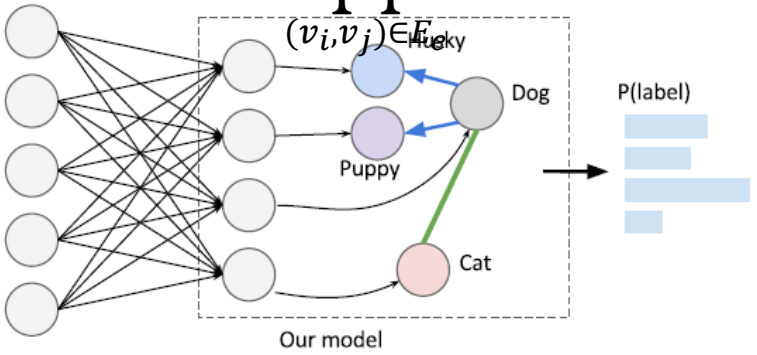
HEX-y Sadie



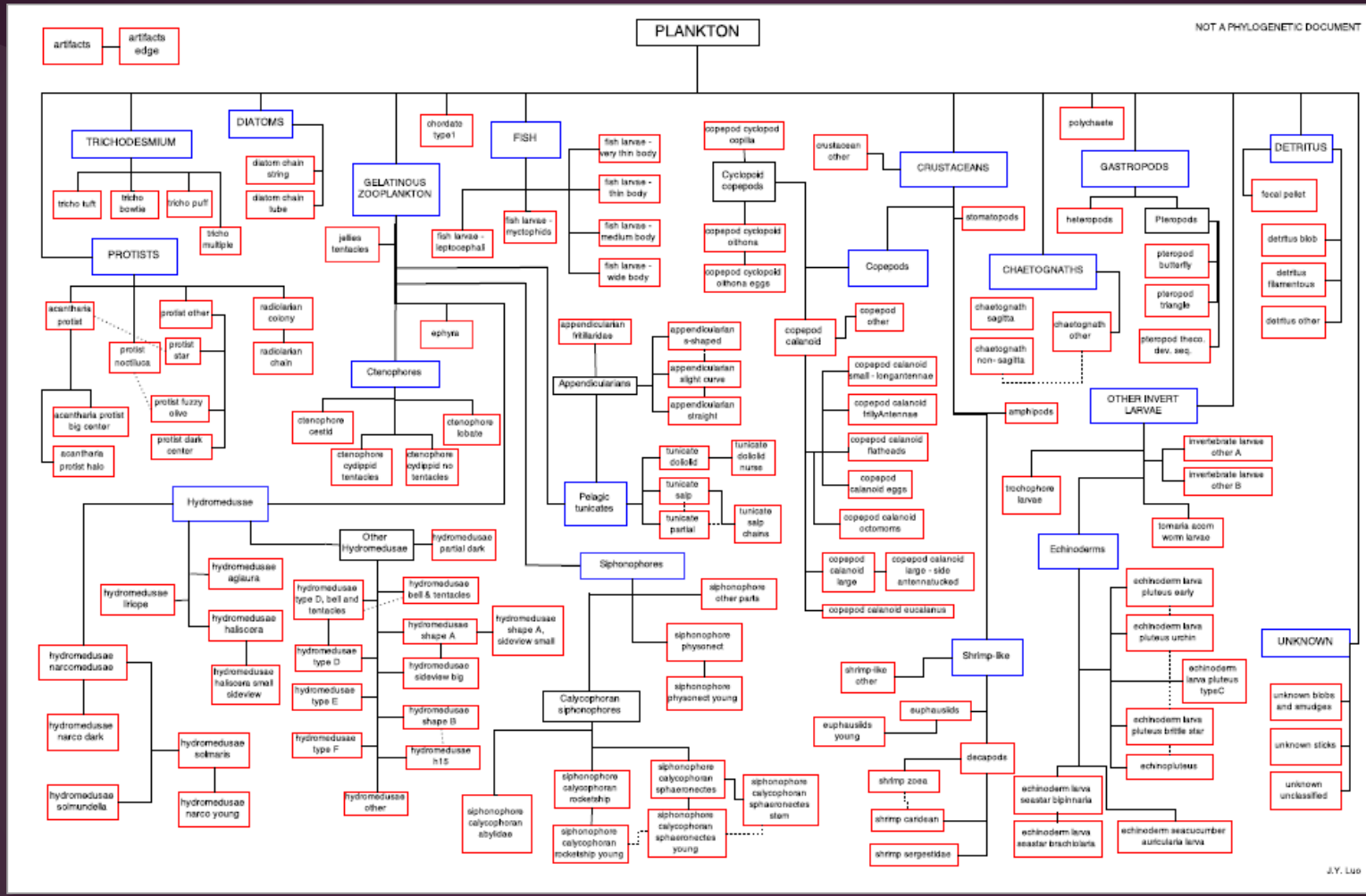


$$P(y|x) = \prod_i e^{f_i(x;w)[y_i=1]} \prod_{(v_i,v_j)\in E_h} [(y_i, y_j) \neq (0,1)] \prod_{(v_i,v_j)\in E_e} [(y_i, y_j) \neq (1,1)]$$

