AI OVERVIEW

Samuel M. Smith Ph.D.
2018.02.08
sam.smith@consensys.net

A.I.

Computing techniques that attempt to replicate various aspects of human perception and cognition *that is only taught to graduate students*.

Weak or Narrow A.I.

Strong or General A.I.

Many Types

Automated reasoning

Machine Learning

Machine Intelligence

Computational Intelligence

Artificial General Intelligence

Natural Language Processing

Computational Search

Pattern Recognition

Image Processing

Intelligent Control

Reinforcement Learning

Meta learning

Deep Learning

Artificial Neural Networks

Fuzzy Logic

Genetic Algorithms

Evolutionary Algorithms

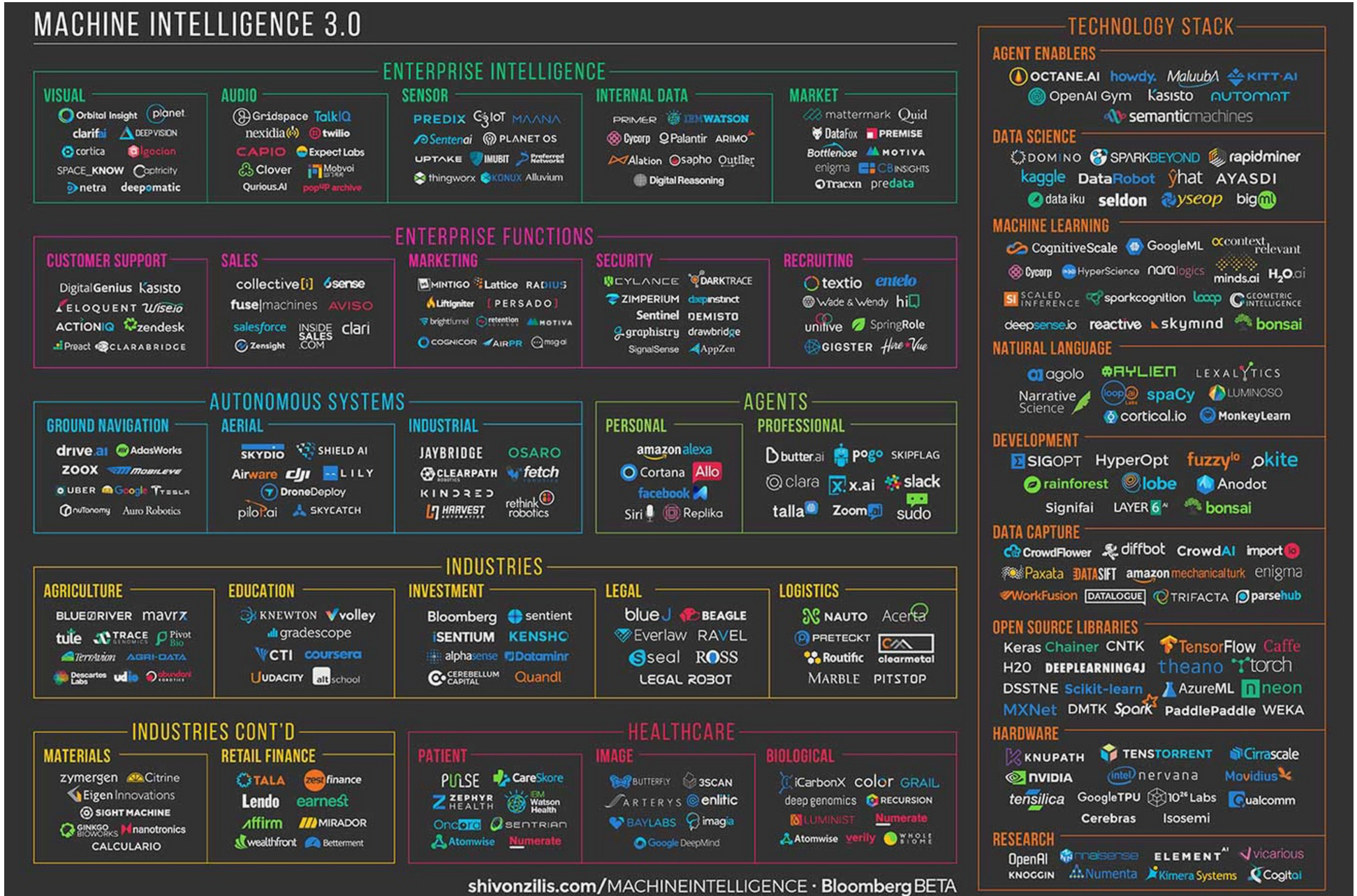
Bayesian Belief Networks

Symbolic Reasoning

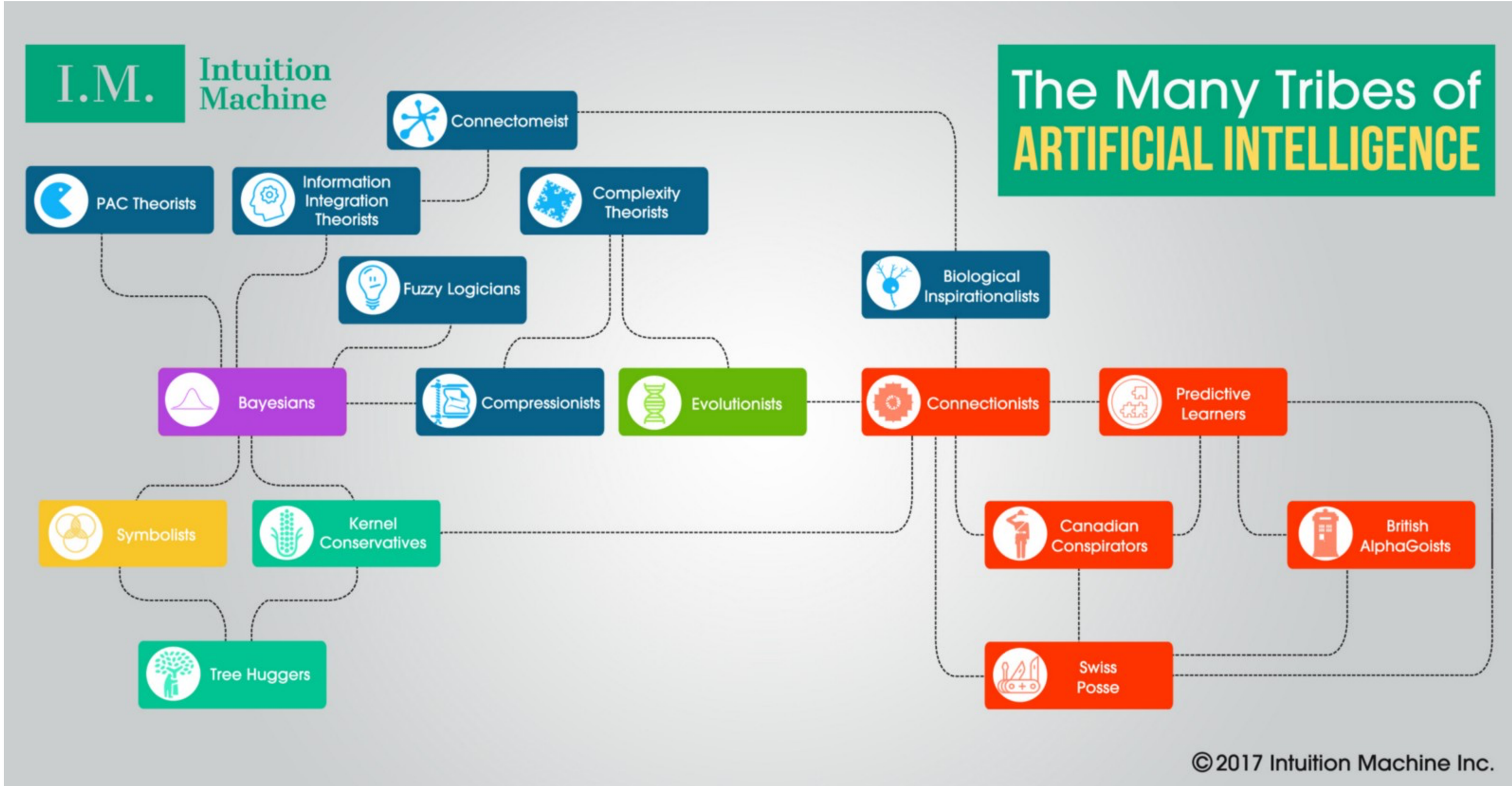
Approximate Dynamic Programming

Expert Systems

Machine Intelligence Landscape



The Many Tribes of AI



Deep Learning

Supervised learning using multi-layer back-propagation, stochastic gradient descent, on pre-classified training data.

