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AUGMENTED POPULATION BASED TRAINING (APBT)

Josias Moukpe • 4-27-2022

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Problem

Searching and Tuning Neural Nets is a difficult and long process!

- Artificial Neural Nets (ANN) are very powerful function approximators
- To use effectively, ANNs require lots of hyperparameters to tune (6+, too much to exhaustively search!)
- Moreover, finding the right topology is even more important and difficult. Wrong topology invalidates best hyperparameters…

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Approach

We propose Augmented Population Based Training!

- Leverage power of Genetic Algorithms to help search both topology and hyperparameters in SINGLE joint training process.
- Produce optimal topology (high accuracy, low size) trained on optimal hyperparameter schedules (adaptive, not just one value)
- Requires fewer hyperparameters (3 at most, 2 usually!)
- Can be parallelize for speed boost.
- Better than manual, grid, and random search

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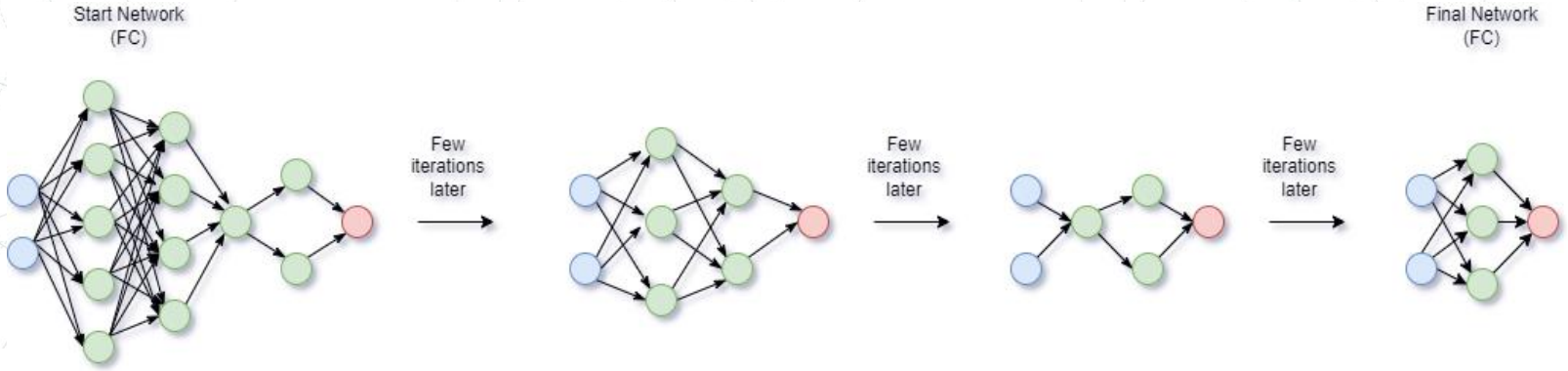
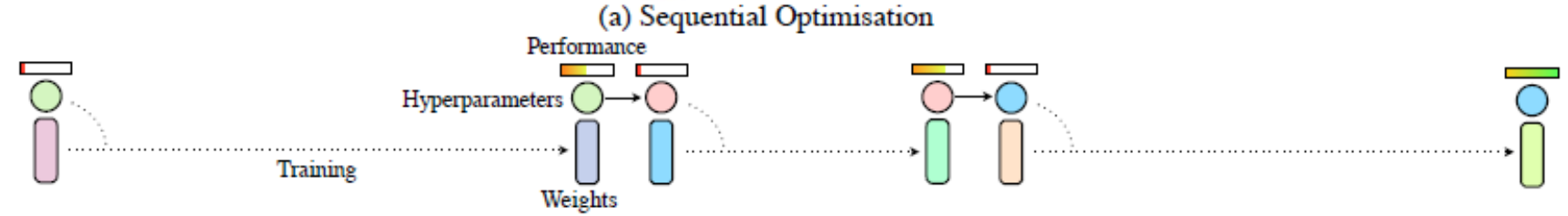
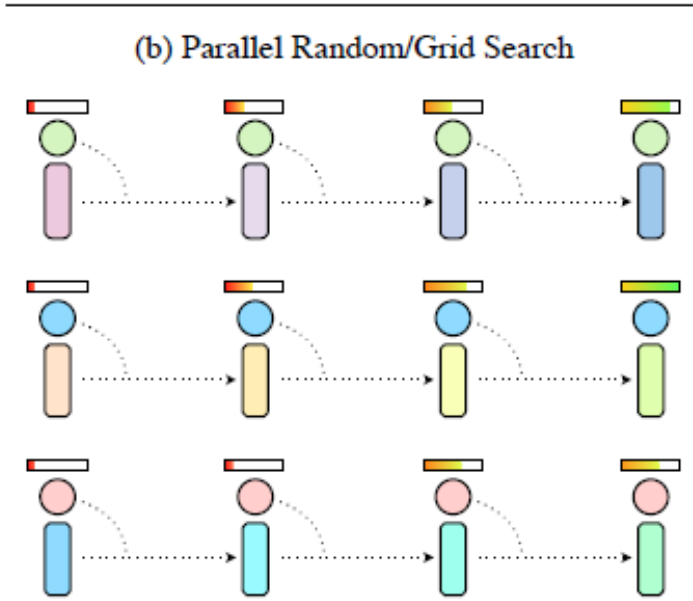
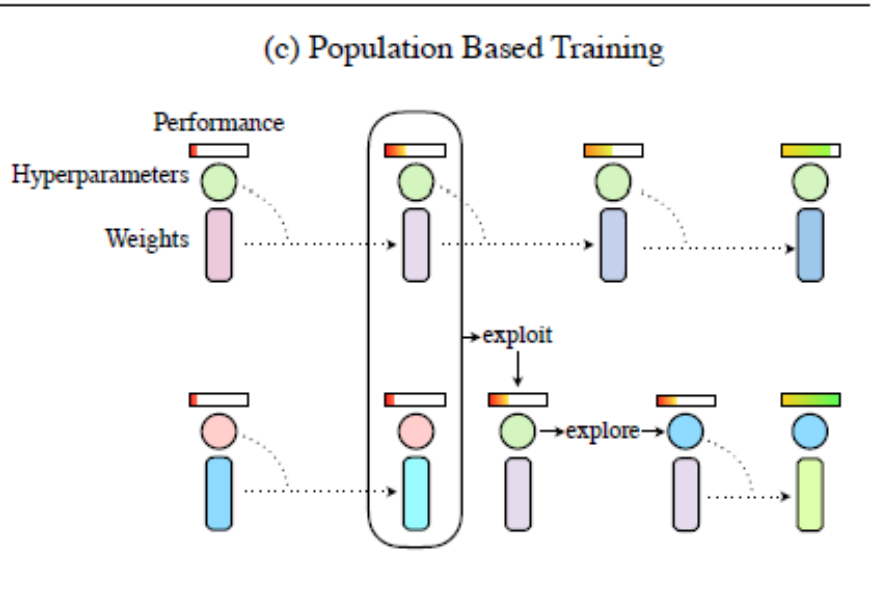
Illustrations









