# Introduction to Machine Learning

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# Outcome of the course

1) **Introduction to Computer System**
2) **Introduction to Machine Learning**
3) **Apply ML on Real-life Problem**
4) **Tools and Techniques**
   - **Basic understanding of cloud-cluster, programming and scripting languages**
   - **Machine Learning Toolkit and Libraries**
   - **Data Feature Engineering**
   - **ML Solvers**
   - **Infographics**

# Introduction

## Education:

**PhD. Barcelona-Tech**
**Microsoft Research, Infineon Technologies France, Microsoft Research Cambridge, IBM**

**Suspenseful record of academic management as Professor and Dean**

**Enhanced Education Quality by Inculcating Outcome Based Education by Applied and Sustainable Projects**

## Experience:

**19+ year's versatile experience** in the area of Computer Architecture, AI, Software Architecture, Big-Data Architecture
Served National and International Academia, Industry and Government

- **Barcelona Science Park Spain**
- **Cambridge Science Park UK**
- **Technopolis Of Sofia-Antipolis, France**

# Innovation, Research and Commercialization


## Innovation and Research

- **110+ Million Pkr National and Int'l Funding.**
  - Supercomputing and Artificial Intelligence
  - Smart Electric Motor Controllers
  - Biomedical Applications
- **80+ Publications**
- **10 Patents**
- **10 MVPs**
- **5 Int'l Collaborations**

- ## Development & Commercialization

**60+ Million of Industrial Investments.**
Developed Digital Systems for Industry.
Transform Idea into product.
Innovation and Commercialization for Sustainable economic and industrial development.

- ## Capacity Building:

Conducted more than **50 national and international workshops** and **training on Commercializable research, Writing successful grant proposal, and research and innovation.**

Provides Consultancy and Support for Entrepreneurship, Start-ups, Business Innovation and Technology transfer.

Barcelona Supercomputing Center
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UVHC
UNIVERSITE DE VALENCIENNES ET DU HAINAUT - CAMBRESIS

NEW ZEALAND COLLEGE OF CHIROPRACTIC
graduating hands, hearts & minds

PAKISTAN SUPERCOMPUTING

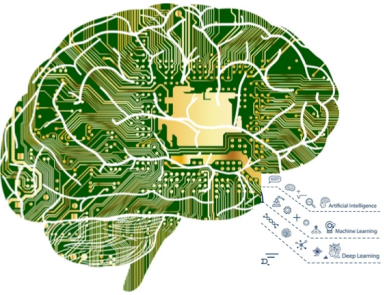
EntrepreneurialPark
Research Innovation Commercialization

Foot Analytic

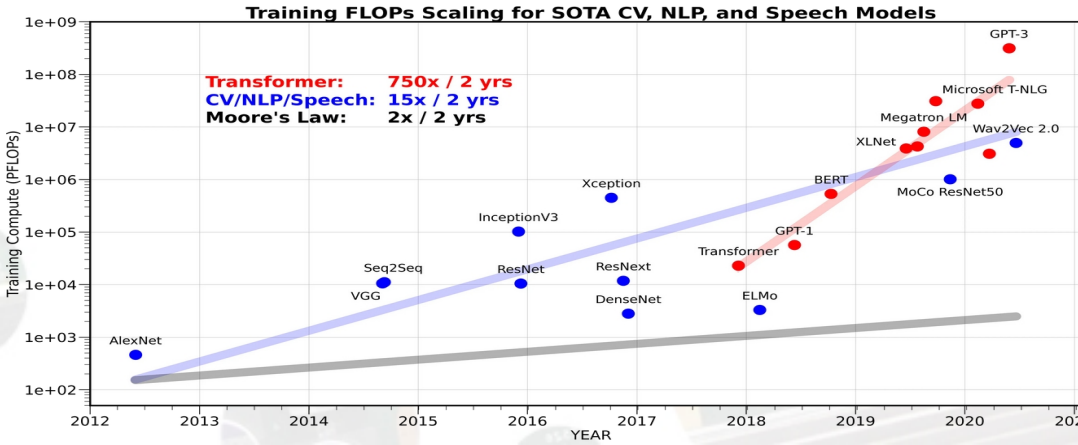
ComputingPark

# Objectives of the Course

- World Data Size = 130 Zettabytes, doubling every 18 months.
- **To handle big-data, AI algorithms are the only solution.**
- The computational demands of AI algorithms are experiencing exponential growth. (ExaFLOPS/Day)
- **Micro-Electronics is the only solution to store big-data and process the AI.**



**Secure**
**Reliable**
**Programmable**
**Customize-able**
**Indigenous**



Mastery of AI is essential; a lack may result in unforeseen consequences.