Most popular. Many open source tool kits.

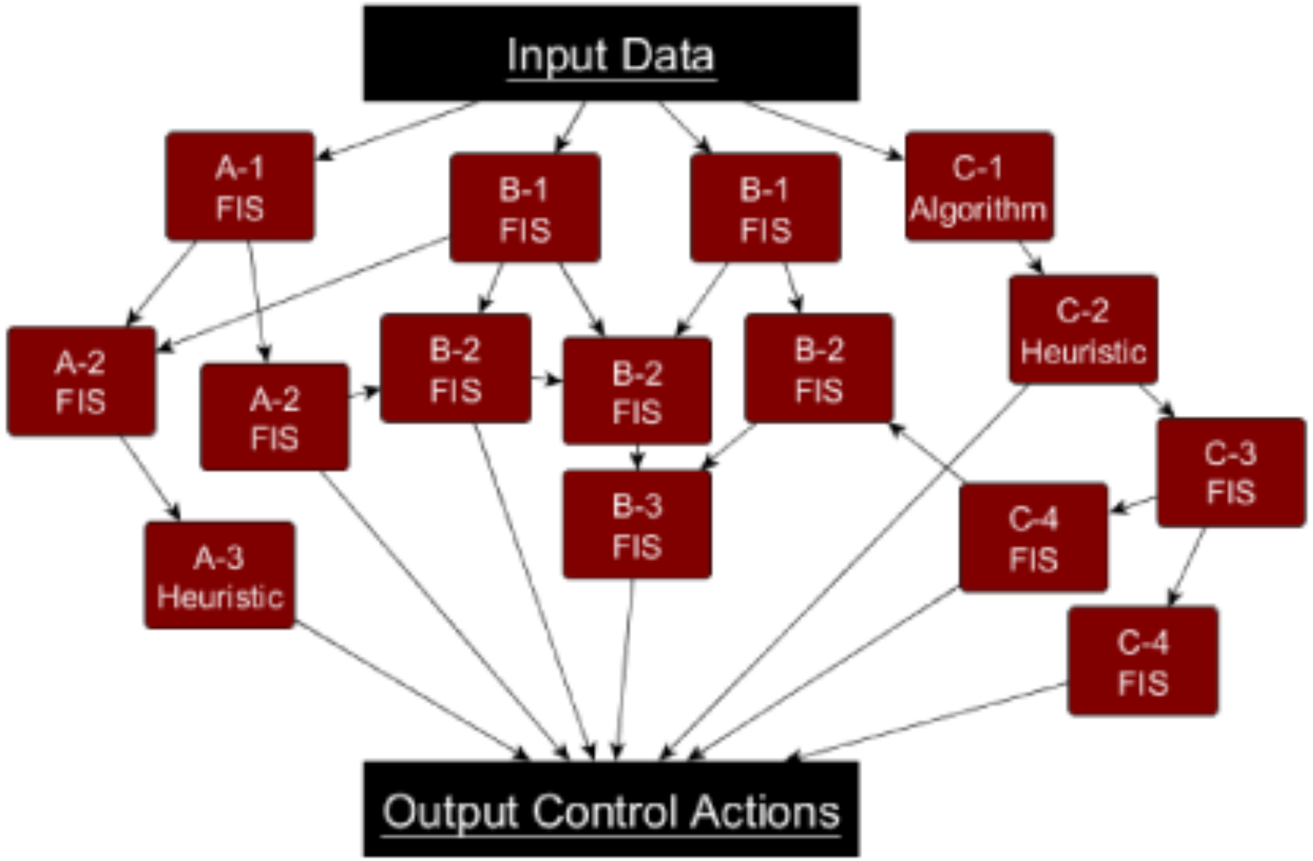
Works best with *very large data sets.*

Simple algorithm

Relatively easy to implement and use

Primary application is pattern recognition or image classification

Hierarchically Decomposed Staged Concurrent Modular Fuzzy Learning Algorithm Defeated Human Every Time in Simulated Air-to-Air Combat



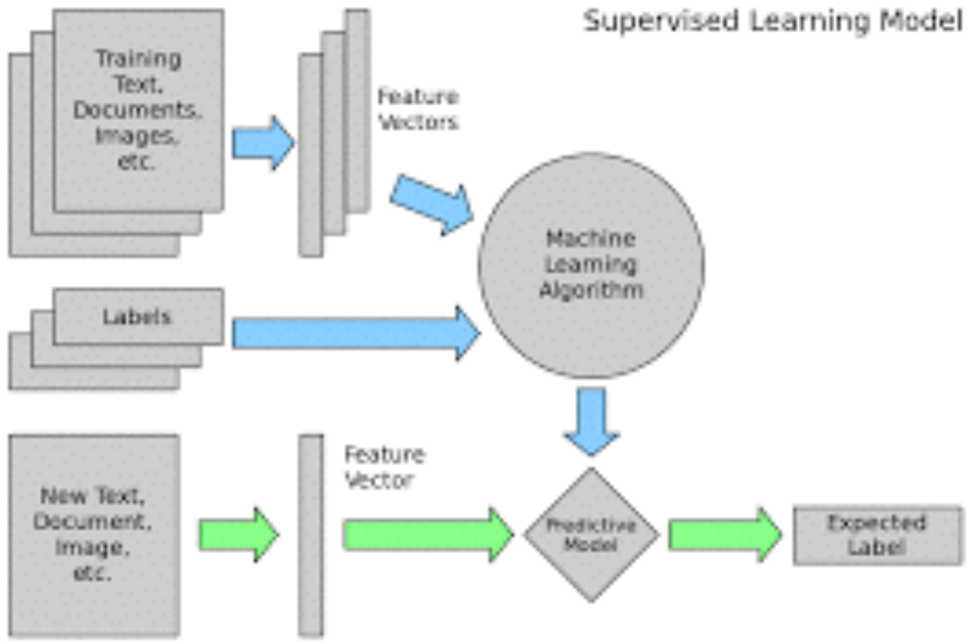
Genetic Fuzzy based Artificial Intelligence for Unmanned Combat Aerial Vehicle Control in Simulated Air Combat Missions. 2016
Ernst et al Journal of Defense Management Volume 6 • Issue 1 http://dx.doi.org/10.4172/2167-0374.1000144