Augmented Population Based Training Operators

Evaluate

- It's our Fitness function here.
- Takes a neural net, a validation/test set, and returns a score
- Evaluate the accuracy (1), get net size (2), and apply a special ratio function (f) on the accuracy and size to get performance score.
- $f(accuracy, size) = \frac{1.09^{accuracy}}{1.02^{size}}$

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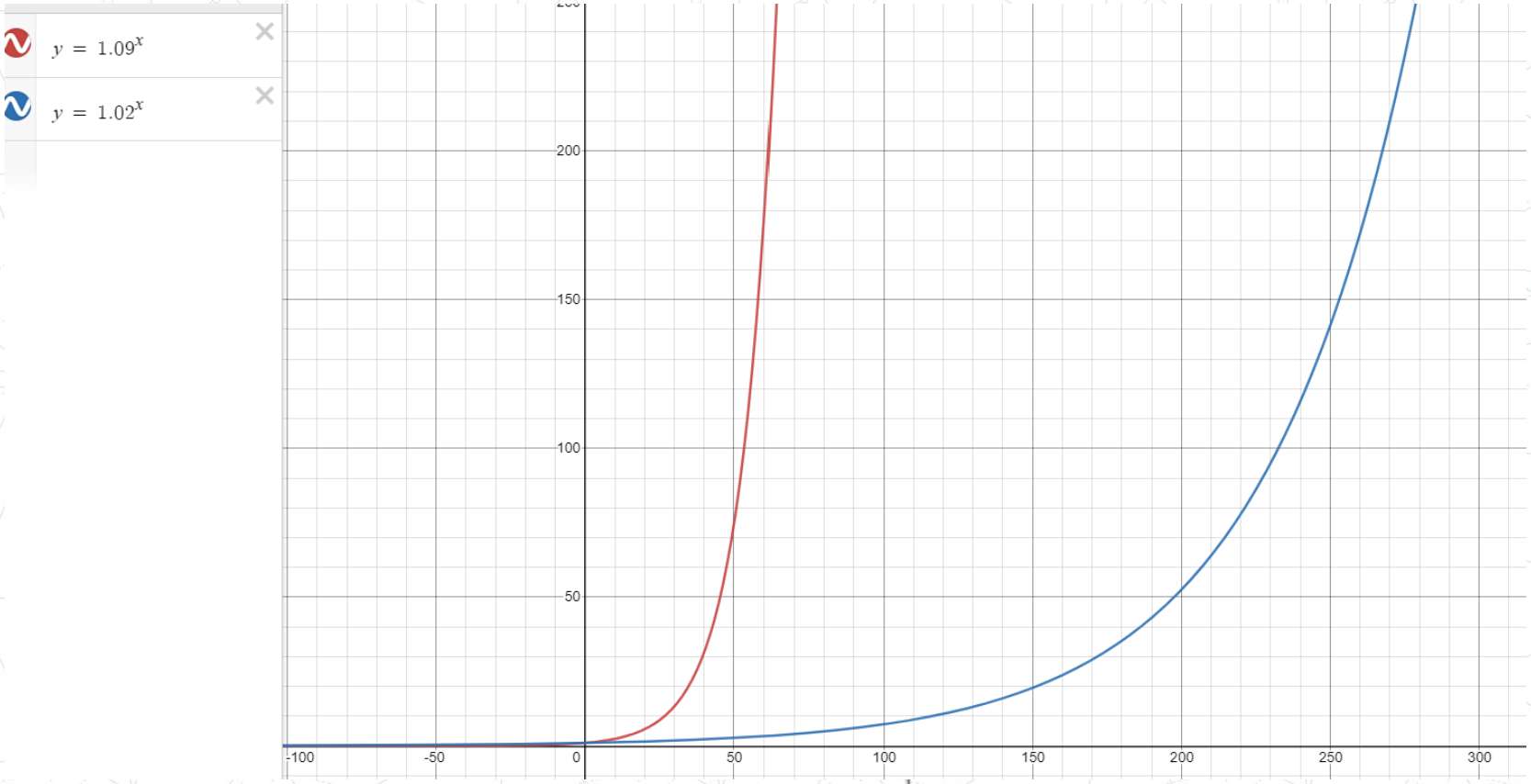