**Deep and steep**

Computing power used in training AI systems

Days spent calculating at one petaflop per second*, log scale

By fundamentals

Language Speech Vision

Games Other

AlphaGo Zero becomes its own teacher of the game Go

AlexNet, image classification with deep convolutional neural networks

3.4-month doubling

Two-year doubling (Moore's Law)

Perceptron, a simple artificial neural network

← First era →

→ Modern era

100 10 1 0.1 0.01 0.001 0.0001 0.00001 0.000001 0.0000001

1960 70 80 90 2000 10 20

Source: OpenAI

*1 petaflop=$10^{15}$ calculations

The Economist

# Objectives

## Learn , Collaborate and Accelerate

The goal of this course is to foster **skills** to **solve real-life problems** through the computing system, data and artificial intelligence (AI).

by:

Leveraging the collective expertise and resources, challenges and opportunities

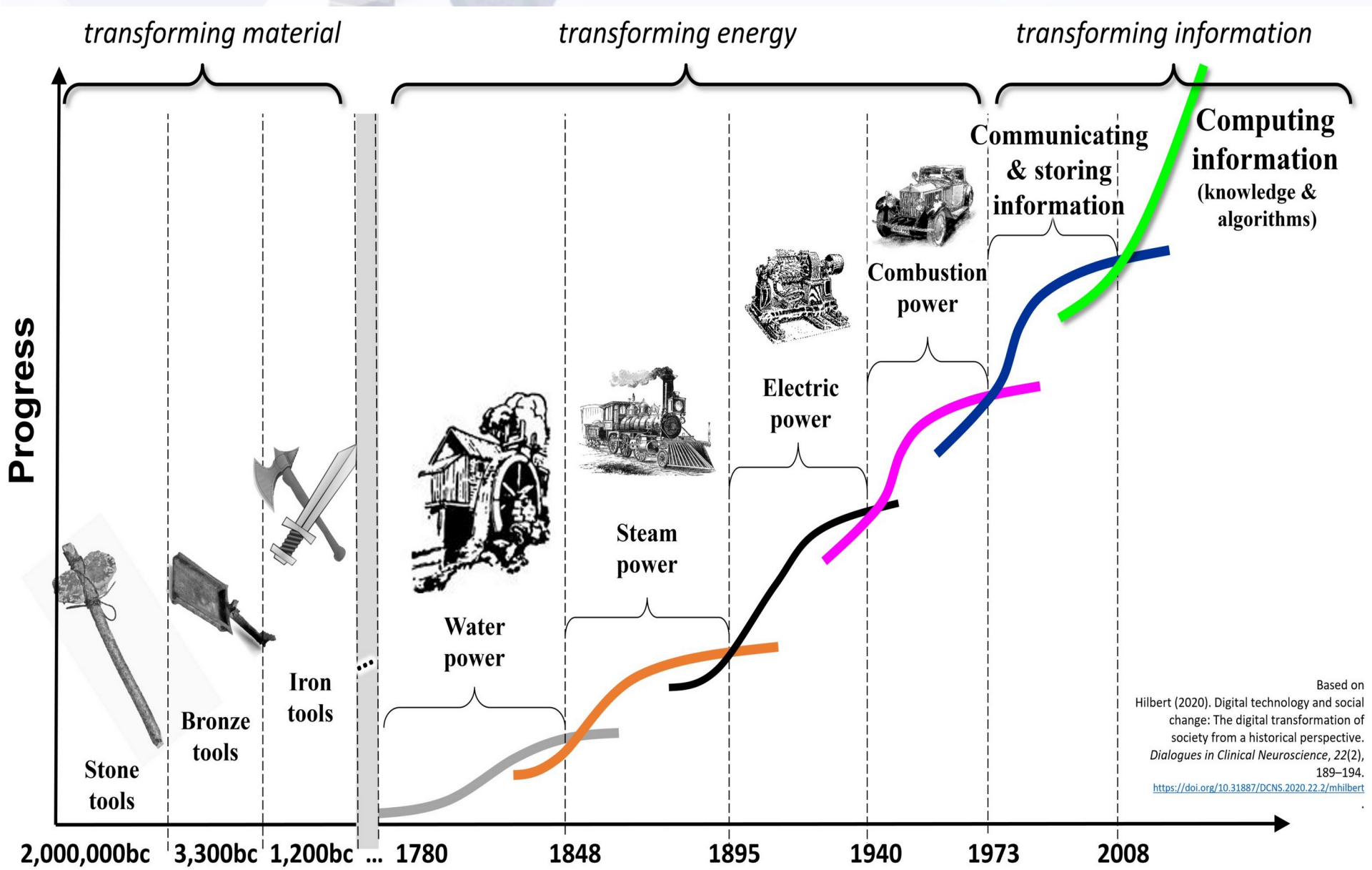
for:

Advancing research, education, and societal impact.

Make Life Visions, Objectives and Targets
Convert your Passion in to Profession

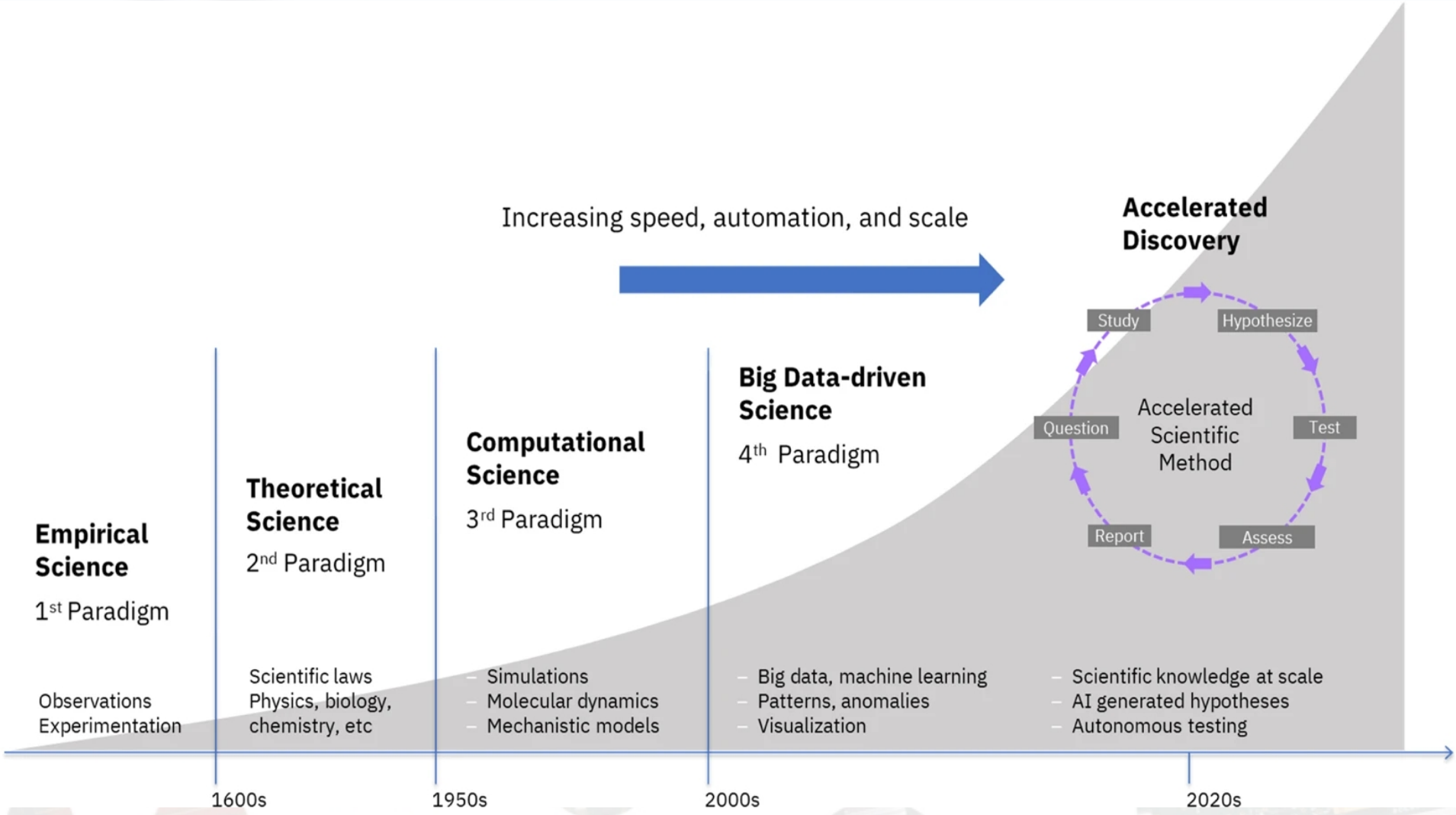
"The future we will "invent" is a choice we make jointly, not something that happens." Jordi