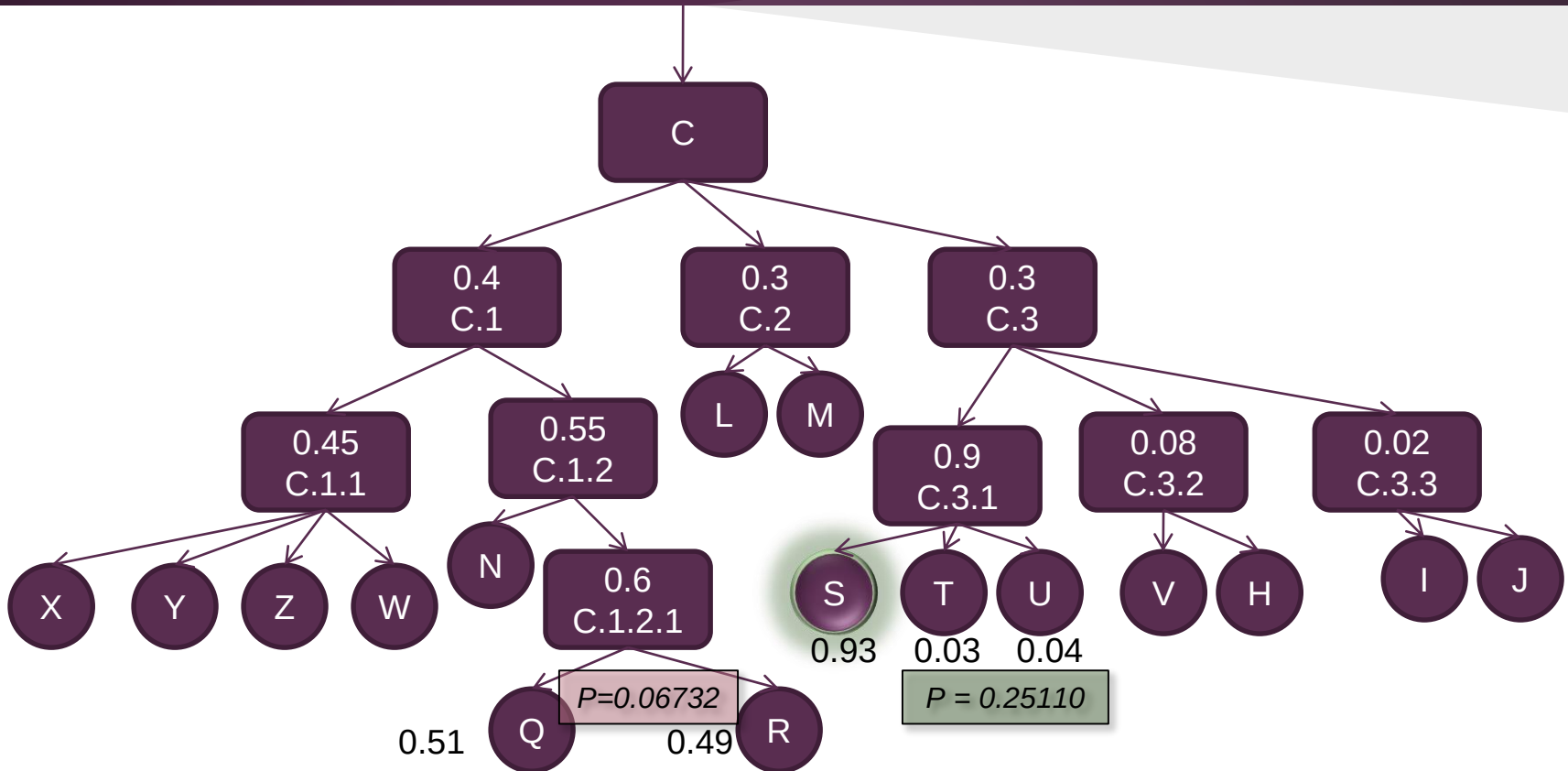




Hierarchically Stacked Classifiers


NOT A PHYLOGENETIC DOCUMENT
PLANKTON
artifacts
artifacts edge
TRICHODESMIUM
tricho tuft
tricho bowtie
tricho puff
tricho multiple
DIATOMS
diatom chain string
diatom chain tube
GELATINOUS ZOOPLANKTON
jellies tentacles
chordate type1
FISH
fish larvae - leptocephali
fish larvae - myctophids
fish larvae - very thin body
fish larvae - thin body
fish larvae - medium body
fish larvae - wide body
PROTISTS
acantharia protist
protist other
protist noctiluca
protist star
protist fuzzy olive
protist dark center
acantharia protist halo
acantharia protist big center
radiolarian colony
radiolarian chain
ephyra
Ctenophores
ctenophore cestid
ctenophore lobate
ctenophore cydippid tentacles
ctenophore cydippid no tentacles
appendicularian fritillaridae
Appendicularians
appendicularian s-shaped
appendicularian slight curve
appendicularian straight
Pelagic tunicates
tunicate doliolid
tunicate doliolid nurse
tunicate salp
tunicate partial
tunicate salp chains
Hydromedusae
Other Hydromedusae
hydromedusae partial dark
hydromedusae agalma
hydromedusae liriope
hydromedusae halicera
hydromedusae halicera small oldeview
hydromedusae narcomedusae
hydromedusae narco dark
hydromedusae solmaris
hydromedusae solmundella
hydromedusae narco young
hydromedusae type D, bell and tentacles
hydromedusae type D
hydromedusae type E
hydromedusae type F
hydromedusae bell & tentacles
hydromedusae shape A
hydromedusae sideview big
hydromedusae shape B
hydromedusae h15
hydromedusae other
hydromedusae shape A, sideview small
Siphonophores
siphonophore other parts