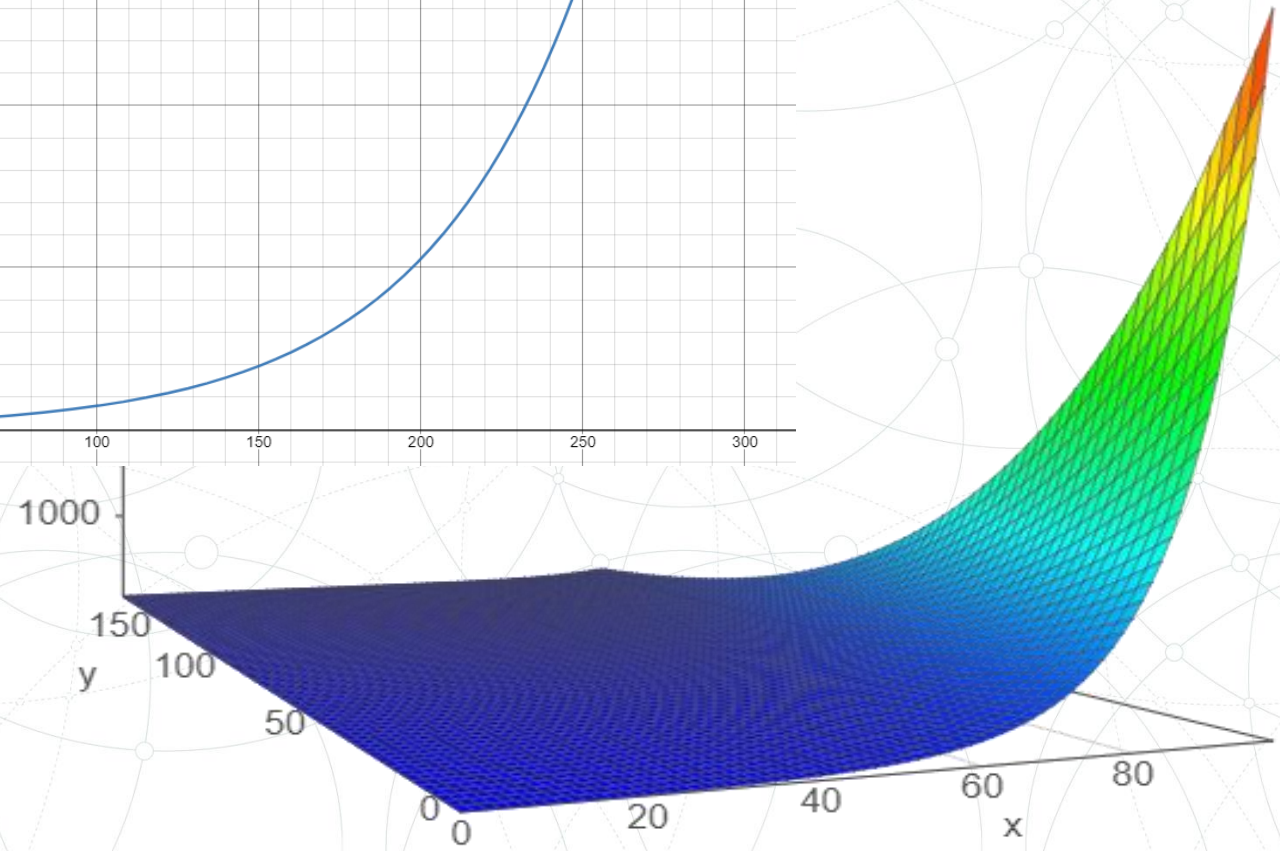

Ratio F

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Augmented Population Based Training Operators

Truncation Selection

- It's our selection function based on the readiness threshold.
- A neural net is simply "ready" after a set number of iteration has elapsed since last time it was ready
- Truncation selection works by first ranking the nets in the population by performance ratio. If current net is in the bottom 20% of the population, we sample another net uniformly from the top 20% of the population to exploit.

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Augmented Population Based Training Operators

Exploit

- It’s our crossover function.