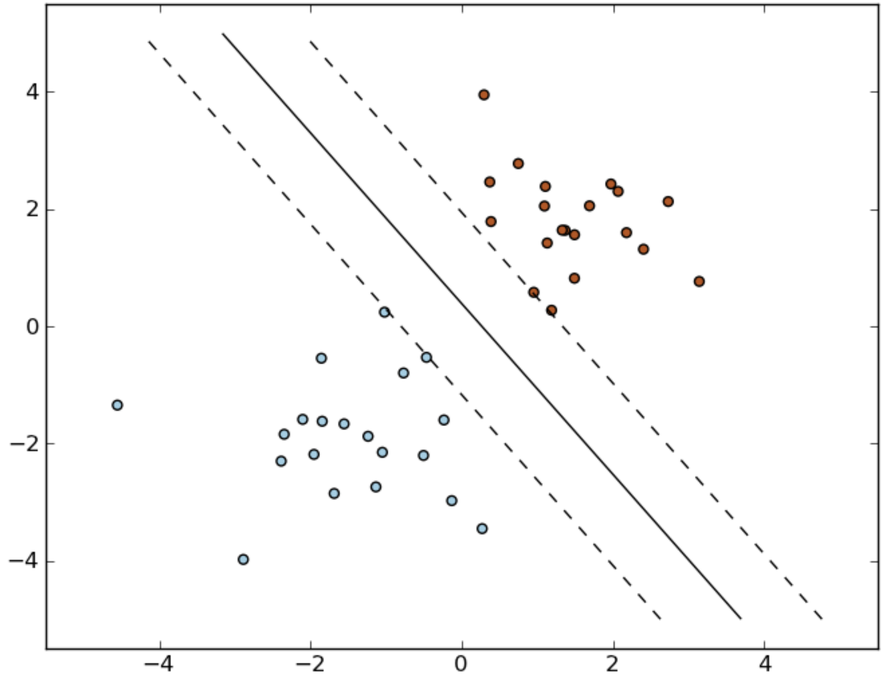
Basic Machine Learning Types

Supervised Learning - Classified Data Set

Unsupervised Learning - Clustering of Unclassified Data Set

Reinforcement Learning - Adaptive Critic



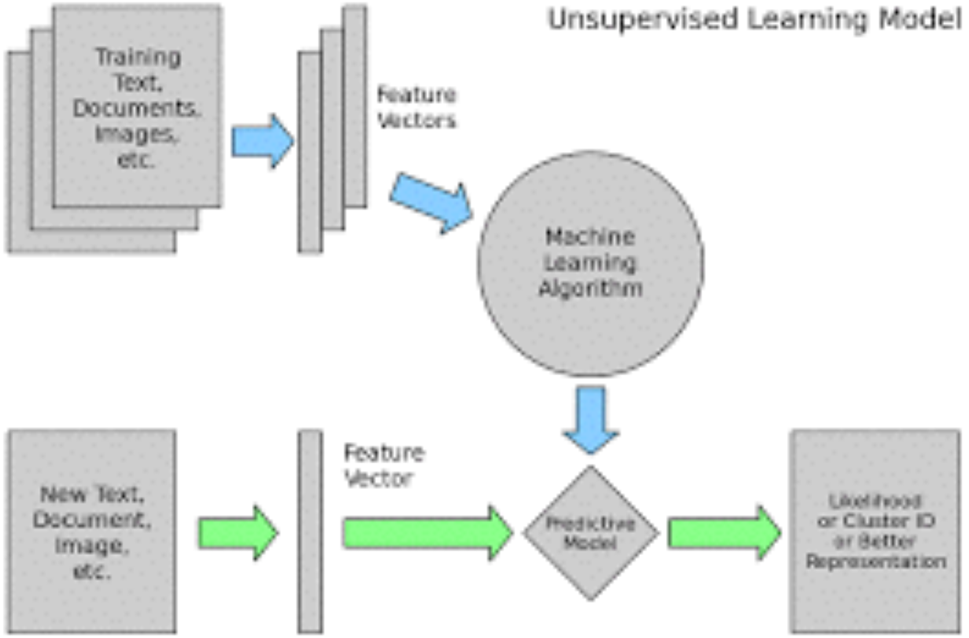


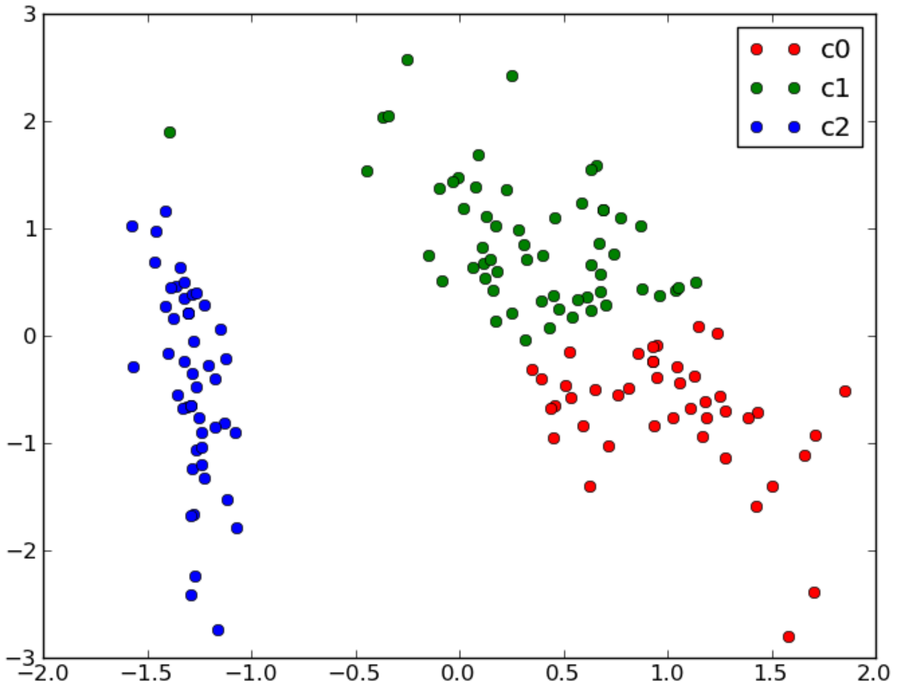
Basic Machine Learning Types

Supervised Learning - Classified Data Set

Unsupervised Learning - Clustering of Unclassified Data Set

Reinforcement Learning - Adaptive Critic



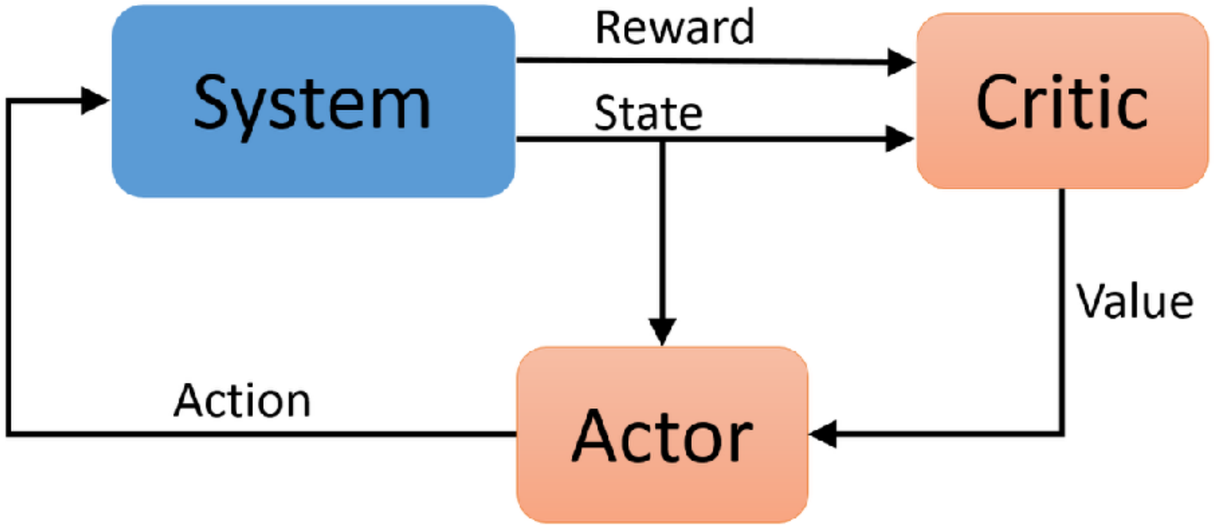


Basic Machine Learning Types

Supervised Learning - Classified Data Set

Unsupervised Learning - Clustering of Unclassified Data Set

Reinforcement Learning - Adaptive Critic



Common Concepts

Stochastic Gradient Descent: Continuous geometric function from input to output with continuous derivative

