**Machine Learning**

***Definitions***

* Basic Definitions
  + **Artificial Intelligence** A branch of Computer Science that aims to enable machines to *behave and think like humans and make decisions*.
  + **Machine Learning** A branch of Artificial Intelligence that aims to enable machines to *simulate human learning*. Machine learning enables machines to automatically learn from data and improve their performance without being explicitly programmed.
* Performance Measures
  + **Accuracy** The ratio of the correctly classified observations to the total observations.
  + **Precision** The ratio of the observations correctly classified as positive to the total positive observations.
  + **Recall/Sensitivity** The ratio of the correctly classified positive observations to the total observations in the actual class.
  + **Specificity** The proportion of actual negatives which were classified as negative.
  + **F1 Score** The weighted average of Precision and Recall.
* Learning Types
  + **Supervised Learning** A type of machine learning where we provide the model with labelled data to train it. The goal is to map the input to the output data.
  + **Unsupervised Learning** A type of machine learning where we provide the model with unlabelled data. In this type of learning, the model performs clustering; that is, restructures the input data into groups with similar characteristics and patterns.
  + **Reinforcement Learning** A feedback-based type of learning where the agent gets a reward for each correct action and a penalty for each wrong answer. The goal is to maximize the number of rewards, hence improving the performance.
* Other Definitions
  + **Cross Validation** A model evaluation technique where the data set is divided into *k* partitions, the model is then trained on each of these partitions.
  + **Linear regression** One of the Machine Learning algorithms. It is a statistical method that is used for *predictive analysis*. It is used with continuous numeric data.

***Model Evaluation Techniques***

* Mean Absolute Error (MAE)
* Root Mean Square Error (RMSE)
* Coefficient of determination or R2
* Adjusted R2

***Machine Learning Cycle***

1. Data Gathering
2. Data Preparation
3. Data Wrangling
4. Data Analysis
5. Model Training
6. Model Testing and Validation
7. Deployment

***Linear Regression Steps***

1. Suppose the final straight line equation is , where is the y-intercept and is the slope of the line.
2. Choose arbitrary initial values for and .
3. Use the gradient descent algorithm to optimize the values of and . That is, to minimize the cost function.

**FPGA**

**Ch1**

***Classification of Device Technologies***

* Discrete logic
* Programmable devices (FPGAs)
* ASIC (Application specific IC)

***System Representation***

* Behavioral level
* Structural level
* Physical level

***System Abstraction Levels***

* Transistor level
* Gate level
* Register transfer level (RTL)
* Processor Level

***FPGA Definition***

An array of gates in addition to some other elements such as memory controllers and communication interfaces that can be programmed and reconfigured more than once.

***FPGA Applications***

Cryptography, ASIC prototyping, Industrial, medical and Scientific Instruments, Audio/Video and Image processing and broadcasting, high-performance computing, AI, and Deep Learning, Military and Space applications, Networking, packet processing, and other communications

***FPGA Design Flow***

1. **Architecture design** involves the analysis of the project requirements, problem decomposition.
2. **HDL design entry** using HDLs to describe the design.
3. **Test environment design** writing test environments and behavioral models to ensure the correctness of the HDL description.
4. **Behavioral simulation** comparing the HDL outputs and the behavioral model to ensure the correctness of the HDL description
5. **Synthesis** involves the conversion of an HDL description to a netlist
6. **Implementation** a synthesizer-generated netlist is mapped onto particular device's internal structure
7. **Timing analysis** to ensure the implemented design satisfies the timing constraints

**Ch3**

***Unfamiliar Verilog Operators***

* Exponentiation: \*\*
* Concatenation: {a, b, …} → {2'b01, 2'b10} yields 4'b0110
* Replication: {{}} → {3{2'b01}} yields 6'b010101

***Coding Styles***

* Structural modeling: gate level → and(x, a, b);
* Dataflow modeling: C-style assignments → assign z = x && !y;
* Behavioral modeling: initial and always blocks →

      always @ (x or y)

        begin

          z = 0;

          if (x == y)

          z = 1;

        end

**More Notes**

***Uses***

* wire VS reg
  + wire is used for continuous assignments and must be continuously driven.
  + reg is used for procedural assignments and can store values.
* Module port directions: input, output, and inout.
* Compiler directives are used to control the compilation of a Verilog description.

***Passing Parameters to Modules***

* module-name instance-name(.formal(actual), …);