siphonophore physonect
siphonophore physonect young
Calycophoran siphonophores
siphonophore calycophoran rocketship
siphonophore calycophoran rocketship young
siphonophore calycophoran sphaeronectes
siphonophore calycophoran sphaeronectes young
siphonophore calycophoran sphaeronectes stem
siphonophore calycophoran abylidae
copepod cyclopod copilia
Cyclopoid copepods
copepod cyclopoid oithona
copepod cyclopoid oithona eggs
crustacean other
CRUSTACEANS
stomatopods
Copepods
copepod calanoid
copepod other
copepod calanoid small - longantennae
copepod calanoid trillyAntennae
copepod calanoid flatheads
copepod calanoid eggs
copepod calanoid octomorra
copepod calanoid large
copepod calanoid large - side antennatucked
copepod calanoid eucalanus
amphipods
Shrimp-like
shrimp-like other
euphausiids
euphausiids young
decapods
shrimp zoea
shrimp caridean
shrimp sergestidae
polychaete
GASTROPODS
heteropods
Pteropods
pteropod butterfly
pteropod triangle
pteropod theco. dev. seq.
CHAETOGNATHS
chaetognath sagitta
chaetognath non-sagitta
chaetognath other
OTHER INVERT LARVAE
trochophore larvae
Invertebrate larvae other A
Invertebrate larvae other B
tomaria acorn worm larvae
Echinoderms
echinoderm larva pluteus early
echinoderm larva pluteus urchin
echinoderm larva pluteus typeC
echinoderm larva pluteus brittle star
echinopluteus
echinoderm larva seastar bipinnaria
echinoderm larva seastar brachiolaria
echinoderm seacucumber auricularia larva
DETRITUS
fecal pellet
detritus blob
detritus filamentous
detritus other
UNKNOWN
unknown blobs and smudges
unknown sticks
unknown unclassified
J.Y. Luo