- When a net is ready after a certain number of iterations, and is struggling in performance (bottom 20%), it can exploit the rest of the population by copying the topology, weights, and hyperparameters of the top net selected from the population with truncation selection.

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Augmented Population Based Training Operators

Explore

- It’s our mutation function.
- Following exploitation, the net experiences a perturbation in its hyperparameters, and topology before continuing training with the new hypermeters and topology.
- Hyperparameters are multiplied by either .8 or 1.2
- Topology either gains a neuron, loses a neuron, or does nothing.

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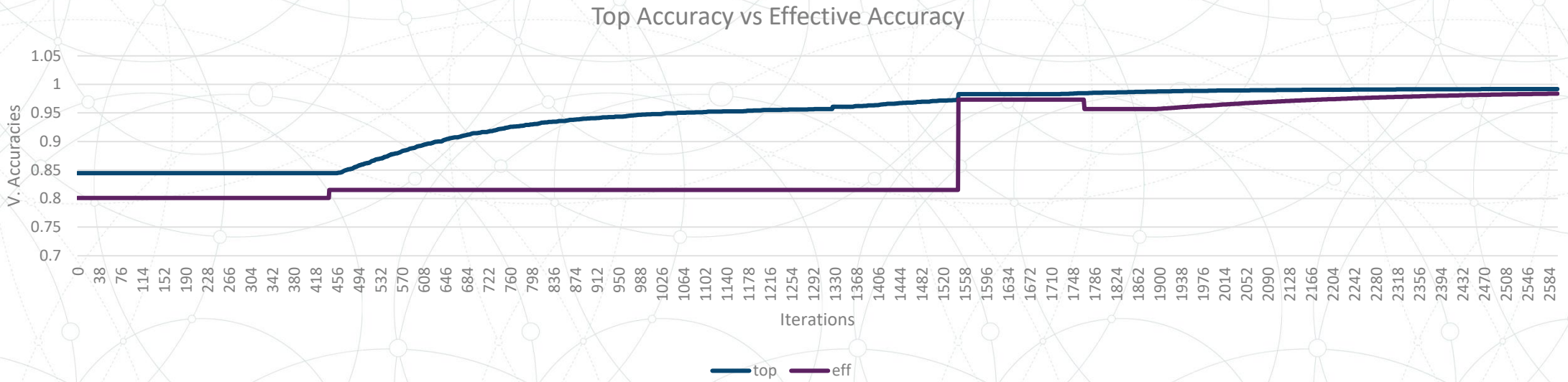
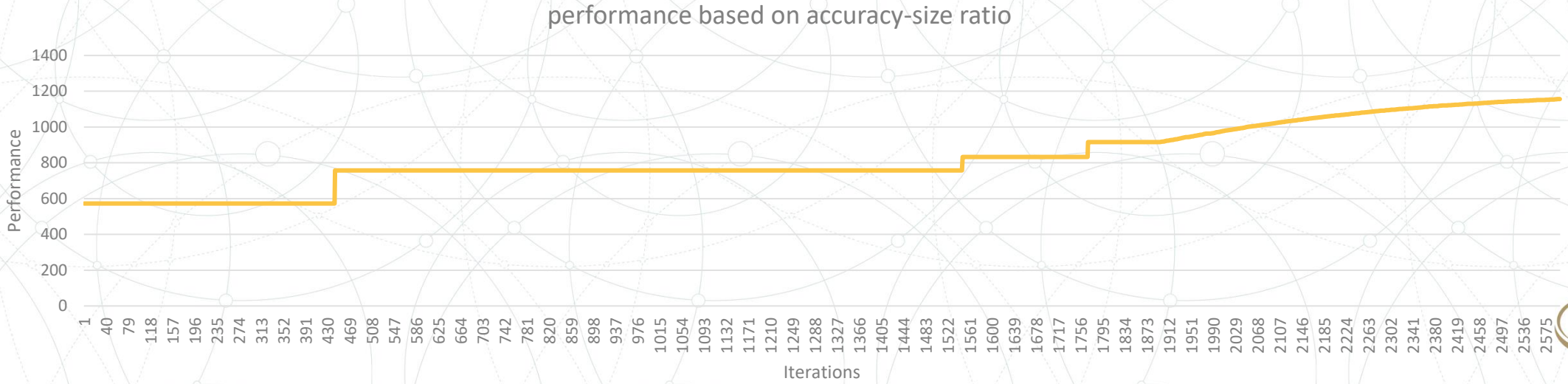
Results