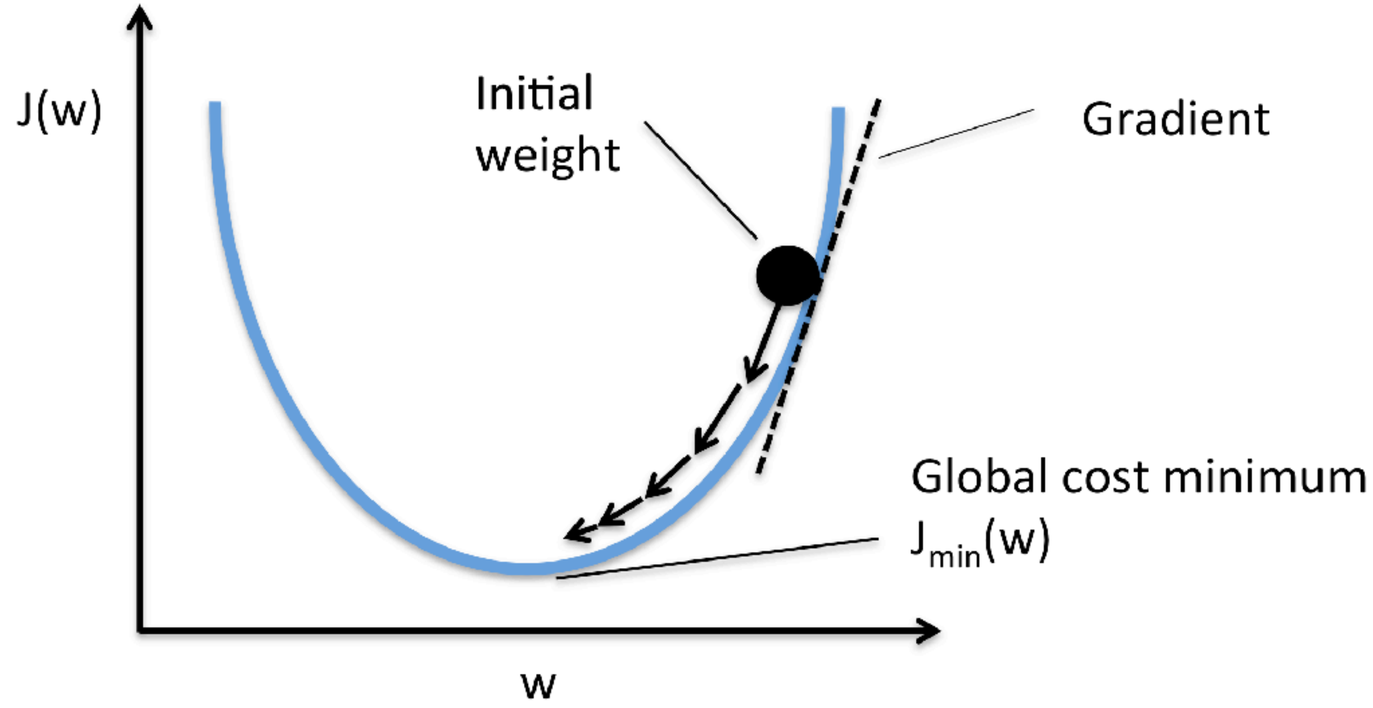
Universal Function Approximators: Neural net, fuzzy inference system, etc

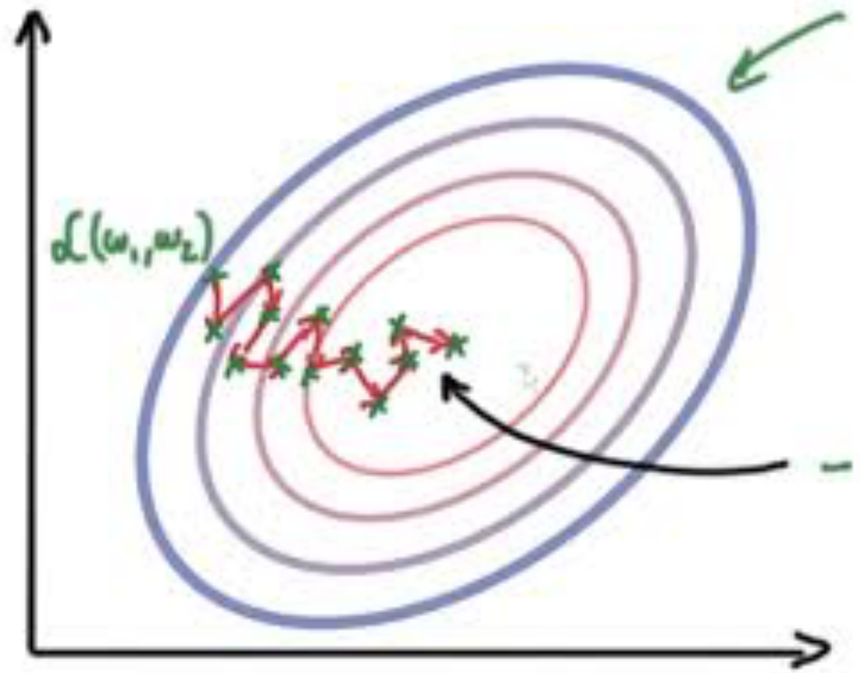
No Free Lunch Theorem

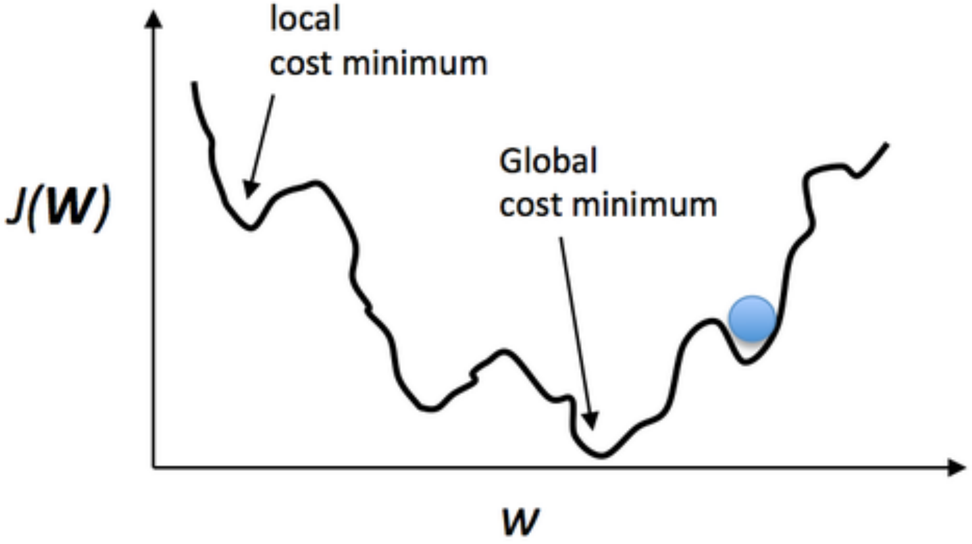
All algorithms that search for an extremum of a cost function perform exactly the same when averaged over all possible cost functions. So, for any search/optimization algorithm, any elevated performance over one class of problems is exactly paid for in performance over another class.

Proficiency of practitioner is often more important than the method used.

