

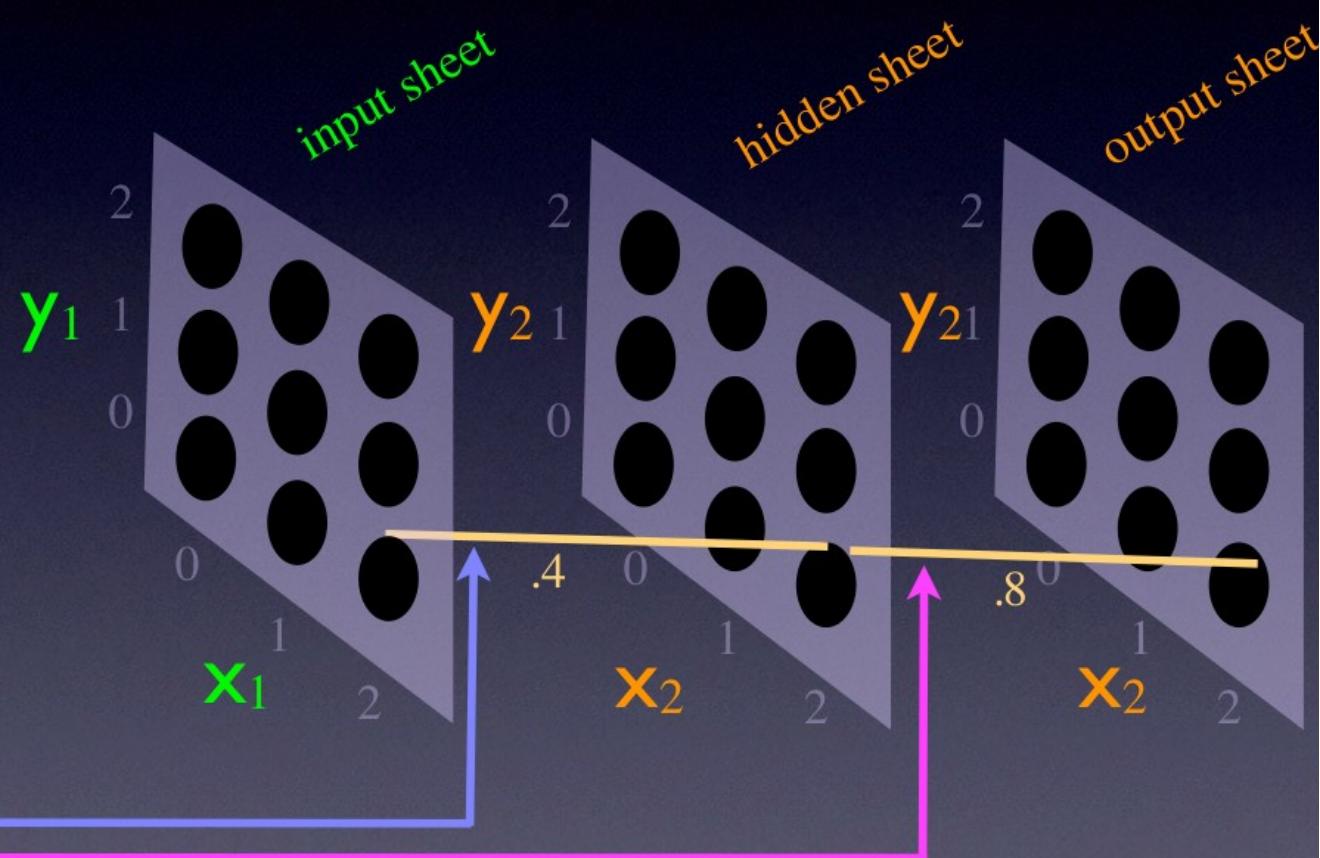
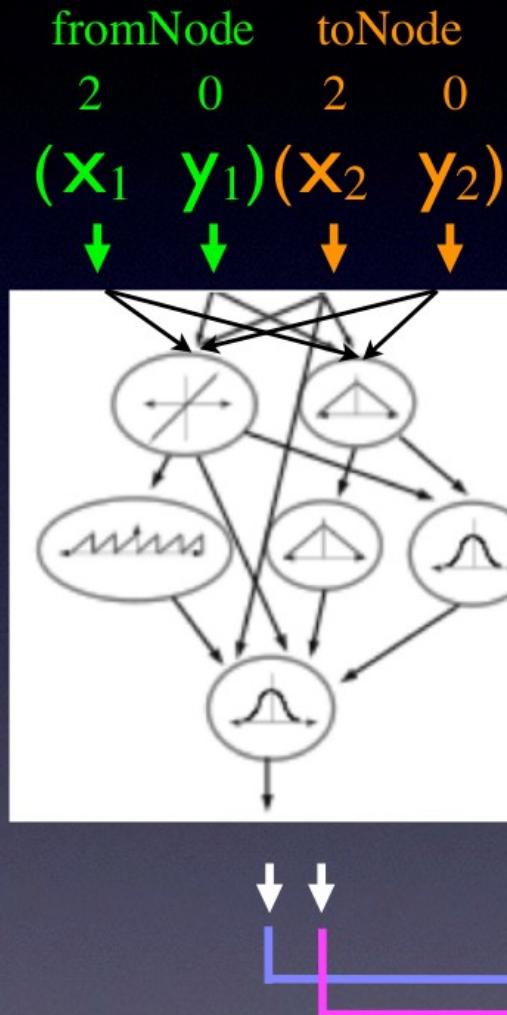
Modern Robotics: Evolutionary Robotics