Tennis Dataset





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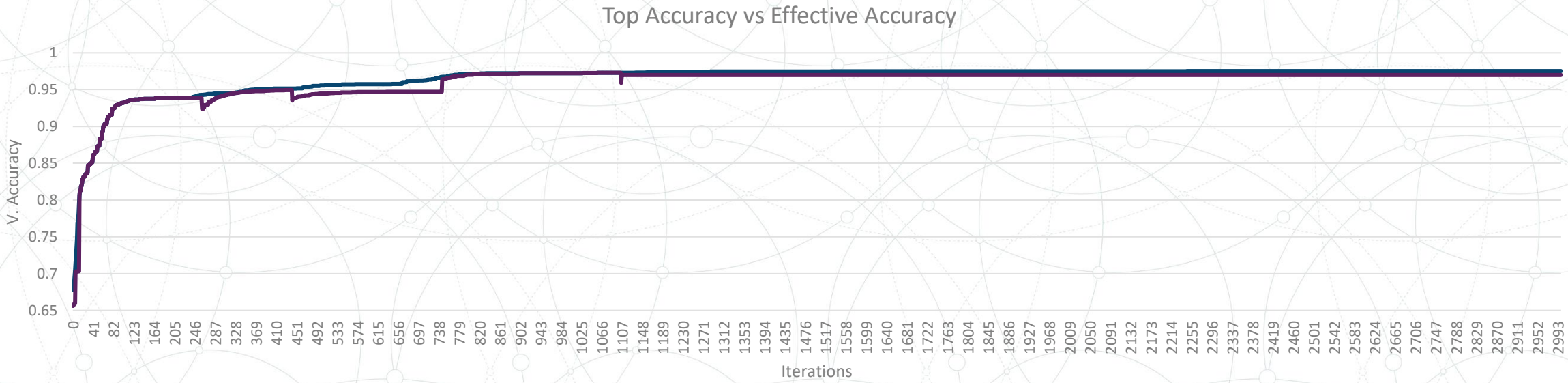
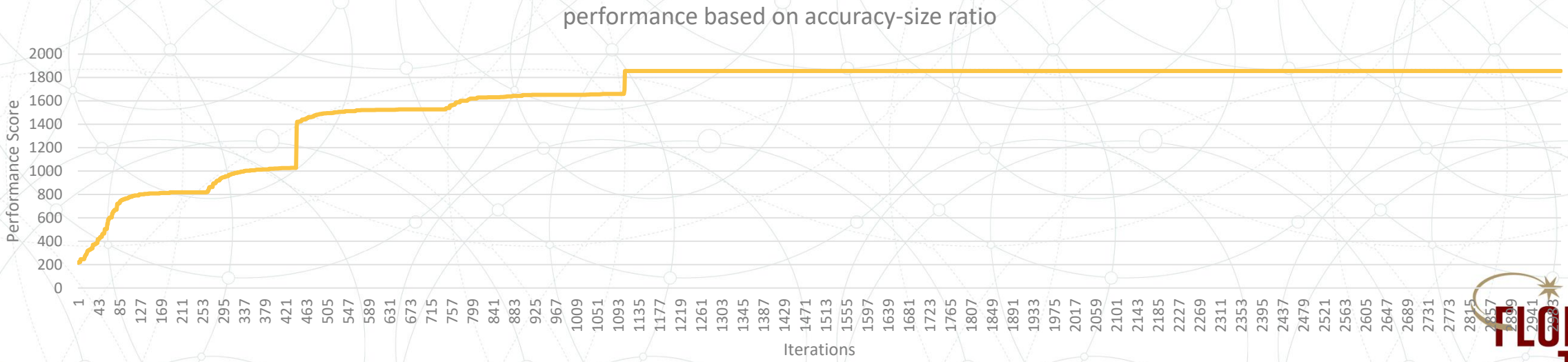
Results