# Mankind Progress




Based on Hilbert (2020). Digital technology and social change: The digital transformation of society from a historical perspective. *Dialogues in Clinical Neuroscience*, *22*(2), 189–194. https://doi.org/10.31887/DCNS.2020.22.2/mhilbert .

# From Age of Empirical Science to Data-Science




https://www.nature.com/articles/s41524-022-00765-z/figures/1

# Past Present and Future

## AGI

Artificial General Intelligence

## ANI

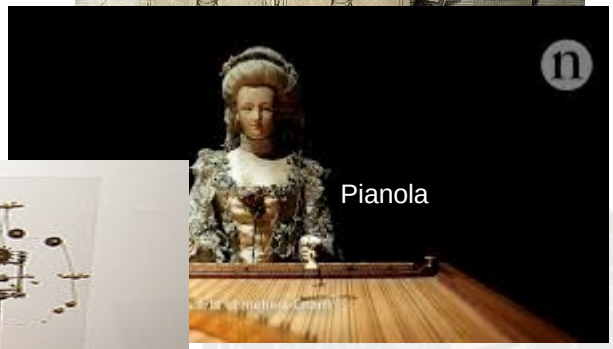
Artificial Narrow Intelligence

**Information/Big Data**

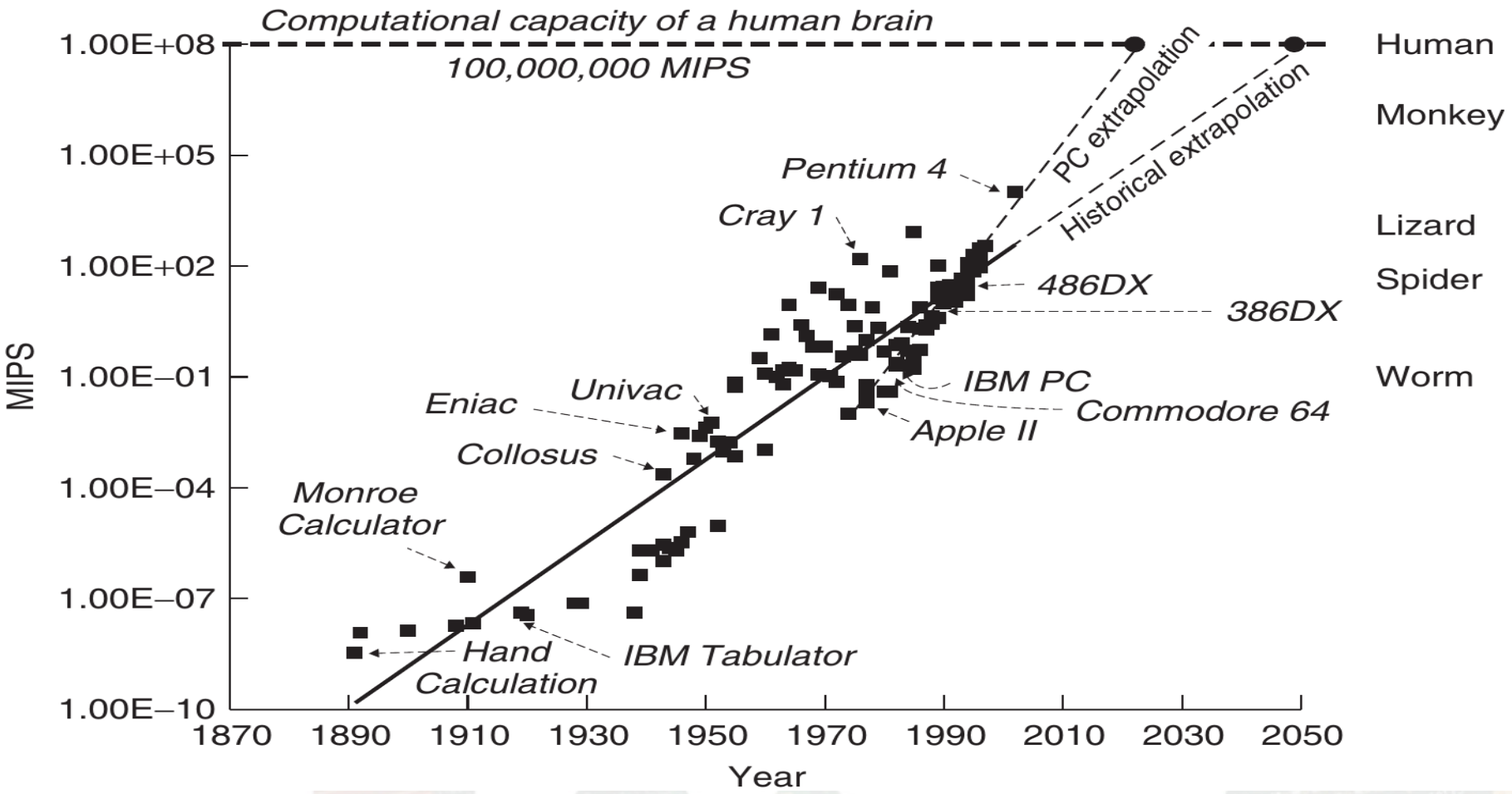
**Complex Adaptive Algorithms**

**Computing Resources**

**“Methods that scale with computation are the future of Artificial Intelligence”**
**— Rich Sutton,**

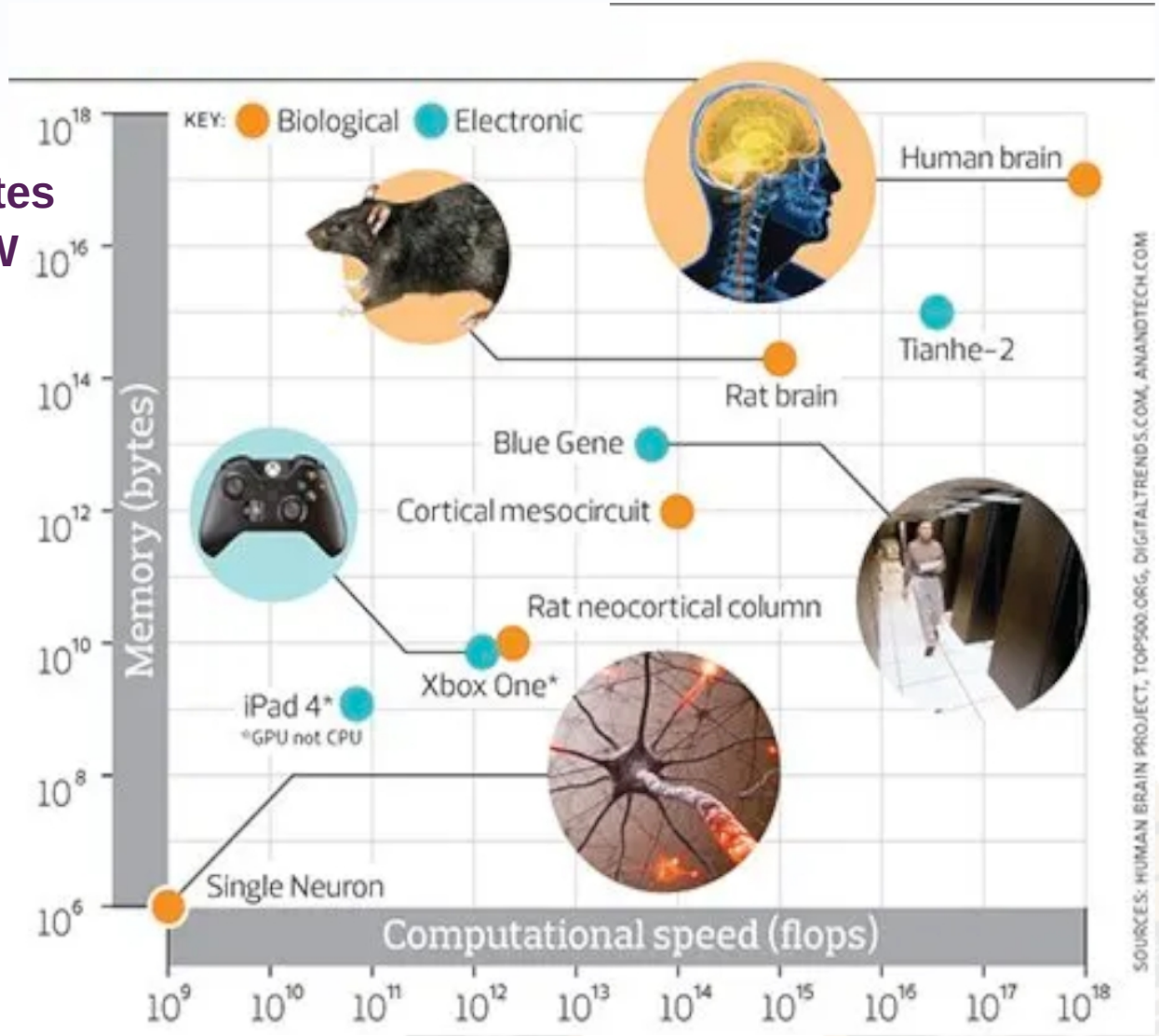

