

**supervised learning**: distinguish input and output, interest in prediction, minimize prediction error

**unsupervised learning**: no distinct variables, look for data structure, minimize compression rate, reconstruction error

**reinforcement learning**: agent interacts with an environment, learn policy, action is rewarded, maximize total reward

**optimal solution** for a set of solutions for a certain formula; could be formulas, or graphs, or salesman-like problems. graph:

1) min  $f(x) = \max \{-f(x)\}$  2) E.g.,  $X = \mathbb{R}^D$ ,  $x = \{0,1\}^D$  3) Optimal solution:  $\forall x \in X, f(x^*) \leq f(x)$  and  $\forall c \in (x^*) = b$

**Blind search**: depth first(dive down), breadth first (left to right, rows). vs **heuristic** → estimate closeness to goal state. Convex/non-convex(always approaching lowest), deterministic/stochastic (same result for input), constrained/unconstrained (rules algo has to adhere to),

continuous/discrete(does environment change?), global/local(individual prediction vs entire problem). **0th order**: derivative-free (hill, iterated local), 1st order, gradient-based (descent, adam), hessian based; 2nd order(newton's). **Gradient** goes towards the lower point (negative derivative in certain points). Step size importance: too low, too slow, too high, bounce around. **Stuck local**, only continuous, function has to be

smooth and differentiable, not differentiable when: objective function unknown, discrete search space. **Random** → fails high-dimensional, high evaluation count. **Local search** can help; find the best in a certain area, then go from best. Similar to gradient in essence. All about

exploitation vs exploration. Population based; multiple solutions, pick best. Derivative slow, many eval, no guarantees. **Probabilistic learning** bernoulli distribution:  $p(c|x) = (x^c)^c(1-x)^{1-c}$ . Chance 1 thing happens depending on other observation odds.  $\mathcal{D} = \{c_1, c_2, \dots, c_N\}$  - iid observations (data) EXAMPLE:  $\mathcal{D} = \{0,0,1,1,0,1,1\}$ . The likelihood function:  $N p(\mathcal{D}|x) = \prod p(c_n|x)_{n=1}$ . We want to minimize

the log-likelihood function,  $\min -\log p(\mathcal{D}|x)_{x \in [0,1]}$ . Negative because easier to minimize, lowest negative is the highest maximum.

logarithm; Because:  $\log \prod = \sum \log$  and optimum is the same.

1) Determine  $p(y|x)$ . 2) Determine  $p(\mathcal{D}|x)$ . 3) Check constraints. 4) Find the best solution by minimizing  $-\log p(\mathcal{D}|x)$ .

**Sampling methods**: perform a lot to see relative frequencies. Used to estimate  $\pi$ . Problem with sampling: curse of dimensionality → grid on unit interval  $(10^2$  points). If  $2d \rightarrow (10^4)$ . Scales insanely fast, unsustainable. So, a sample based on the past (**markov chain**), proposal distribution  $q(x|xt-1)$  makes a chain corresponding to sample original distribution. Has to be irreducible and aperiodicity. Positive probability of visiting all states and not getting trapped in a cycle. **Metropolis Hastings algo**. Work with acceptance probability. Sample only if it gets picked. Too small → omission, large → low accept. Simulated annealing improves, set  $T_{t+1}$  according to the cooling schedule. SLOWly accept less over time. Version with sampling is

stochastic, the best current is deterministic. **Evolutionary algo 1**. Improve performance, search through multiple candidate solutions. Use info about quality to speed up optimization? example; multiple chains diff temperature. Generate options through probability distributions, or

transform candidates previous solutions. Take insp from nature; genotype, gene.

**Genetic algorithm**; fitness for each option. 2 parents, have crossover points (take digits from the other parent) and mutate 1 thing. **Evo algo 2**: selection operator.

Evolve free structured programs (function set, terminal set), symbolic regression, LISP. (encode program in string). **Distribution algorithm** The general scheme; 1.

(init) Initialize a population of solutions,  $\mathcal{P}_1 := \mathcal{P}_0$ , and evaluate. 2.Repeat until STOP: (i) (Modeling) Learn a distribution  $p_1(x, f)$  using  $\mathcal{P}_1$ .

(ii) (Generate) Generate new solutions,  $\mathcal{P}_{t+1}$ , by sampling from  $p_t(x, f)$ . (iii)

(Evaluate) Evaluate new solutions. (iv)(Select) Set  $\mathcal{P}_{t+1}$  to  $\mathcal{P}_t+1$ . With linear dynamic scaling, we can **adapt fitness function**:  $f(x) =$

$af(x) - \min(b|x) : x \in \mathcal{P}_t$ . Issues; dominance (individual surpasses all), crowding: dense population in few regions, vanishing selective pressure (difference too small, may fail to improve solution). Selection mechanisms either build upon survivors or recombination of parents.