Stochastic Gradient Descent







New Kinds of AI for Blockchain

Artificial Social Intelligence

Artificial Network Intelligence

Group AI

Decentralized AI

Distributed AI

All need identity, reputation and distributed consensus

Distributed Consensus

Proof of Work

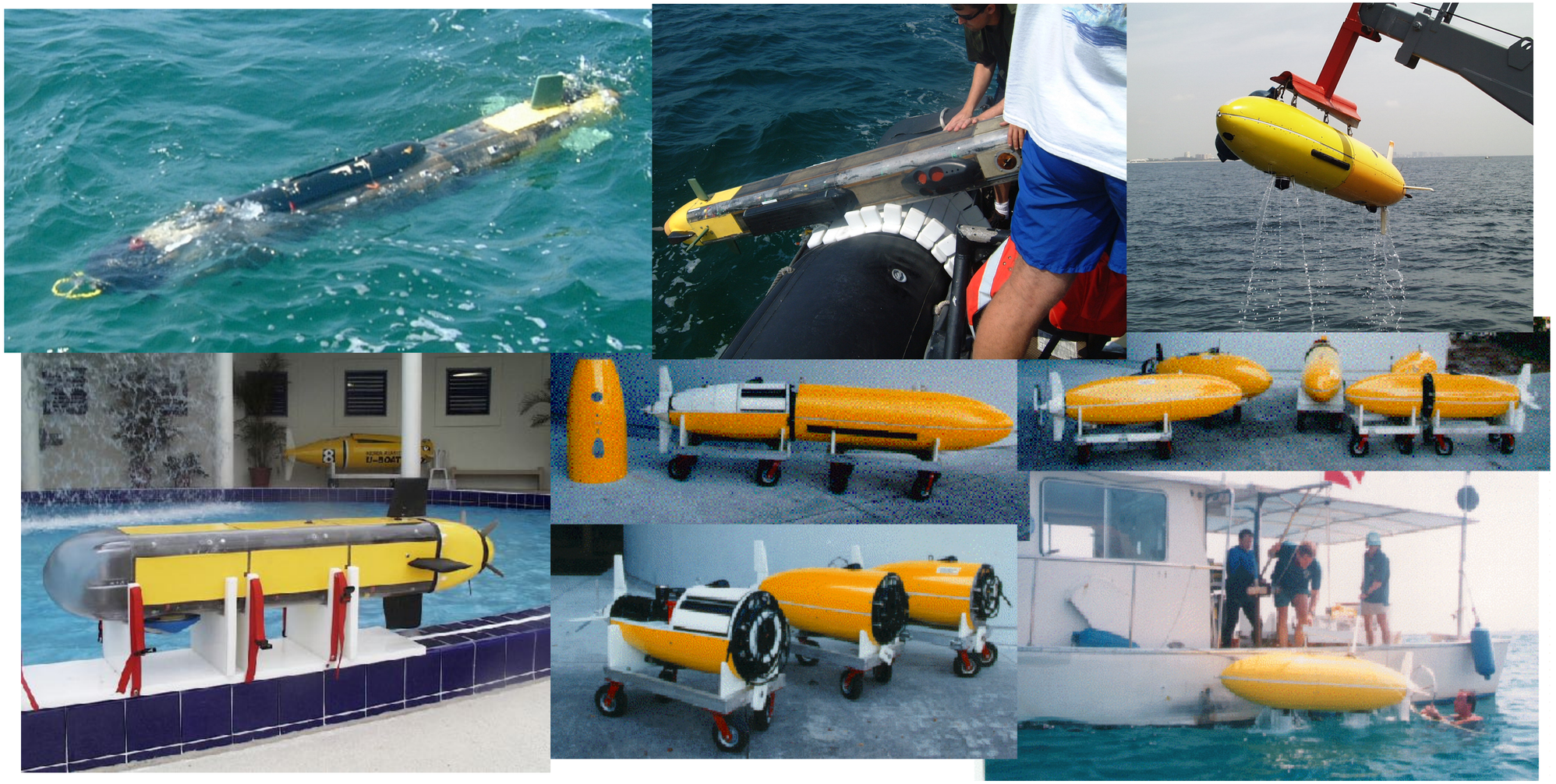
Proof of Stake

Byzantine Agreement

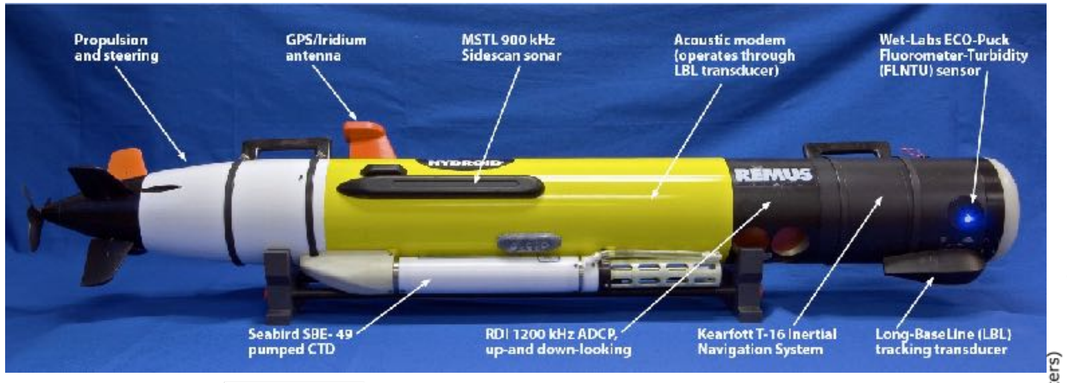
Coordinated Control

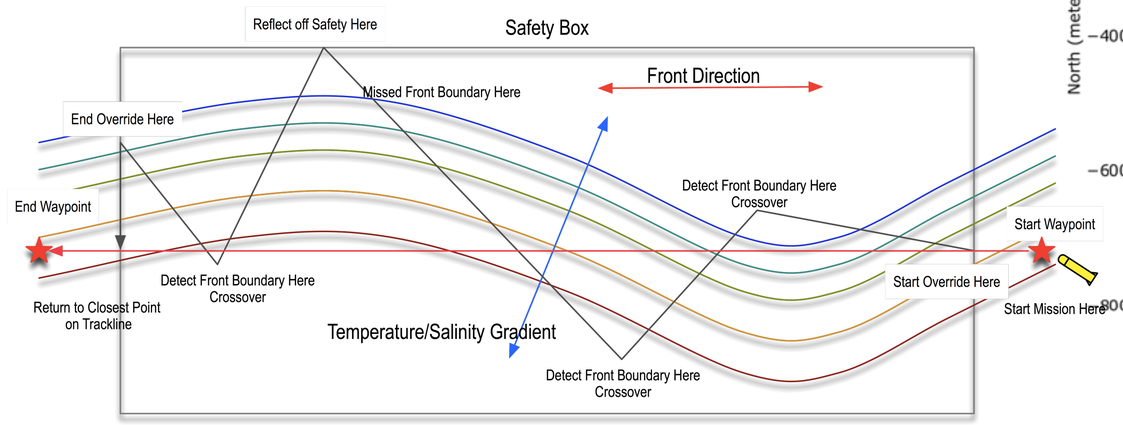
Background

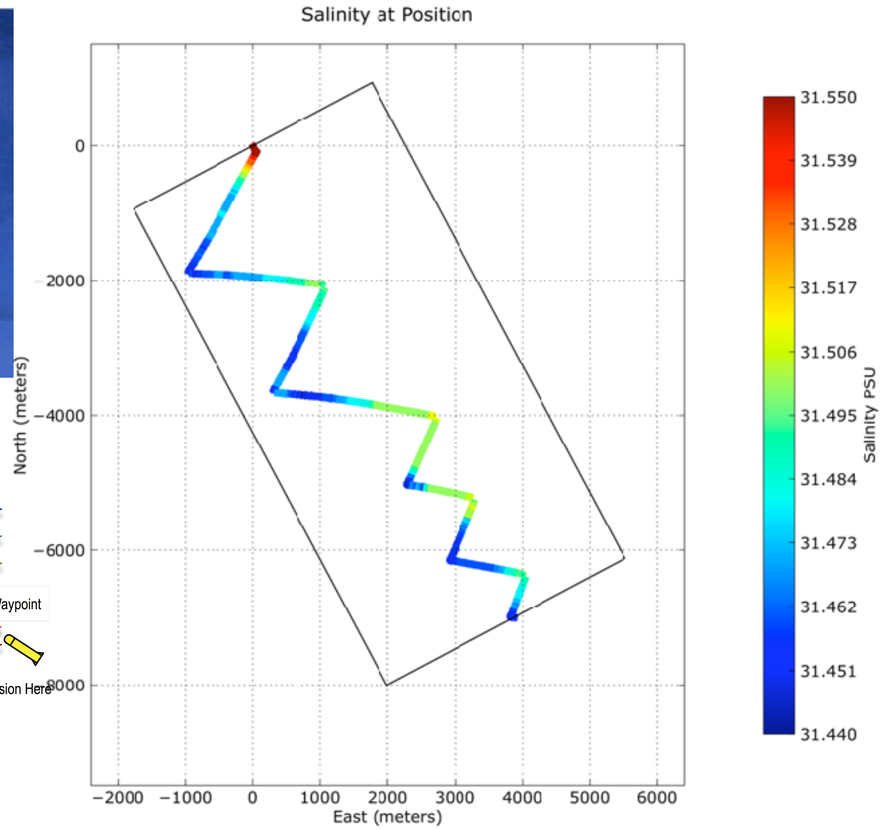
Autonomous Underwater Vehicles



Environmental Adaptive Sampling







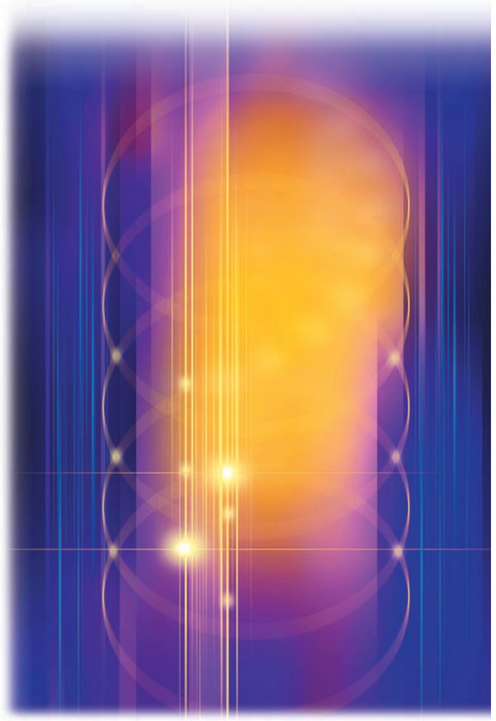
Shipboard & Building Automation

Reinforcement Learning:
Heuristic Dynamic Programming Computational Search

FEATURE

Cell-State-Space-Based Search

By Feijun Song and Samuel M. Smith



©IMAGESTATE

The exponential growth in computer processing power has spawned a plethora of computational methods for designing, evaluating, training, adapting, and tuning digital control systems. One promising family of methods is based on the cell-state-space concept.

Over the last decade, we have continually improved and refined some of these cell-state-space methods. This effort has culminated in an automated controller optimization algorithm called incremental best estimate directed search (IBEDS). IBEDS starts from an initial training set obtained through the sampling of the control surface of a controller with poor performance. Using the least-mean-square (LMS) learning algorithm with the