COSC 4560 / COSC 5560

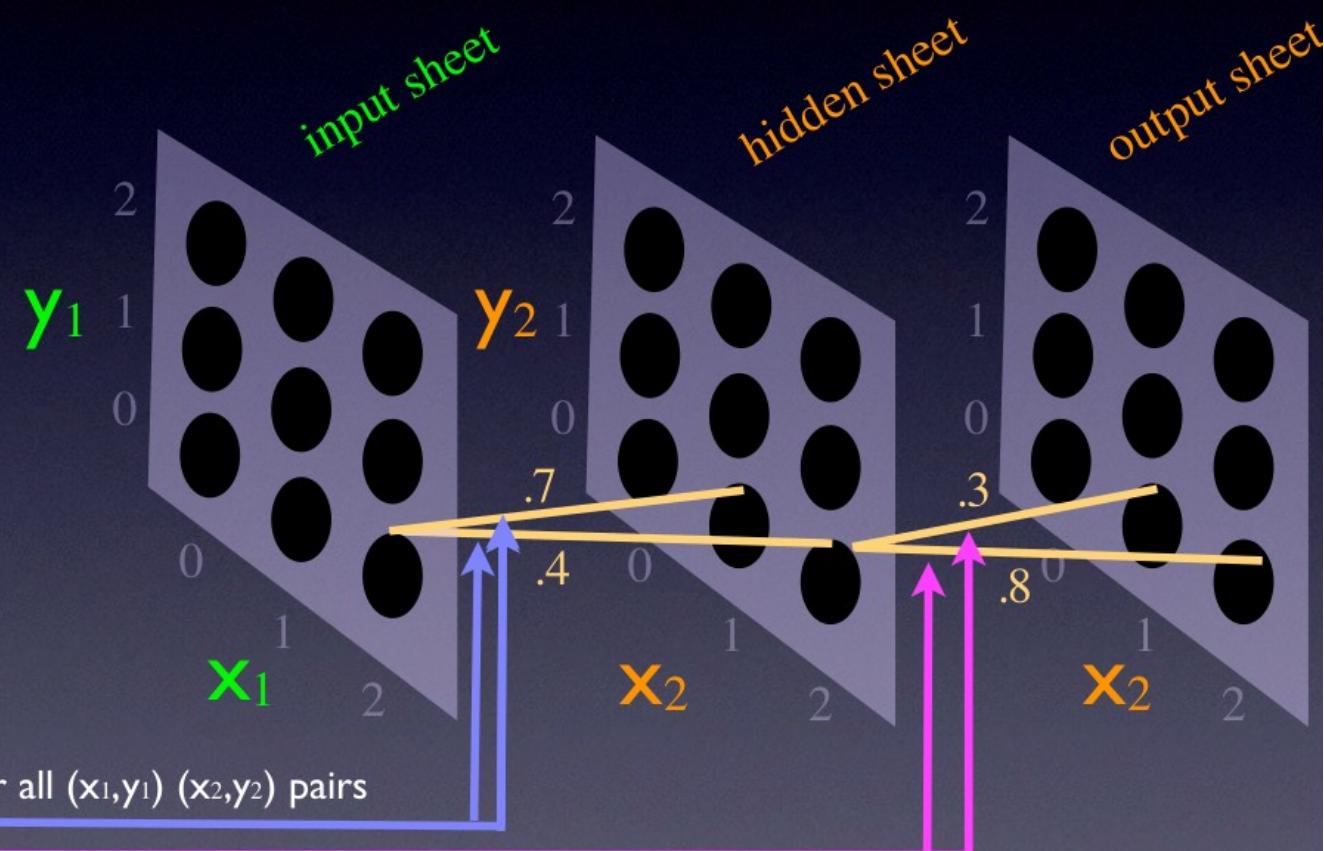
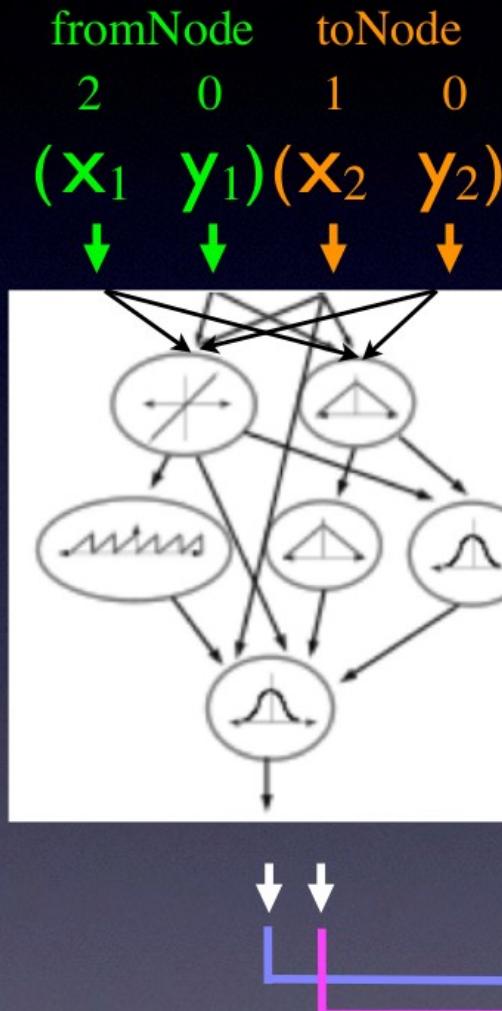
Professor Cheney
2/21/18

HyperCube NeuroEvolution of Augmenting Topologies (Hyper-NEAT)

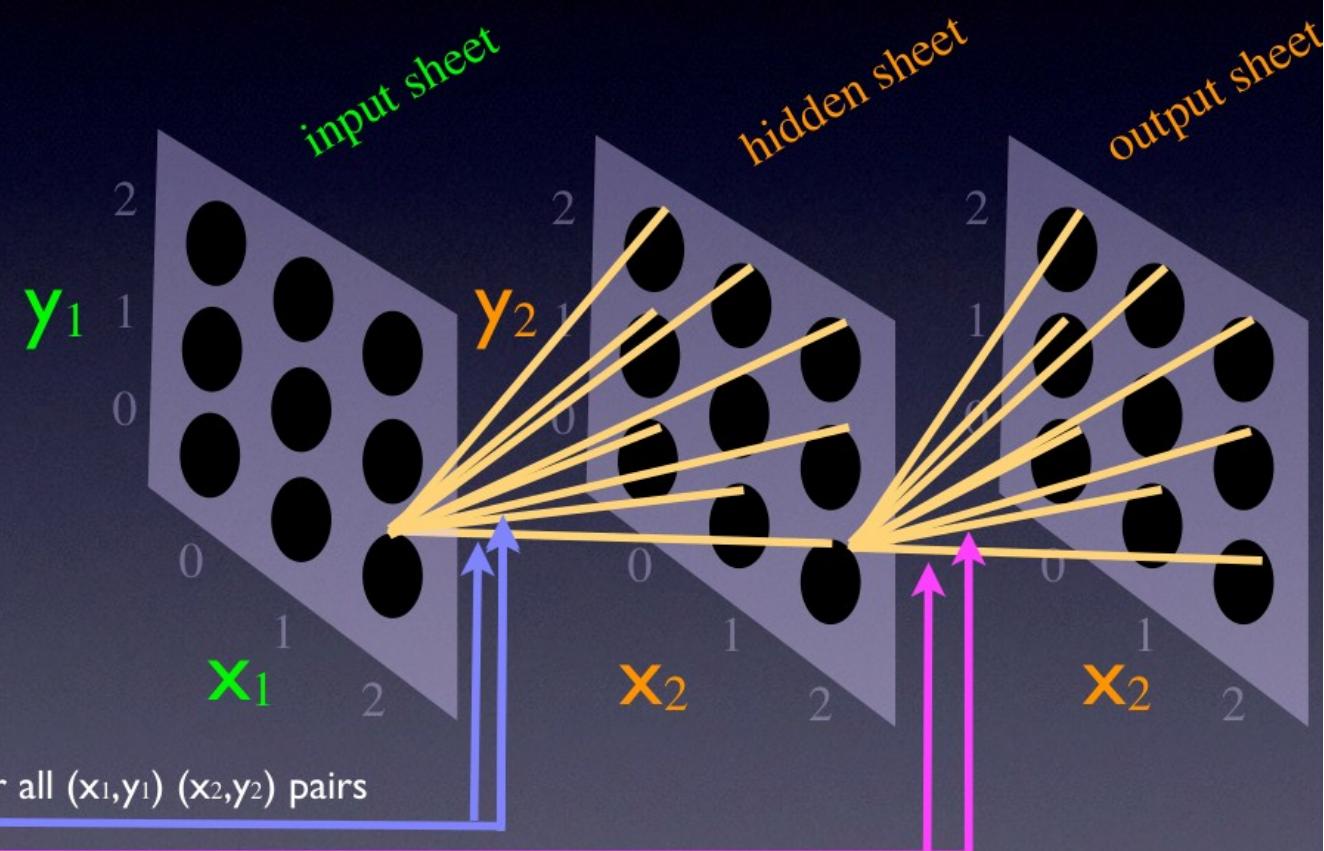
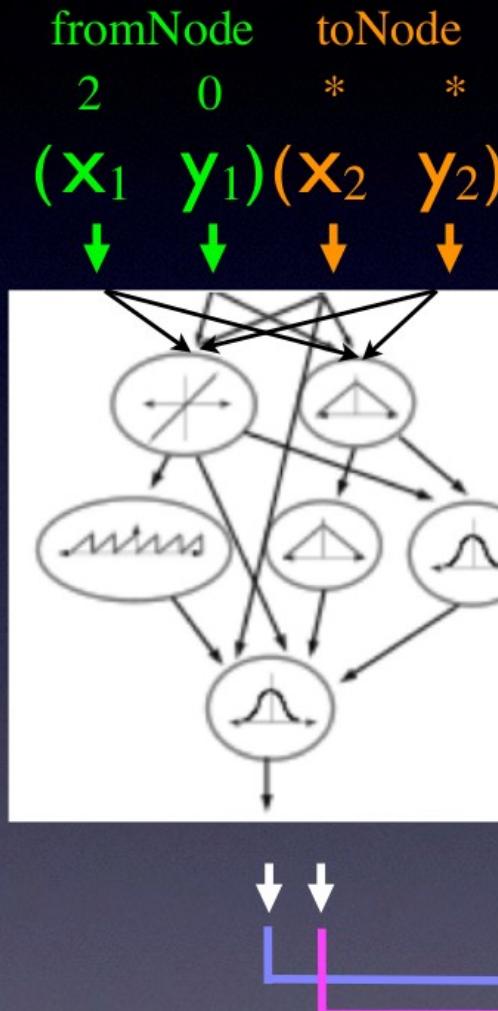
HyperNEAT