# Computational Capability ?




It is estimated that sometime between the years **2025 and 2050**, a **personal computers** will exceed the calculation power of a human brain.

# Compute Vs Intellectual Capbity

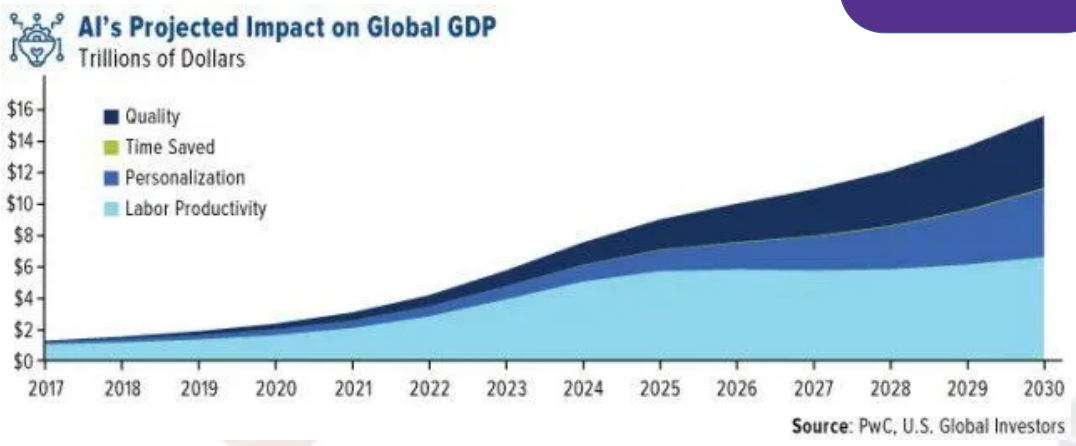
- **Human Brain:**
- **1 Exa FLOPS**
- **Memory 100 Peta bytes**
- **100 Tera OPS @ 10 W**