training set, another controller with randomly initialized parameters is trained in an iterative procedure. In each iteration, the trained controller is evaluated with cell-state-space-based global and local performance measures; the training set is then updated based on the evaluation using the *best kept policy*. In this way, the training set is optimized in every iteration, and the controller trained by the training set is also optimized progressively. Since IBEDS makes use of every controller evaluated, fast convergence is expected. In addition, IBEDS is found to be able to bootstrap from an empty initial training set. Those properties make IBEDS an efficient search algorithm for controller optimization for high-order systems.

IBEDS is based on the cell state space, which is a finite quantized version of a given system's state space [1]. The quantization may or may not be uniform. The point of the quantization is to provide a systematic and hopefully less computationally costly means of examining the behaviors of a dynamic system.

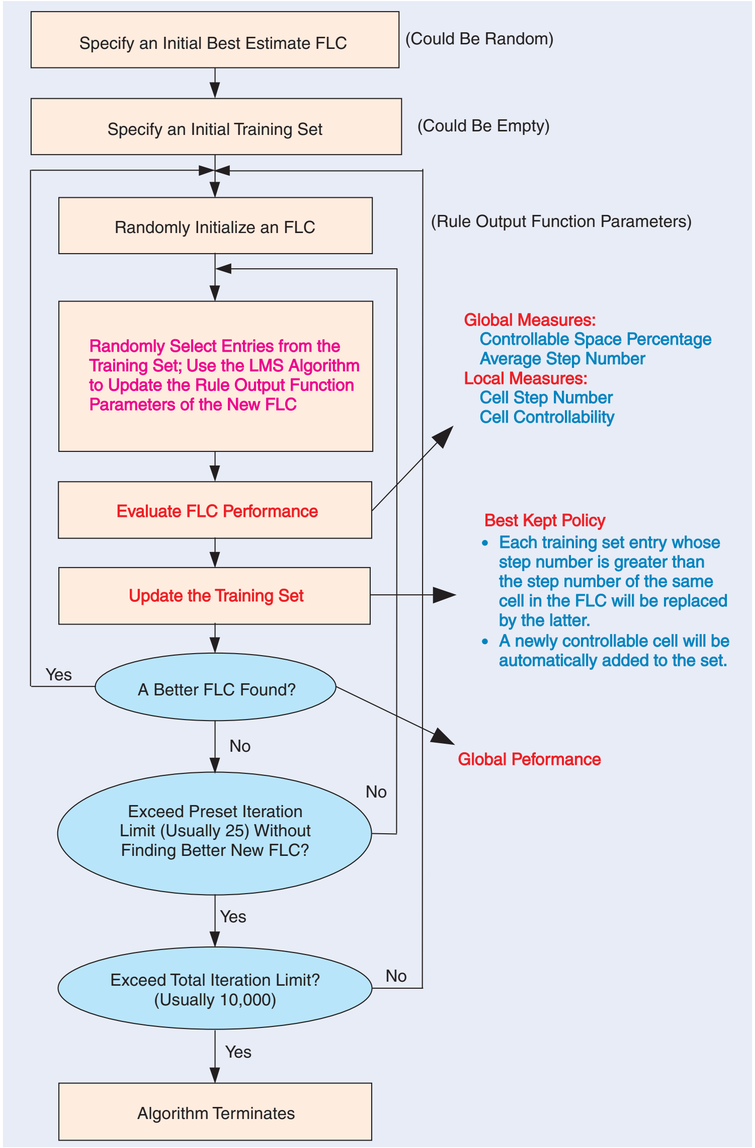
Because system state trajectories are evaluated in discrete time, we need a discrete-time system state update equation of the form

$$X(t_{k+1}) = h(X(t_k), u(t_k)) \qquad (1)$$

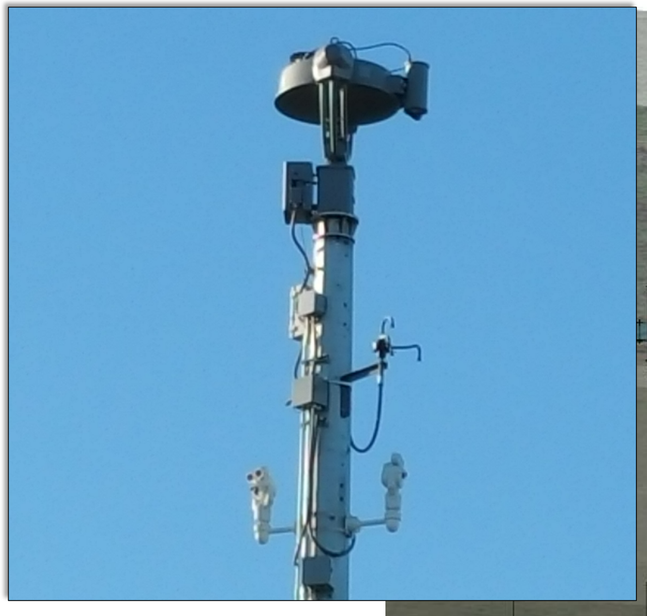
where X is the n-dimensional state space of the process, $X(\cdot) = [x_1, \ldots, x_n]^T$ is the process state vector, U is the one-dimensional domain of interest for $u(\cdot)$, the control input to