The Road Not Taken



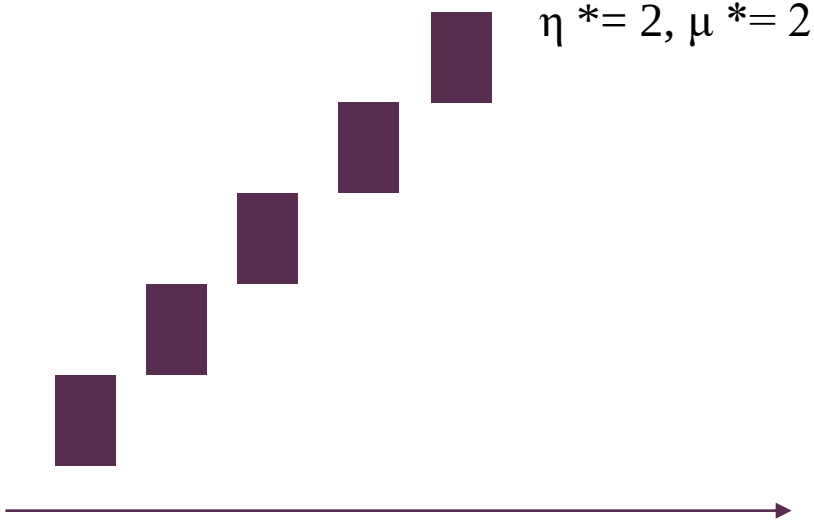
Goldilocks

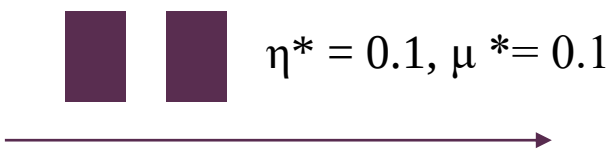
$$argmax_{y_i \in \{y_1 \ldots y_n\}} P(y_n, y_{n-1} \ldots y_1 | x)$$
$$=$$
$$argmax_{y_i \in \{y_1 \ldots y_n\}} P(y_n | x, y_{n-1} \ldots y_1) P(y_{n-1} | x, y_{n-2} \ldots y_1) P(y_1 | x)$$
$$where\ n\ is\ the\ depth\ of\ the\ tree$$