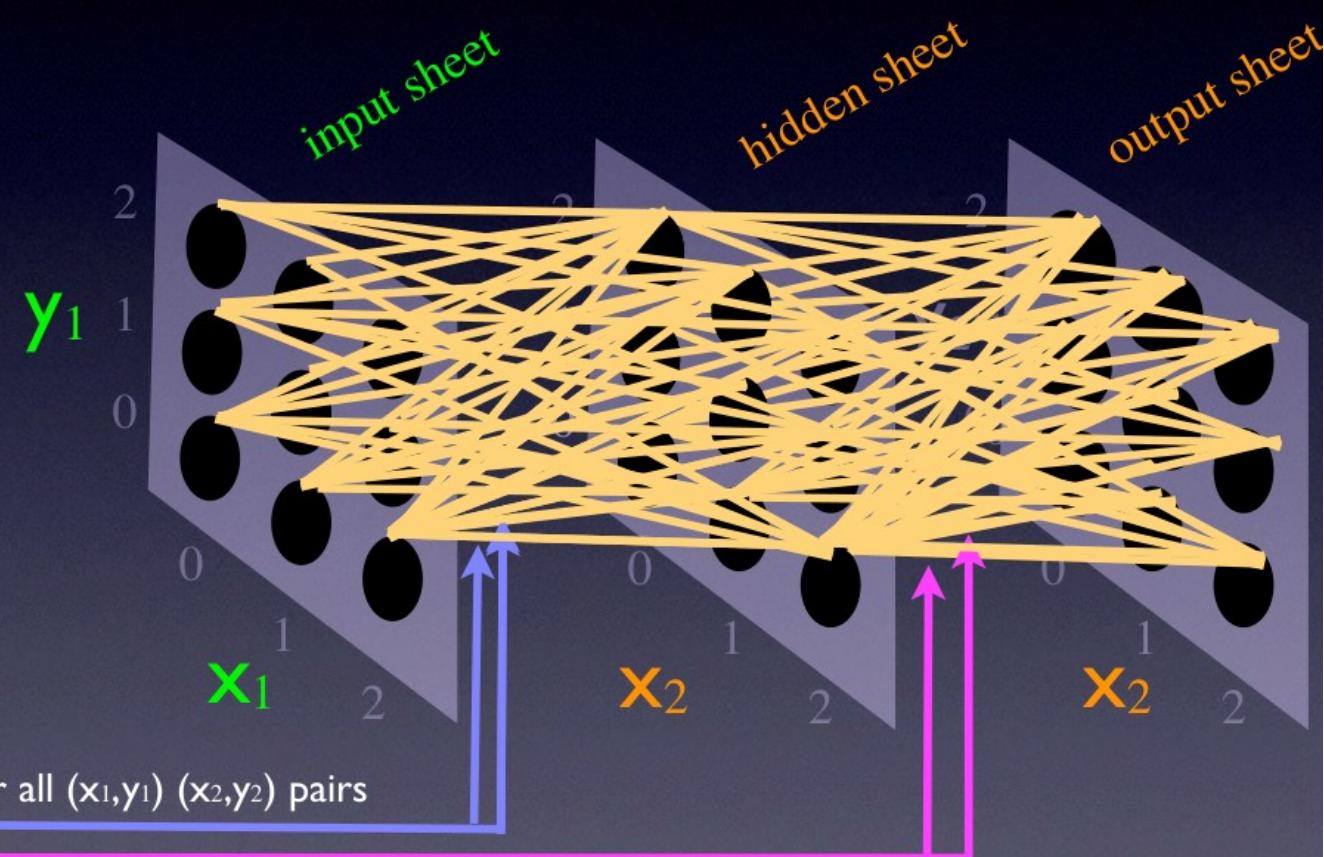
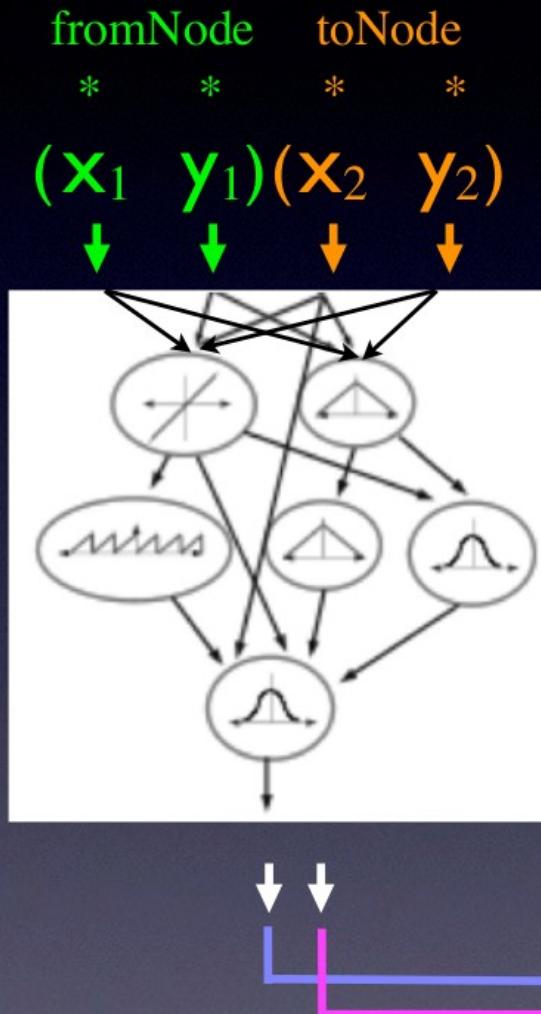
HyperNEAT