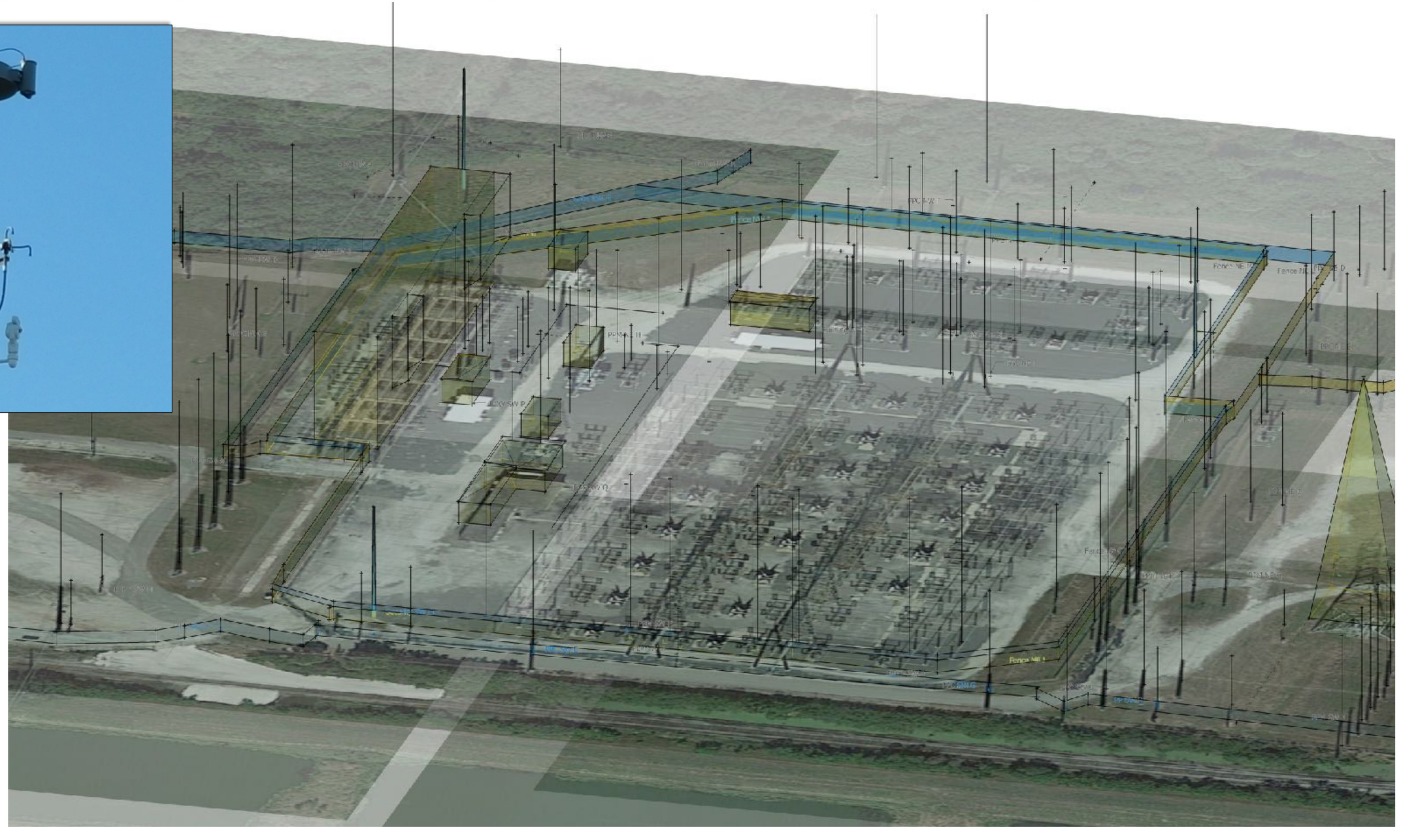
Song (fsong@oe.fau.edu) is with Digital Recorders Inc., 4018 Patriot Dr., Durham, NC 27719, U.S.A. Smith is with Adept Systems Inc., Orem, UT 84057, U.S.A.