Adaptive Rates Training

What happens in Vegas

Learning Rate and Momentum Rate adapted via mechanism similar to TCP

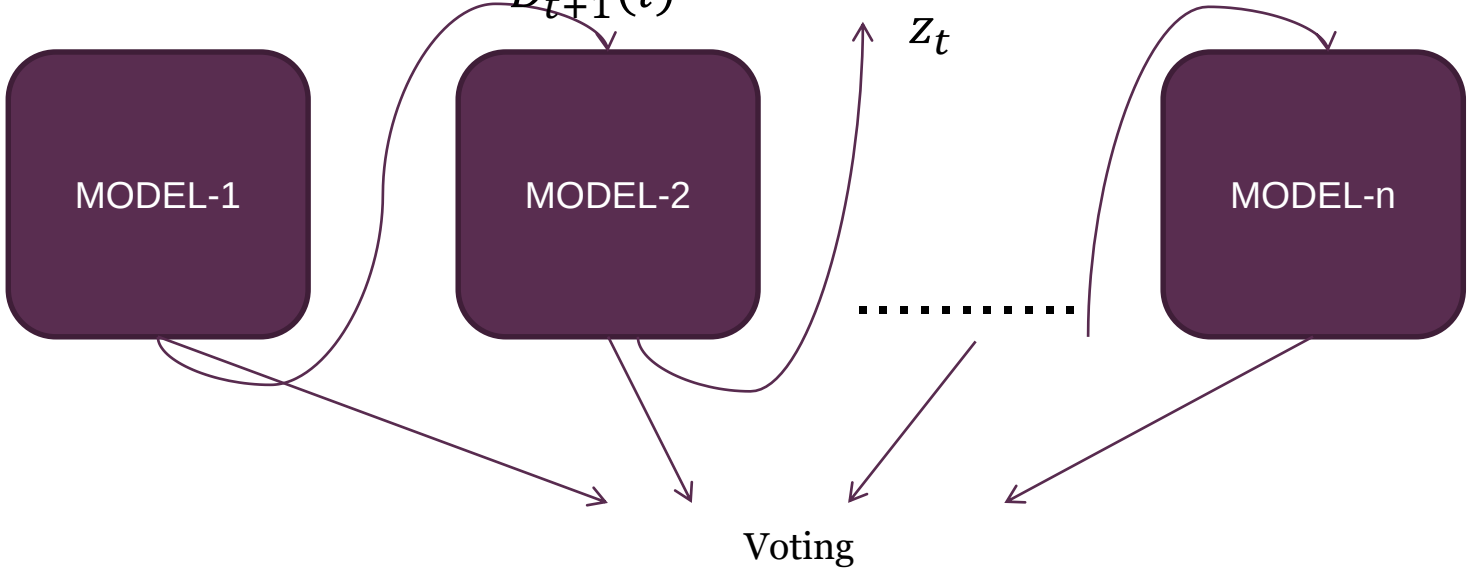




Boosting, Augmentation and Equalisation

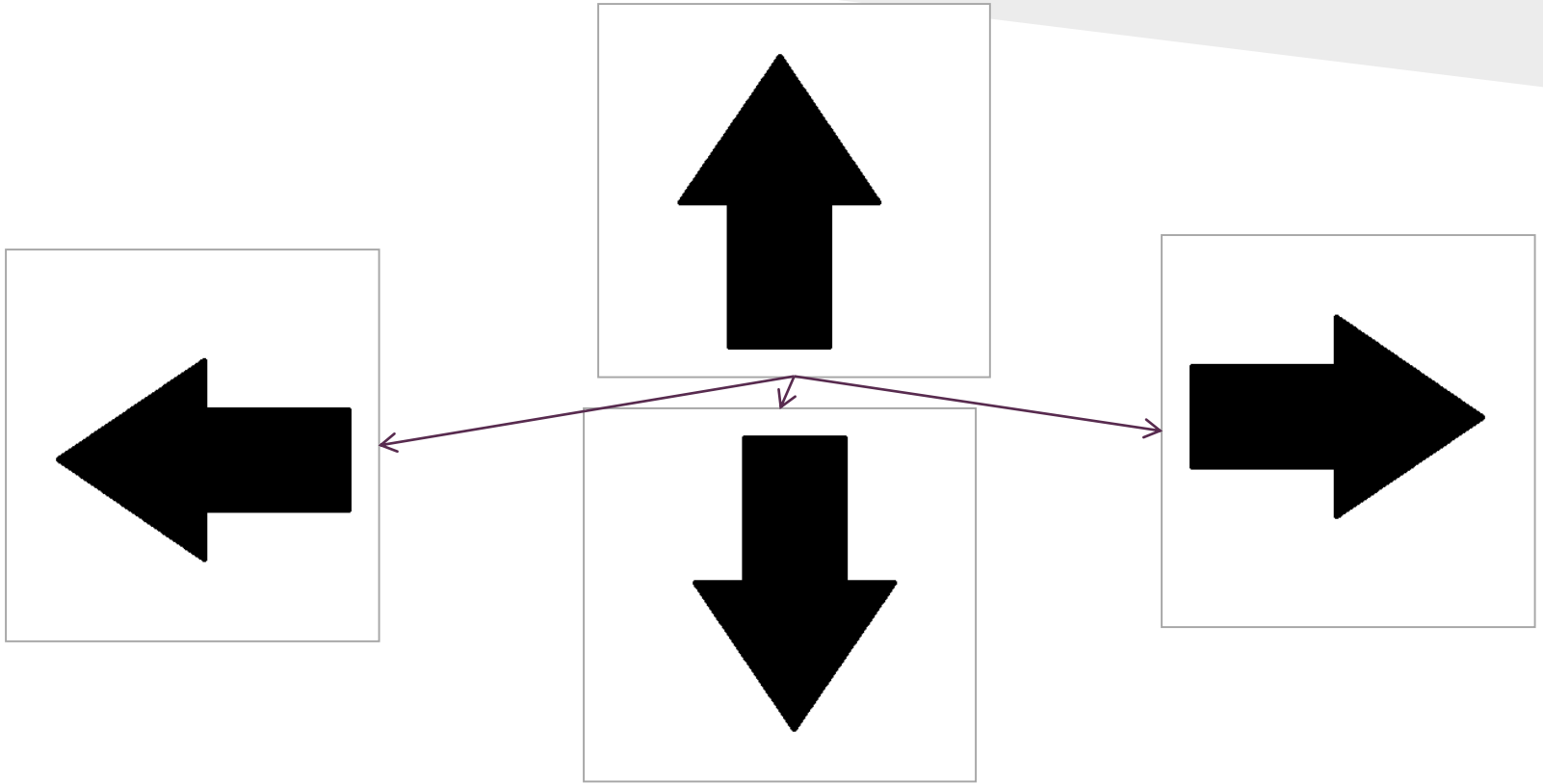
History Repeats Itself