Iris Dataset





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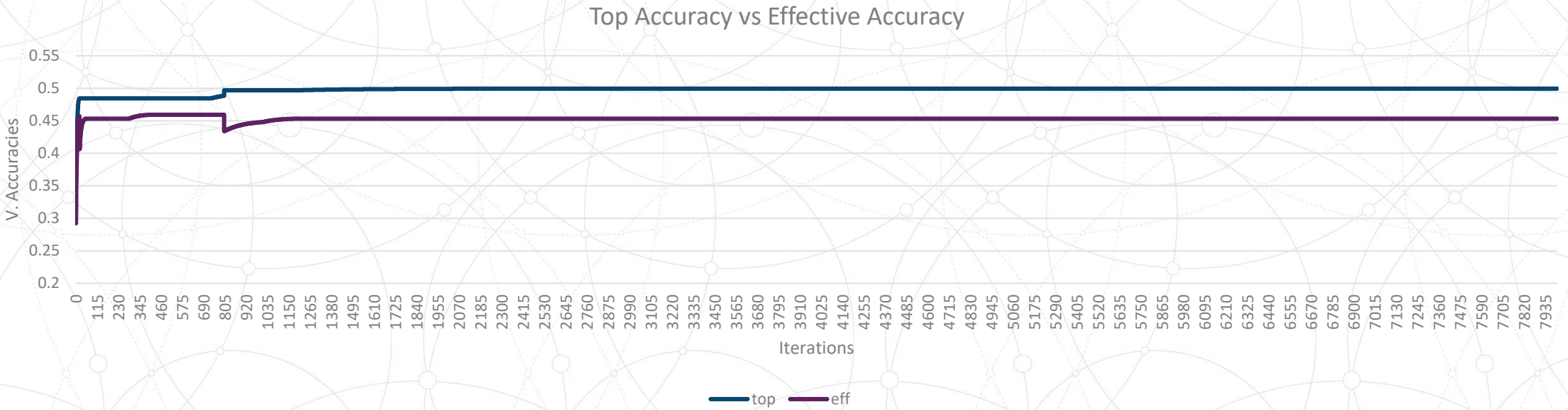
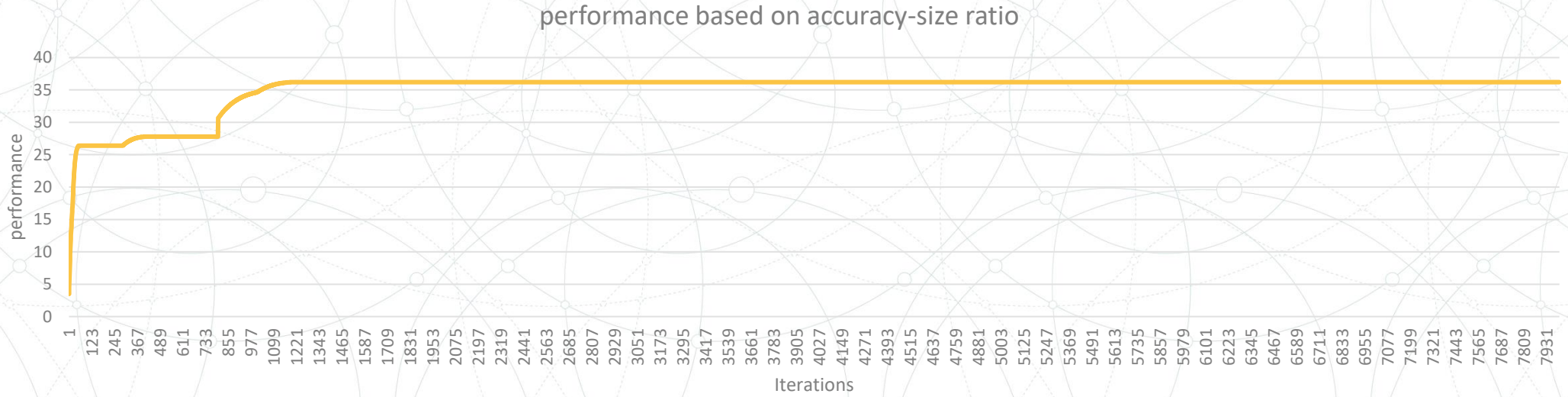
Results