HyperNEAT



HyperNEAT

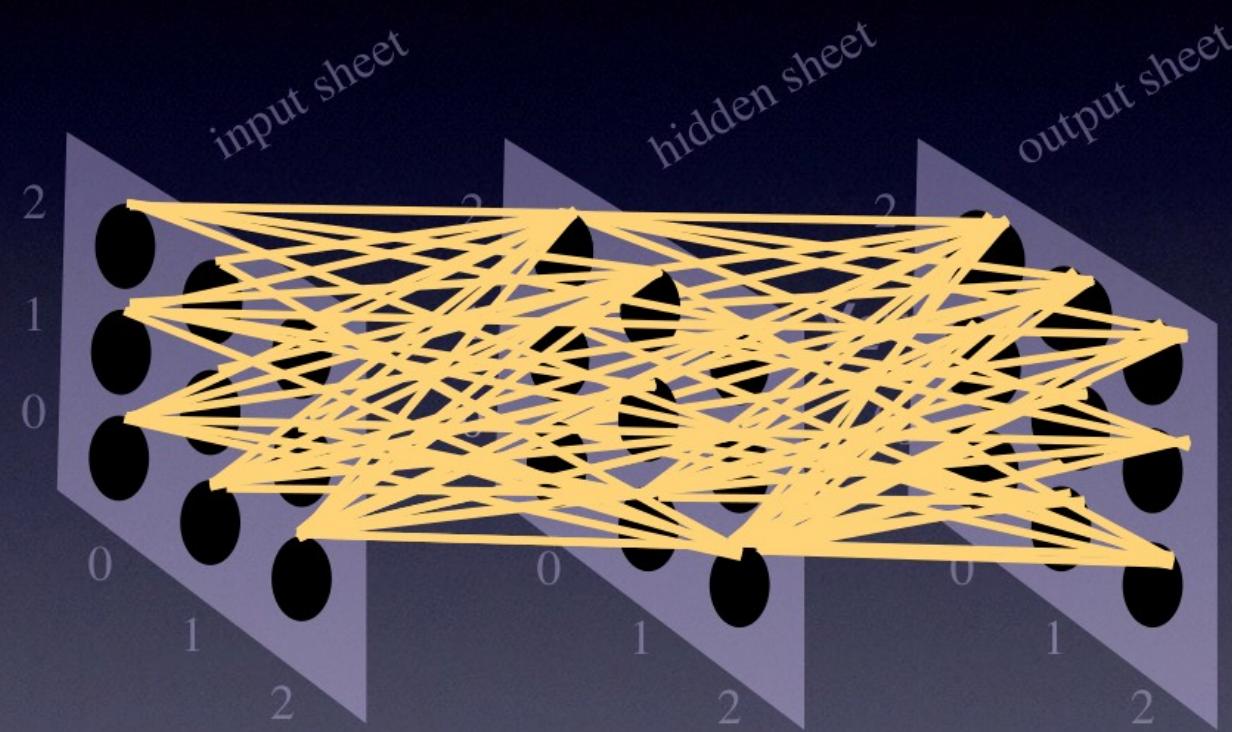


generative encoding

Fixed Topology (FT) NEAT

x_1	$y_1 \rightarrow x_2$	y_2	weight
0	0	0	.1
0	0	1	.4
0	0	2	-.1
0	1	0	-.8
0	1	0	.9
0	1	0	-.3
0	2	0	0
0	2	0	1

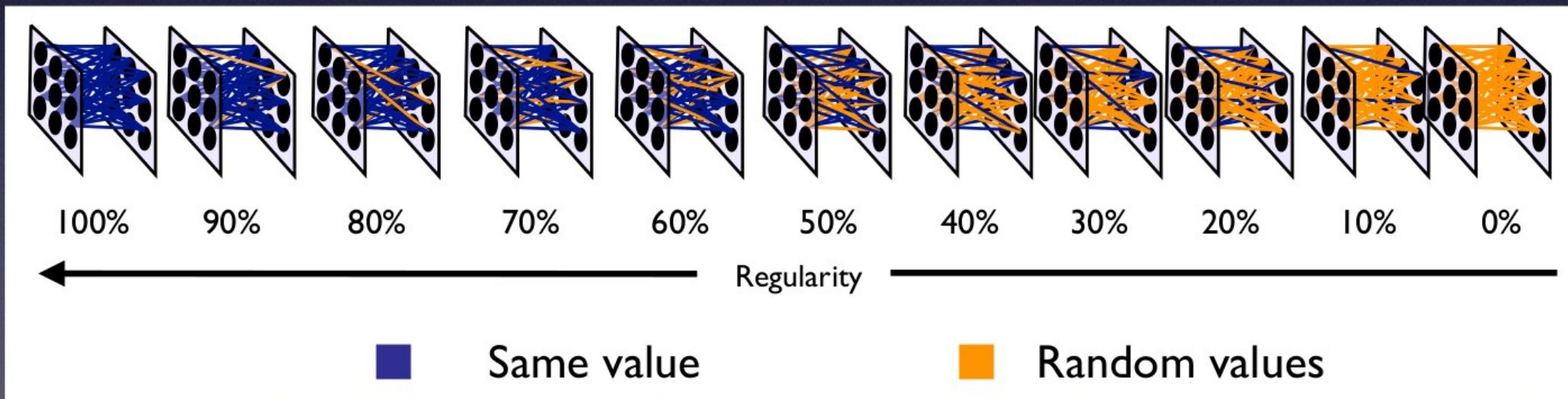
etc...



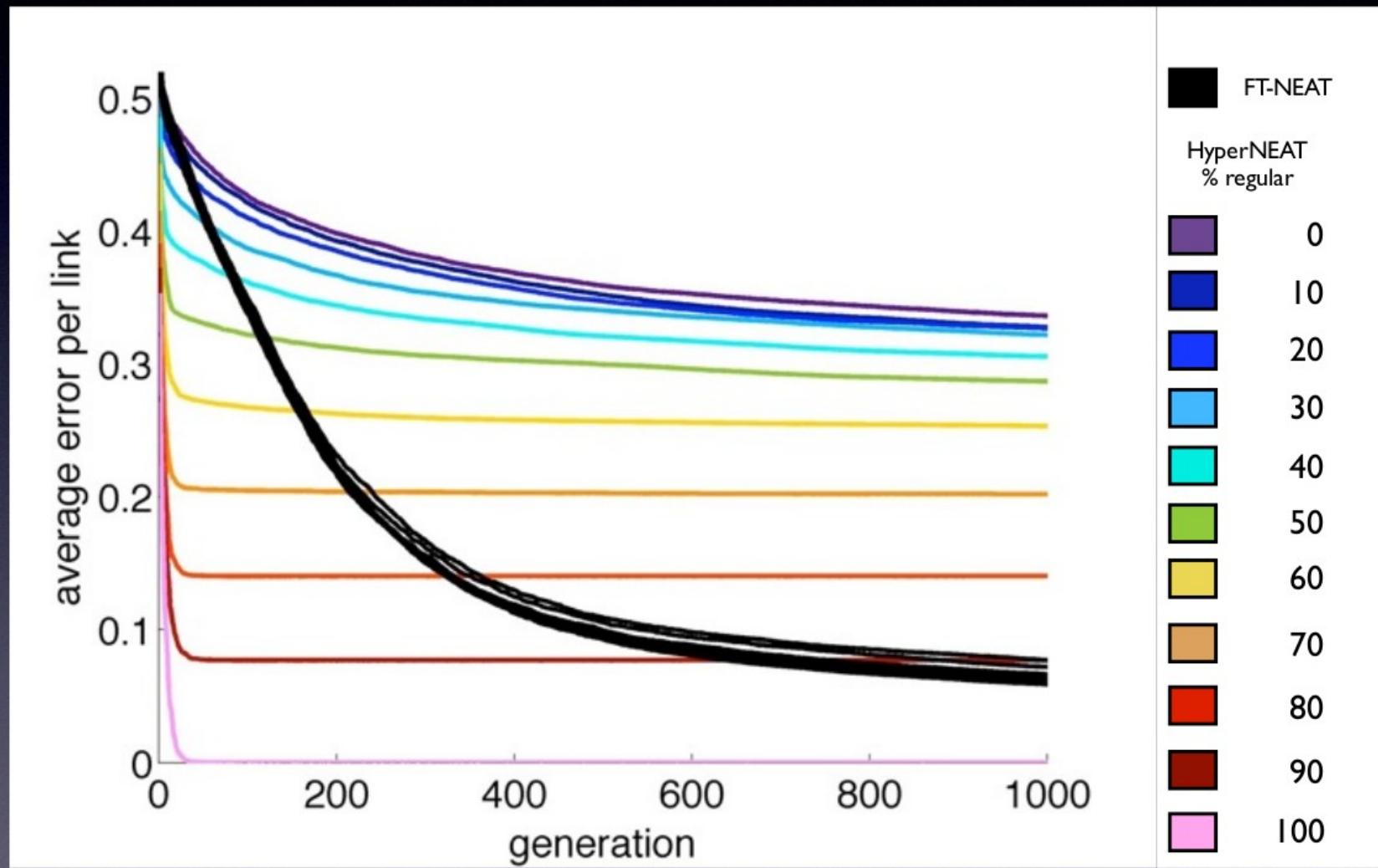
direct encoding

Target Weights Problem

- match target ANN
- intuitive, scalable regularity, no epistasis



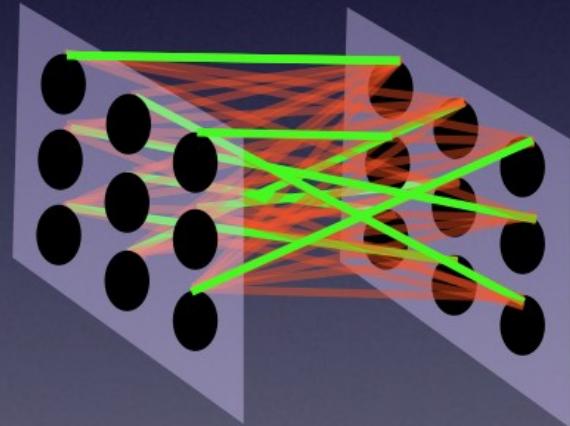
The Generative Encoding Exploits Regularity