$$D_{t+1}(i) = \frac{D_t(i)e^{-\alpha_t y_i h_t(x_i)}}{z_t}$$

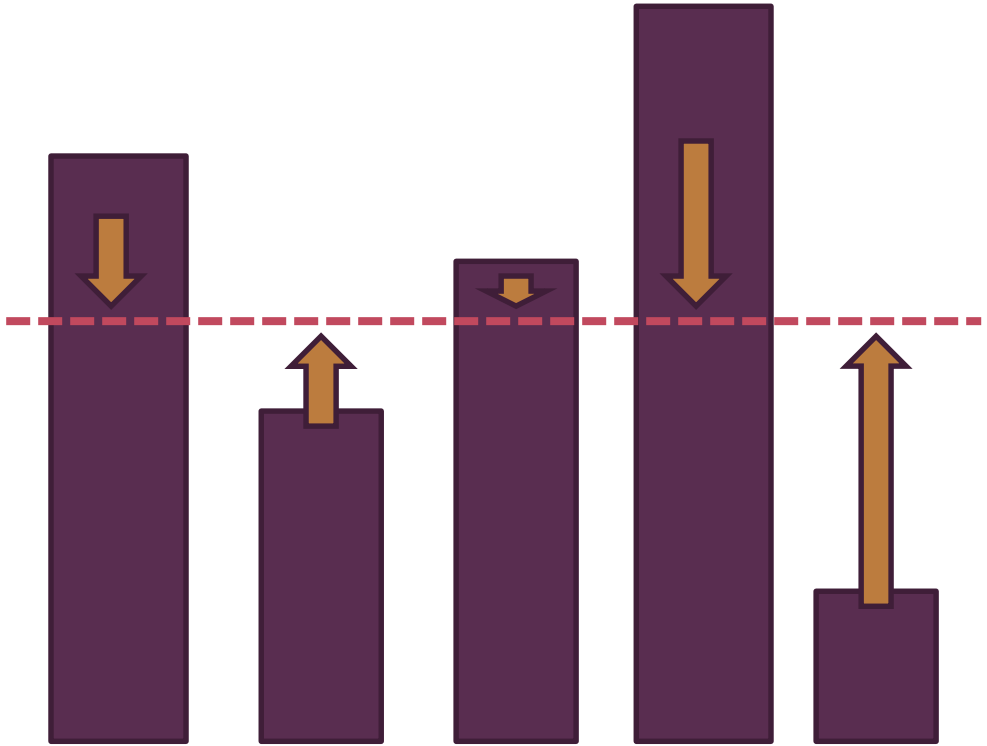


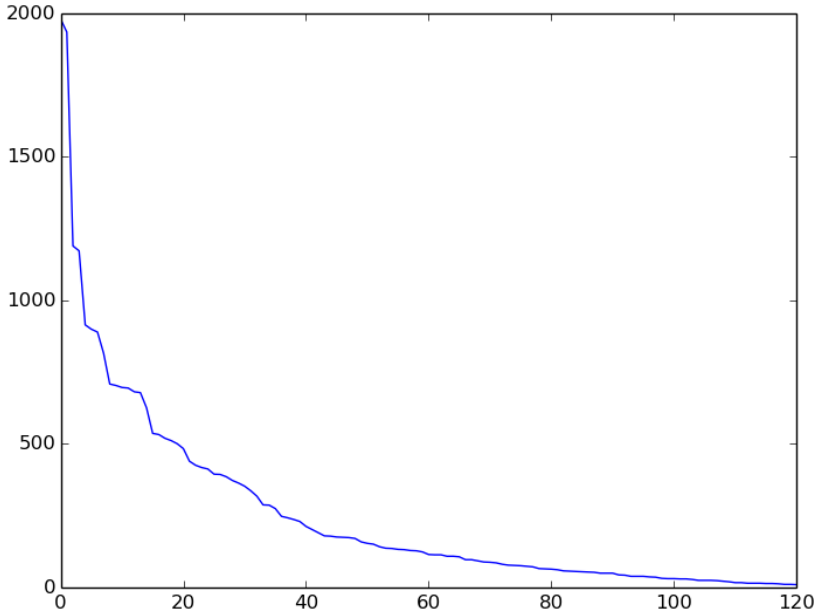
Schapire, *The Boosting Approach to Machine Learning – An Overview*, MSRI Workshop on Nonlinear Estimation and Classification, 2002