Identity Dataset





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Results

	Iris					
	Trial 0		Trial 1		Trial 2	
	Best	Most acc	Best	Most acc	Best	Most acc
Test Acc %	***94.24***	***96.6***	***91.24***	***94.88***	***66.42***	***68.8***
Num Params	***42***	***63***	***28***	***49***	***7***	***70***
Topology	***4,6,3***	***4,9,3***	***4,4,3***	***4,7,3***	***4,1,3***	***4,10,3***
	Tennis					
	Trial 0		Trial 1		Trial 2	
	Best	Most acc	Best	Most acc	Best	Most acc
Test Acc %	***96.72***	***97.14***	***85.33***	***90.59***	***92.49***	***95.77***
Num Params	***72***	***120***	***12***	***96***	***12***	***24***
Topology	***10,6,2***	***10,10,2***	***10,1,2***	***10,8,2***	***10,1,2***	***10,2,2***
	Identity	(struggles here…)				
	Trial 0		Trial 1		Trial 2	
	Best	Most acc	Best	Most acc	Best	Most acc
Test Acc %	***55.2***	***93.38***	***54.81***	***92.39***	***55.32***	***89.11***
Num Params	***16***	***144***	***16***	***160***	***16***	***144***
Topology	***8,1,8***	***8,9,8***	***10,1,2***	***8,10,8***	***8,1,8***	***8,9,8***

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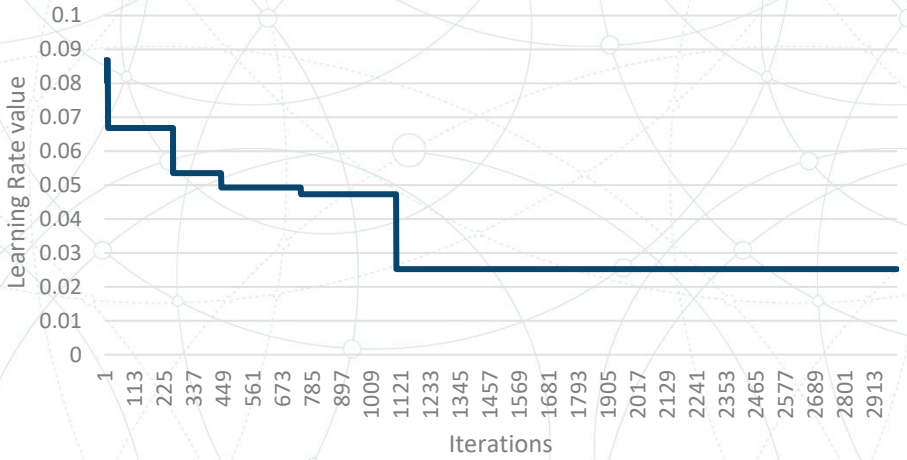
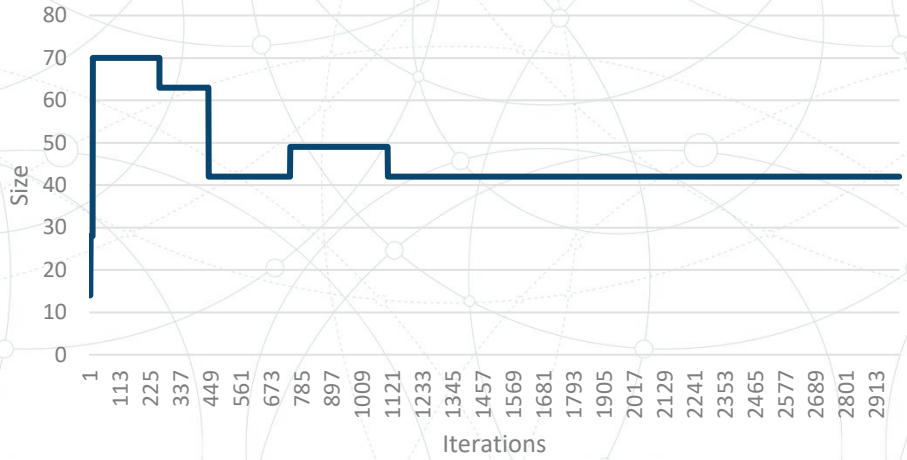
Hyperparameter schedules (think of what they mean)