$p = f(x) / \sum f(x)$  (Assume maximization). **Mutation**: Transformation depends on representation. Change integers, bits, graphs/trees? Flipping bits is the easiest example. integers; random resetting (sample mask/integers). Mutate continuous: random perturbation (gaussian, cauchy, uniform). Perturb:  $x' = x+y$ . Differential; sample two individuals, perturb:  $x' = x+a*(x1-x2)$ . Permutations mutate; swap, insert, scramble, inverse. For trees; crossover point at intersection. **Parents-evol**: n-point crossover. Uniform; every other digit. Arithmetic;

simple; change part, single arith; single position, whole; change all. In trees, select two points where the other tree is continuous and the other way around. **Collective intel**. Ants and bees work based on others. decentralized, distributed, self-organization, emergence, bottom-up, agent-based, irreducibility. Artificial ants pick a data object with a probability inversely proportional to the number of similar objects around, and drop the object with the probability proportional to the number of similar objects around. **Neural network** Fully connect;

input → hidden → output (all nodes connected). Recurrent; hidden points to itself. convolutional; feature extraction phase+classification with fully connected. Convolution and pooling first. This makes a convolutional network. In a neuron;  $z = x1w1+x2w2+b$ . **Sigmoid neuron**; converters to numbers based on formula;  $(1/1+\exp(-z))$ . **Fully connected neural net**: Linear layer;  $a: Wx = \sum w_j x_j$ , j times. After linear layer →

nonlinearity. Make it so the line can curve. These nonlinearities are: sigmoid, tanh, relu, leaky relu. Sigmoid is good for the last layer. **Multiclass sigmoid** → softmax, sums probabilities up to 1. **tanh**; converts numbers into probability between -1,1, centering around 0. **RELU** → 0 if

negative, else z ( $f(z) = \max(0,z)$ ). Zero gradient though. **Leaky relu**;  $g(z) = \max(ez,z)$  with  $e < 1$ . Fast computation and no more zero gradient! **Logistic regression** model y with Bernoulli distribution.  $p(y|x, \theta) = \text{Bern}(y|\text{sigmoid}(\theta^T x))$ . We make use of sigmoid → can model probabilities. Make it so we

find the best set of parameters for O with a line. Either analytical ( $\delta/\delta\theta = 0$ ), or gradient (sum over the earlier formula (bern) for each node). Use mini batches if n is large during gradient. **neural 2**: parameters of distribution:  $\mathcal{D} = \{(x_i, y_i)\}_{i=1}^N$ .

	Genetic Algorithms	Genetic Programming	Evolution Strategies	Differential Evolution	Estimation of Distribution Algorithms
Representation	Binary strings	Tree-structured programs	Real-valued	Real-valued	Real-valued
Encoding length	Fixed	variable	Fixed	Fixed	Fixed
Operators	Selection, crossover, mutation	Selection, crossover, mutation	Selection, mutation	Selection, crossover, mutation	Selection, (modeling, mutation)
Self-Adaptation	None	None	Standard deviations and covariance	None	Standard deviations

# Comp Intel Modelling Control 1

**F Rizvi**



## **Comp Intel Modelling Control 1:**

The book delves into Comp Intel Modelling Control 1. Comp Intel Modelling Control 1 is a vital topic that needs to be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Comp Intel Modelling Control 1, encompassing both the fundamentals and more intricate discussions.

1. The book is structured into several chapters, namely:

- Chapter 1: Introduction to Comp Intel Modelling Control 1
- Chapter 2: Essential Elements of Comp Intel Modelling Control 1
- Chapter 3: Comp Intel Modelling Control 1 in Everyday Life
- Chapter 4: Comp Intel Modelling Control 1 in Specific Contexts
- Chapter 5: Conclusion

2. In chapter 1, the author will provide an overview of Comp Intel Modelling Control 1. This chapter will explore what Comp Intel Modelling Control 1 is, why Comp Intel Modelling Control 1 is vital, and how to effectively learn about Comp Intel Modelling Control 1.

3. In chapter 2, this book will delve into the foundational concepts of Comp Intel Modelling Control 1. The second chapter will elucidate the essential principles that must be understood to grasp Comp Intel Modelling Control 1 in its entirety.

4. In chapter 3, the author will examine the practical applications of Comp Intel Modelling Control 1 in daily life. The third chapter will showcase real-world examples of how Comp Intel Modelling Control 1 can be effectively utilized in everyday scenarios.

5. In chapter 4, this book will scrutinize the relevance of Comp Intel Modelling Control 1 in specific contexts. This chapter will explore how Comp Intel Modelling Control 1 is applied in specialized fields, such as education, business, and technology.

6. In chapter 5, the author will draw a conclusion about Comp Intel Modelling Control 1. The final chapter will summarize the key points that have been discussed throughout the book.

This book is crafted in an easy-to-understand language and is complemented by engaging illustrations. This book is highly recommended for anyone seeking to gain a comprehensive understanding of Comp Intel Modelling Control 1.

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