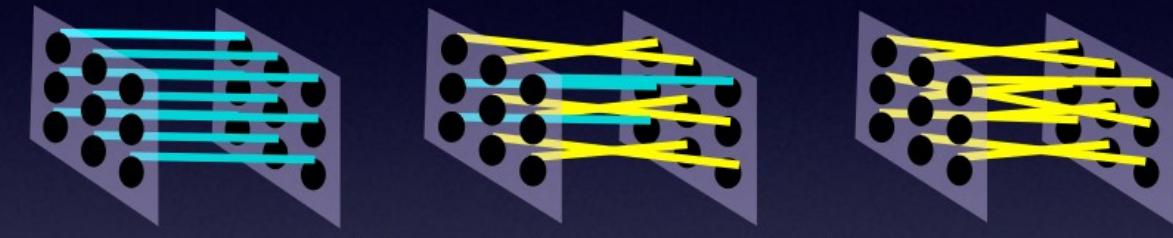
Bit Mirroring Problem

intuitive, scalable regularity, *has epistasis*

Solution

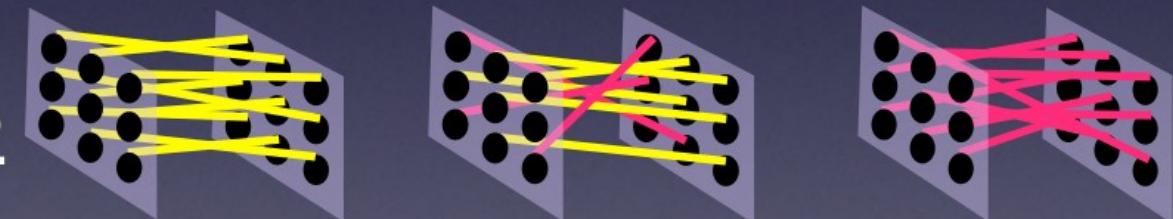


Type I



within-column regularity →

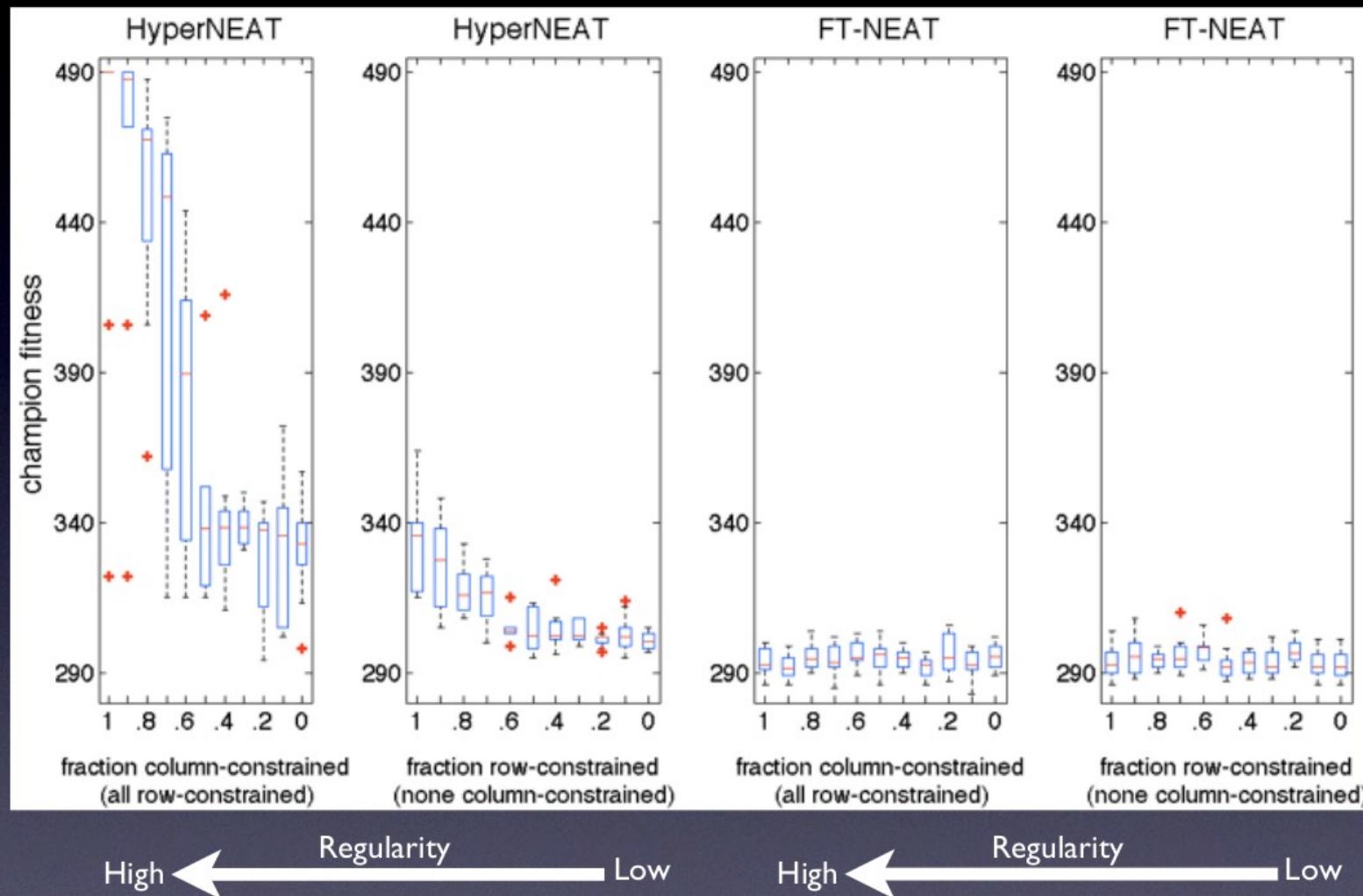
Type 2



within-row regularity →

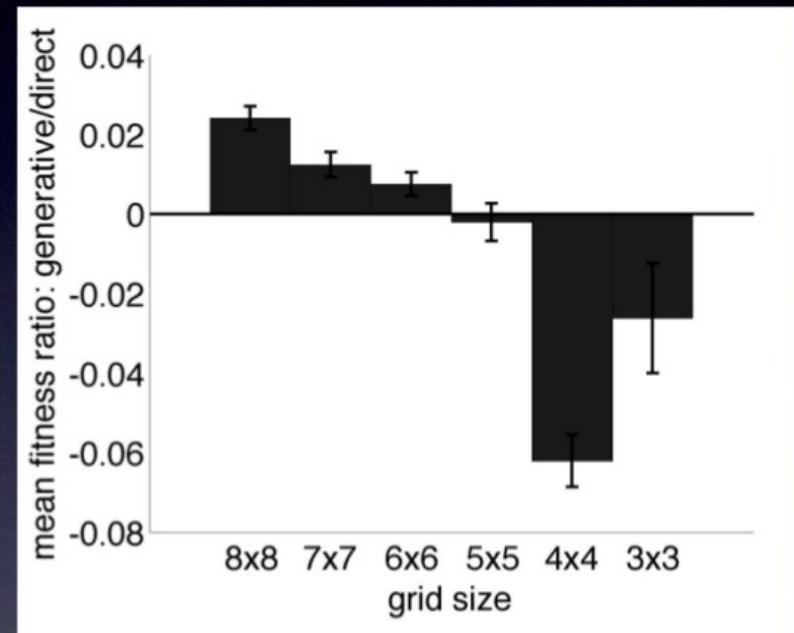
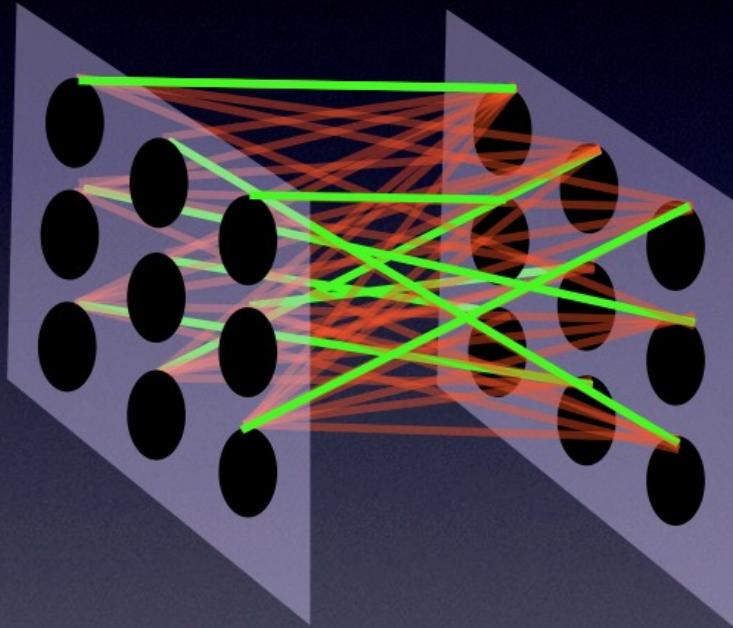