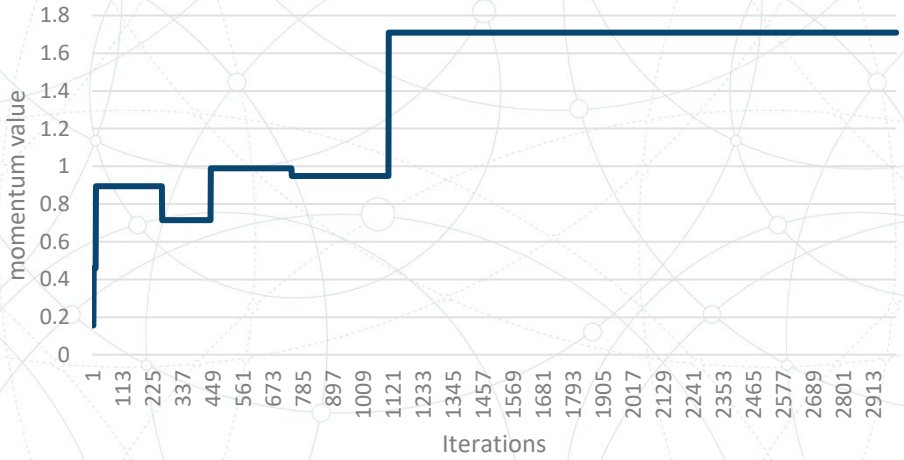
adaptive learning rate schedule



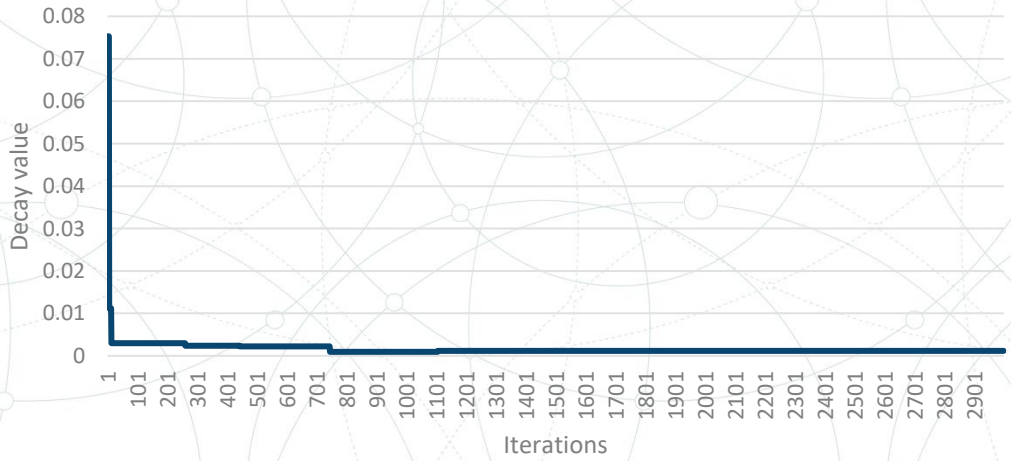
Size or Number of learnable parameters



momentum rate schedule



weight decay schedule



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Discussion: Advantages

- Works quite well in optimizing topology and hyperparameters!
- Provides both absolute highest accuracy net and highest accuracy with lowest size net.
- Trains ANN adaptively on hyperparameter schedules as opposed to values for efficient training
- Requires much less tunable parameters.
- Found 10.2.2 at 96% on Tennis
- Not sensitive to local minima or overfitting
- Can be parallelized

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Discussion: Drawbacks

- APBT uses **k** (population size) times more space to run than BP, runs **k** times longer. But it can be parallelized to run much faster!
- APBT is inconsistent with too small **k** and to small datasets
- APBT struggles to find minimum size net with Identity dataset
- Doesn’t support early stopping yet

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Some Observations

- Higher k the better, as long as resources allow it. Increases diversity in population
- Higher Selection Readiness allows nets to train for longer before sharing. But too high readiness and it's just k-random search.
- Most effectively accurate net is not always the most absolutely accurate
- Longer epochs range allow for rest of population to catch up to the top performers.

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Summary

- APBT can work really well and requires far less hyper parameters, providing the most accurate, lowest size neural net, which is trained on the optimal hyperparameter schedule.
- However, APBT takes k (population size) times more space to run than BP, and without parallelism runs k times longer than BP. Can be inconsistent with smaller k and very small datasets. Struggles with Identity
- In all, to solve the problem of ANN topology and hyperparameters optimization, Augmented Population Based Training is a powerful step in the right direction.

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Thank you.

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Questions ?