0272-1708/02/$17.00©2002IEEE



PHYSICAL SECURITY OF CRITICAL INFRASTRUCTURE

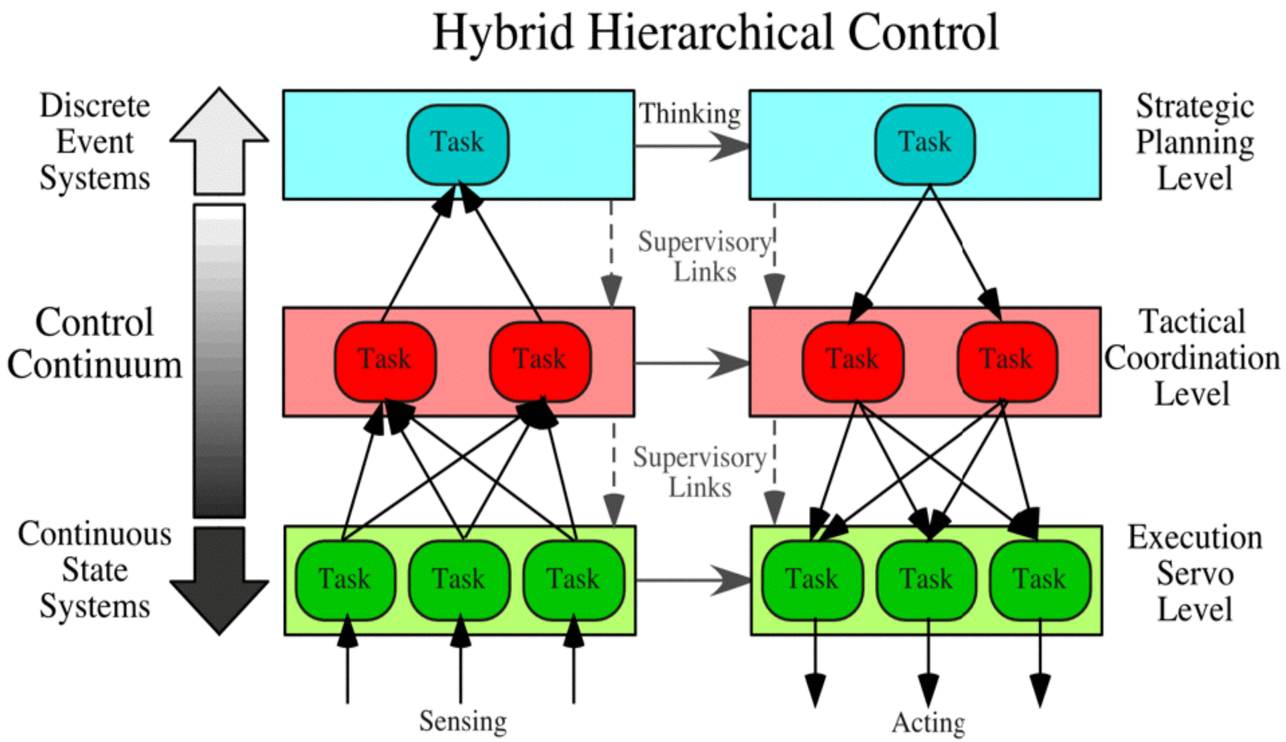


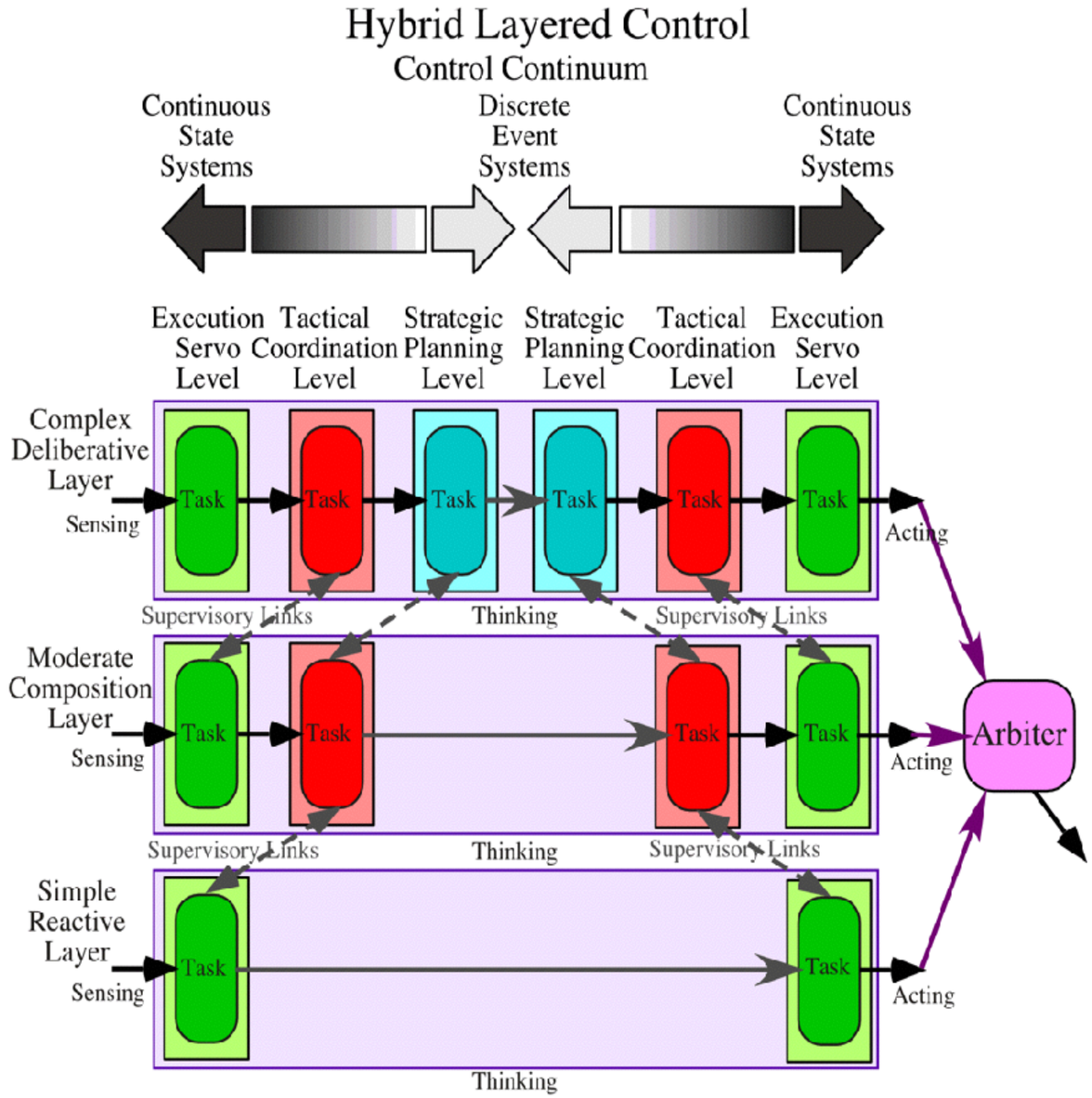


AI for Control

Strategic, Tactical, Executive

Deliberative, Compositive, Reactive





Coordinated Control - Distributed Consensus

Groups of autonomous agents from different circumstances cooperating to achieve shared objective(s) in an environment of uncertainty

Think Decentralized Autonomous Organizations

Think Distributed Autonomic Services

Coordinated Control Types

Leader-Follower

Behavioral

Role Based (Virtual Structure)

Leader Follower

Full state of the leader is broadcast to followers

Leader sequences group tasks

Followers execute a “formation” relative to the leader

Allows mathematical analysis and performance guarantees

Centralized

Fragility to communication failure and member loss

Heterogenous behavior difficult

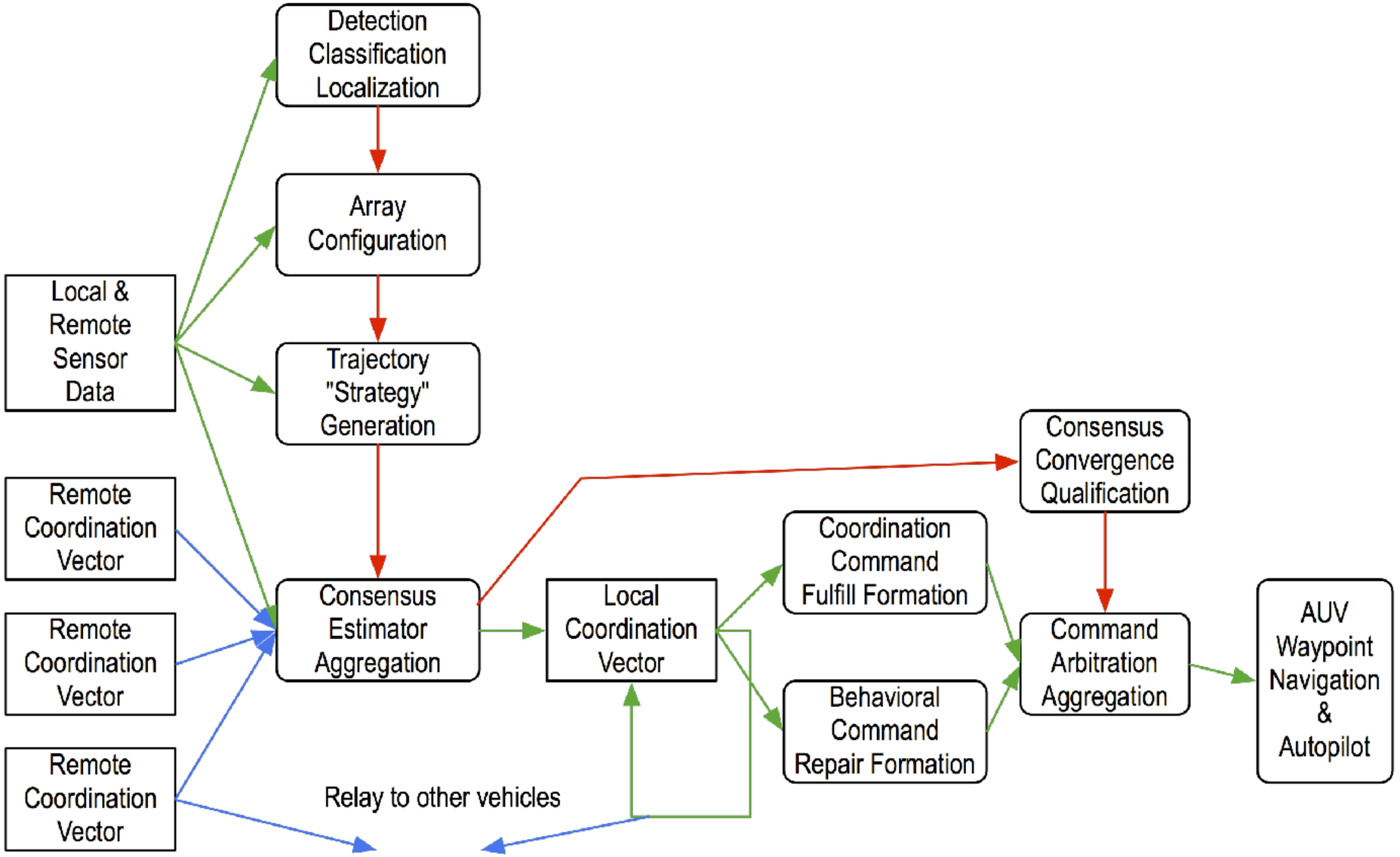
Behavioral

Each agent follows prescribed behavior rules relative to environment.
Several “behaviors” are prescribed for each “agent” or vehicle and the Control is derived from a weighted combination of the behaviors
Difficult to analyze mathematically or guarantee performance
Decentralized
Robust to communication failure and member loss
Heavily dependent on environmental coherence
Precise coordination difficult
Swarming, flocking

Role Based

Peer-to-peer sharing of role, local state, and neighbor state
Global shared task sequencing
Consensus function to cohere disparate state information
Eventual global view enables analyzable performance
Decentralized
Robust to communication failure and member loss
Allows precise coordinated heterogenous behavior
Can be hierarchical
Scalable

Role Based Coordinated Control



Discussion: Artificial Network Intelligence

Why should we care about identity and reputation?
What does distributed consensus buy us?
How do humans complicate things?
What about Coalition formation?
How does uncertainty complicate things?
Why use automated reasoning?