constraints: column and row, row, none

Bit Mirroring Problem



- HyperNEAT can exploit intermediate regularity ($p < .05$)
- Outperforms direct encoding ($p < .05$)

Varying Inherent Regularity in the Bit Mirroring Problem

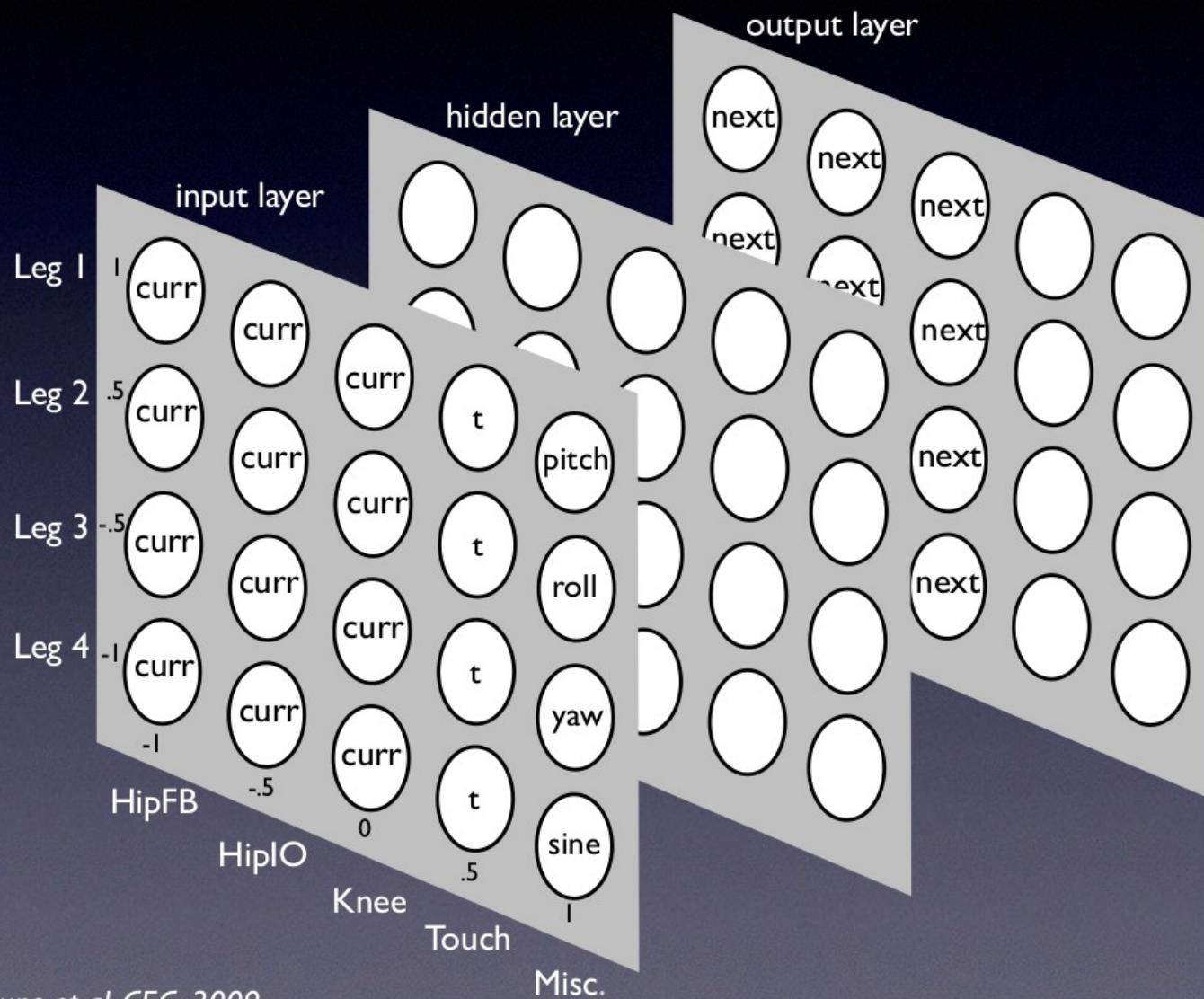


- HyperNEAT exploits intermediate regularity
- FT-NEAT better when problem is irregular enough