Two Sides of the Same Coin

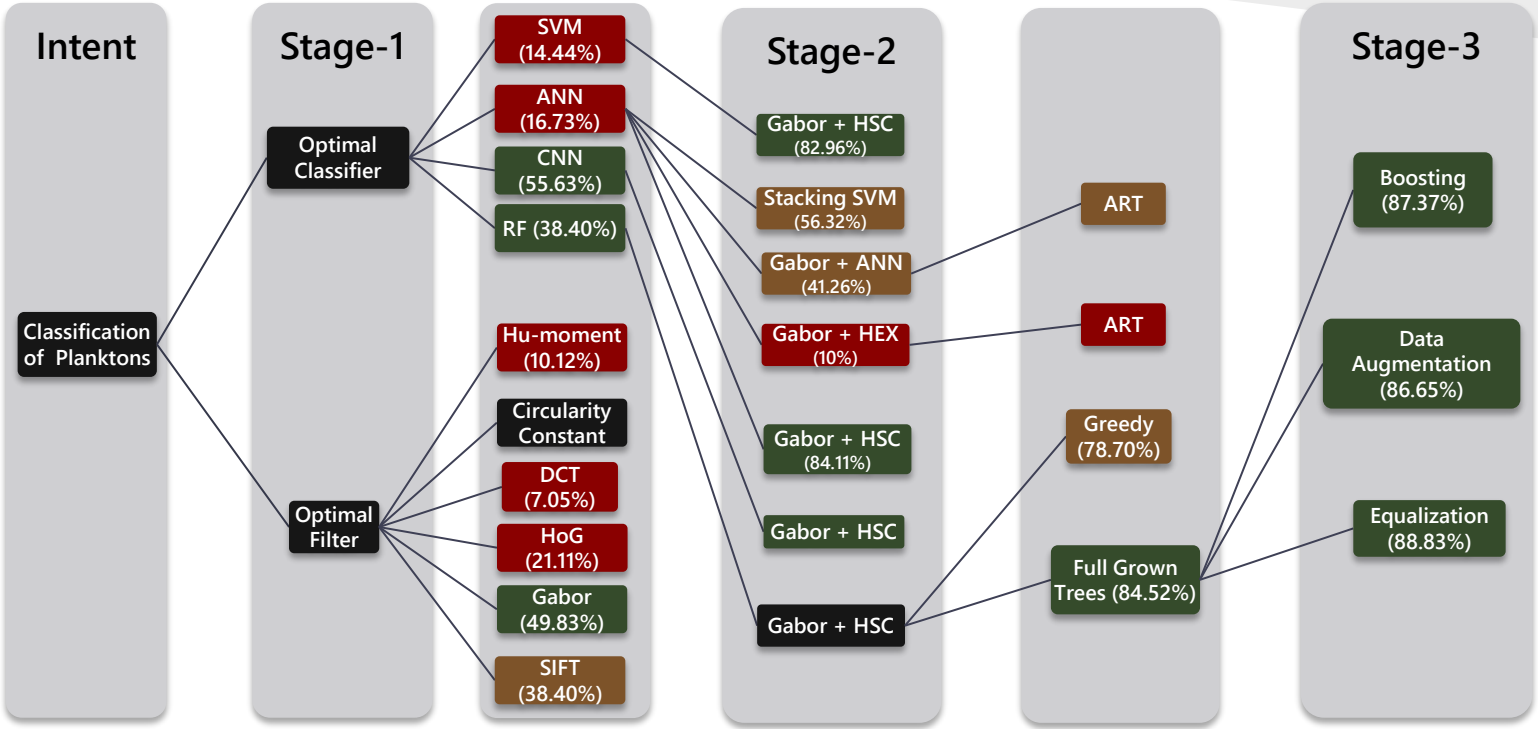


Communist Manifesto





The Odyssey, Revisited



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Miles to go before I sleep

- HSC:
- Customised Classifier for each Node
- Filter combinations for every Classifier
- HEX:
- Soft instead of Hard Assignments in legal ground truths
- Exploring Adaptive Rates Learning (ARL):
- Mathematical nuances of this heuristic

Implications

Thank You, Questions?

“Whereof one cannot speak, thereof one must be silent.”

Ludwig Wittgenstein