Gaits for Quadruped Controller



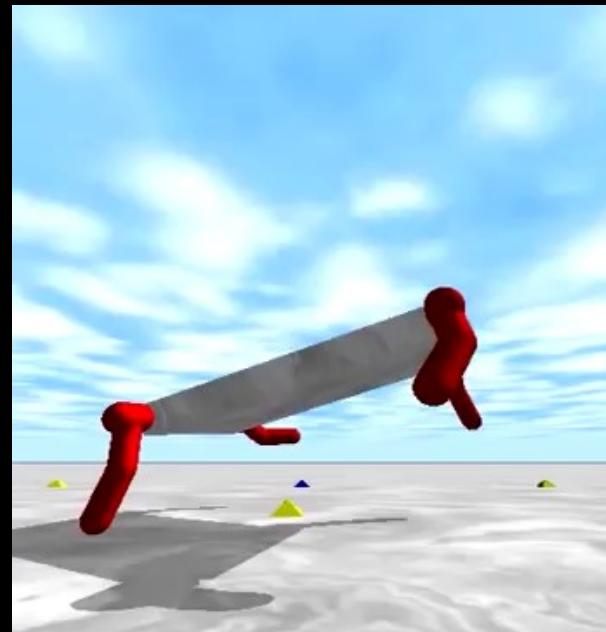
ANN Controller



Goal: speed



FT-NEAT best



FT-NEAT worst

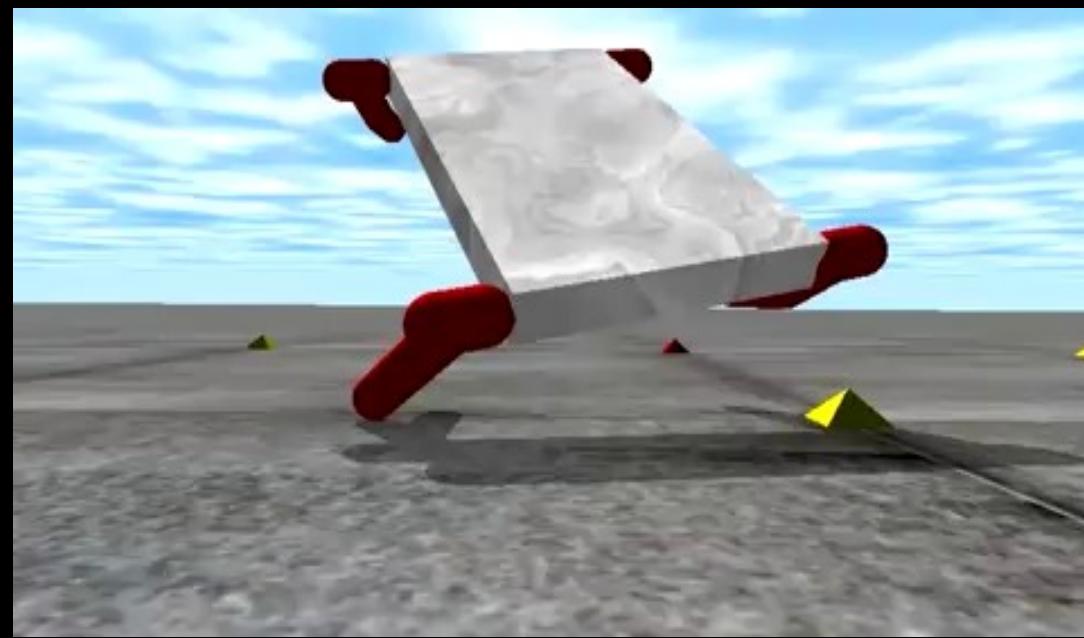


Hyper-NEAT best

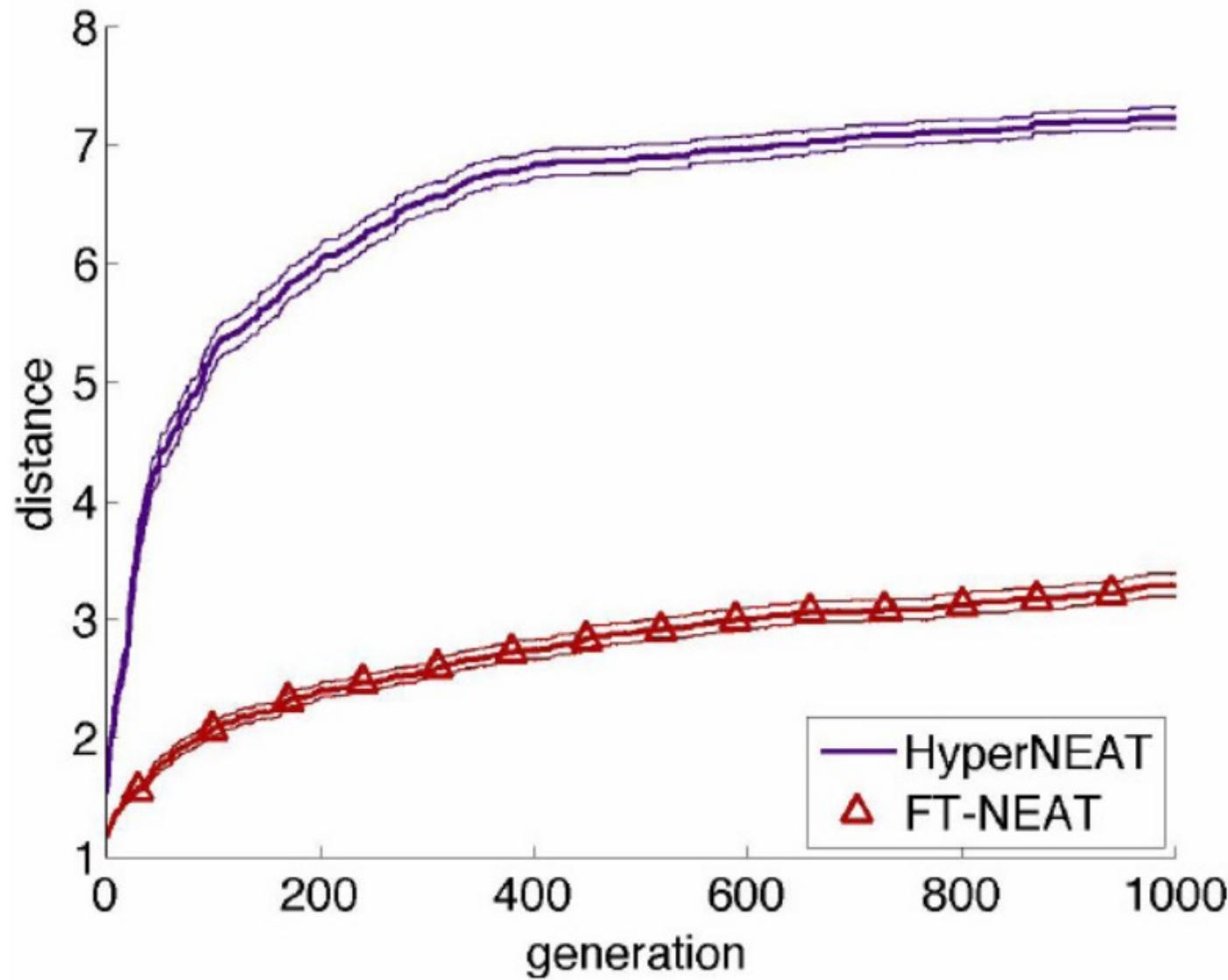


Hyper-NEAT worst



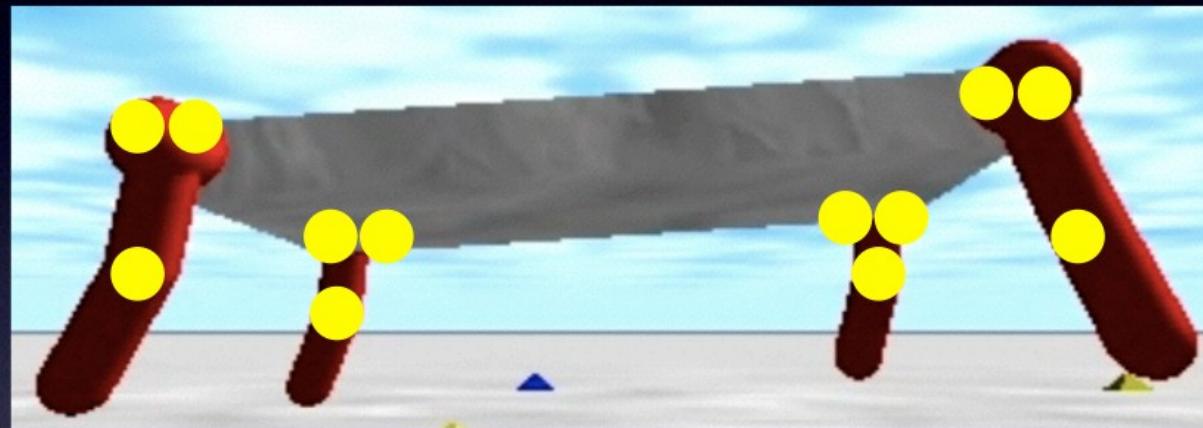


for Legged Robots



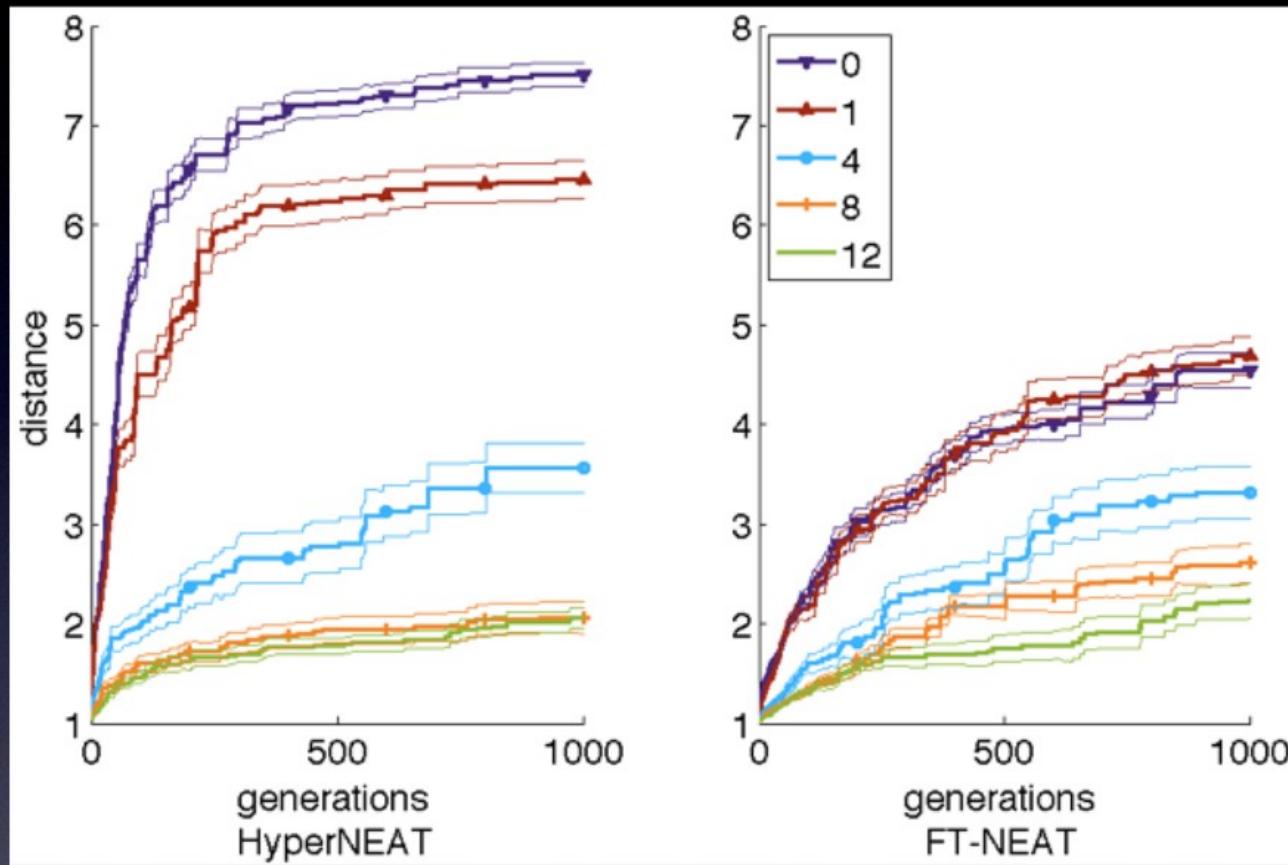
Scaling Regularity in Quadruped Controller

0 | 4 8 |2



- Add faulty joints
 - request Angle, get Angle + Error
 - constant throughout run
 - emulates manufacturer error

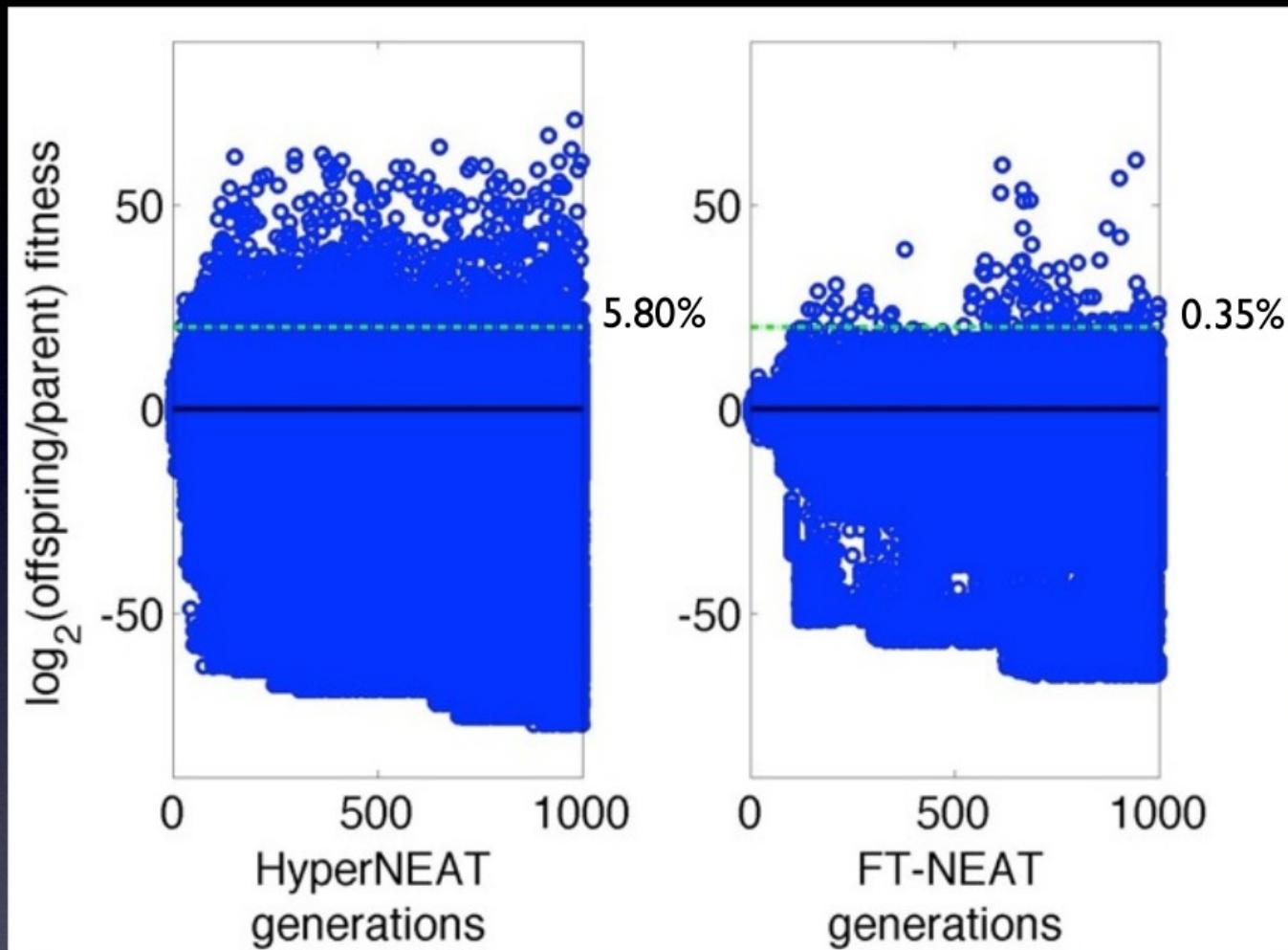
Quadruped Controller



HyperNEAT exploits problem regularity

- performance increases with problem-regularity
- outperforms FT-NEAT on two most regular version of the problem ($p < .001$)

HyperNEAT ANNs are More Evolvable



- HyperNEAT's median higher ($p < .001$)
- Extreme positives outweighs the extreme negatives

HyperNEAT ANNs are More Regular on More Regular Problems

Genome node number indicates compressibility

- Target Weights: $r = 0.54$ ($p = .08$)
- Quadruped: $r = 0.58$ ($p > .1$)
- Bit Mirroring: $r = 0.91$ ($p < .001$)