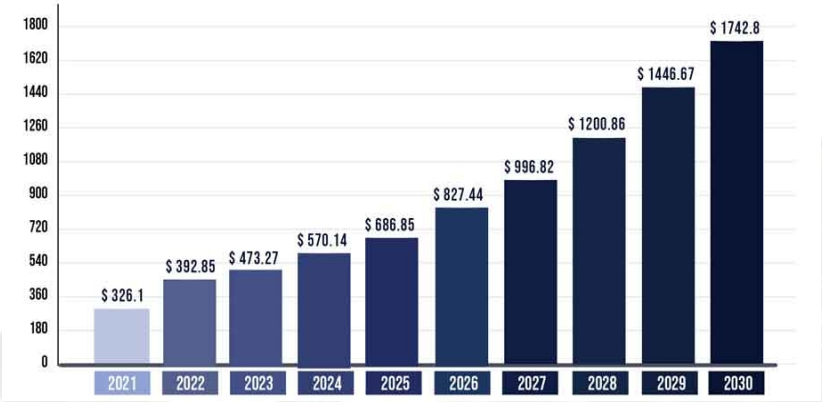



https://www.theguardian.com

# Market

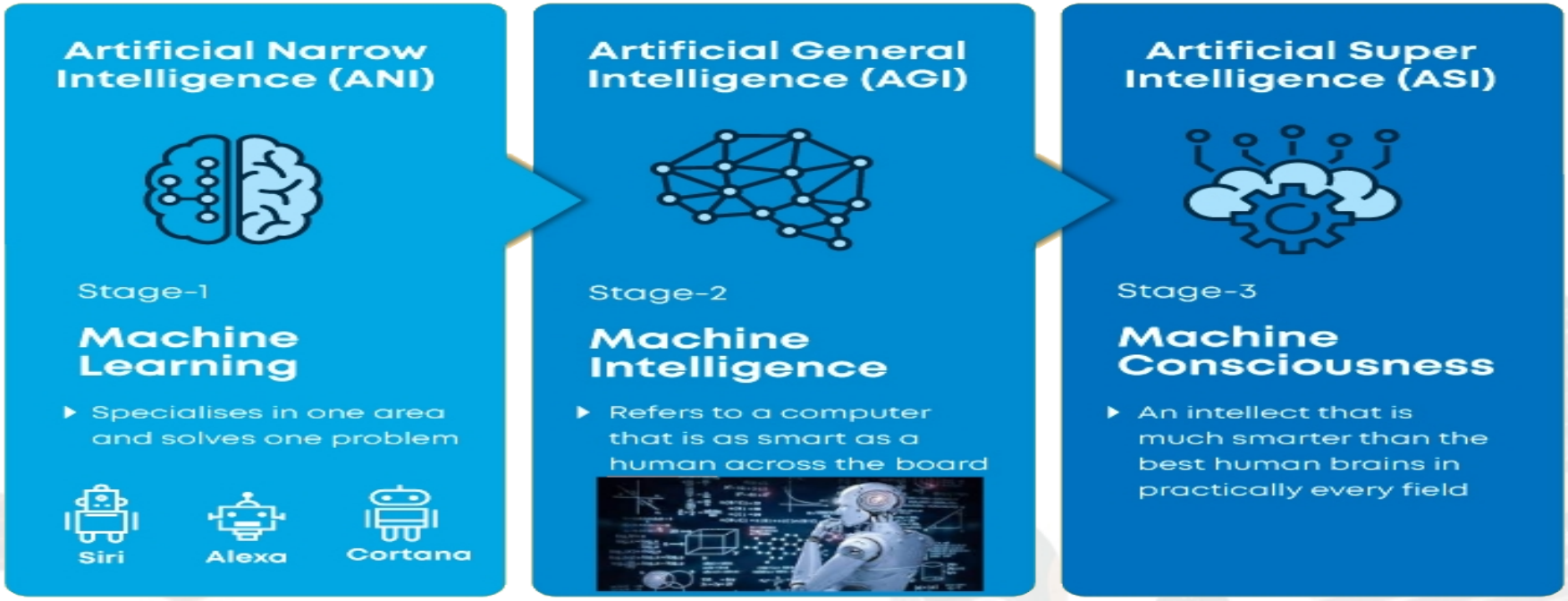
| | Billion $ | Trillion $ |
|---|---|---|
| BigData | 250 | 3 |
| AI | 150 | 5 |
| Computing<br>Cloud, Bare-metal, Embedded | 600 | 4 |



# Intelligent Algorithms

- **Performance**
  - **Execution Time**
  - **Accuracy** “The accuracy of the model is inherently tied to the quality, diversity, and representativeness of the data used for training and evaluation."
  - **Scalability** “Methods that scale with computation are the future of Artificial Intelligence” — Rich Sutton,



# Real-time System

A **Real-time System** is a system which execute/process an application or task in a "real-time constraint".

Real-time constrains can be an  event to system response.

# Artificial Intelligence

Study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals like human.

# Intelligent System

Capture behavior of real life problems using multiple sensor data.

Understand phenomenon of the problem using complex mathematical models and algorithms.

# What is Learning

“Learning denotes changes in a system that ... enable a system to do the same task ... more efficiently the next time.”

- Herbert Simon

“Learning is constructing or modifying representations of what is being experienced.”

- Ryszard Michalski

“Learning is making useful changes in our minds.”

- Marvin Minsky

**“Machine learning refers to a system capable of the autonomous acquisition and integration of knowledge.”**

# Machine Learning Definition

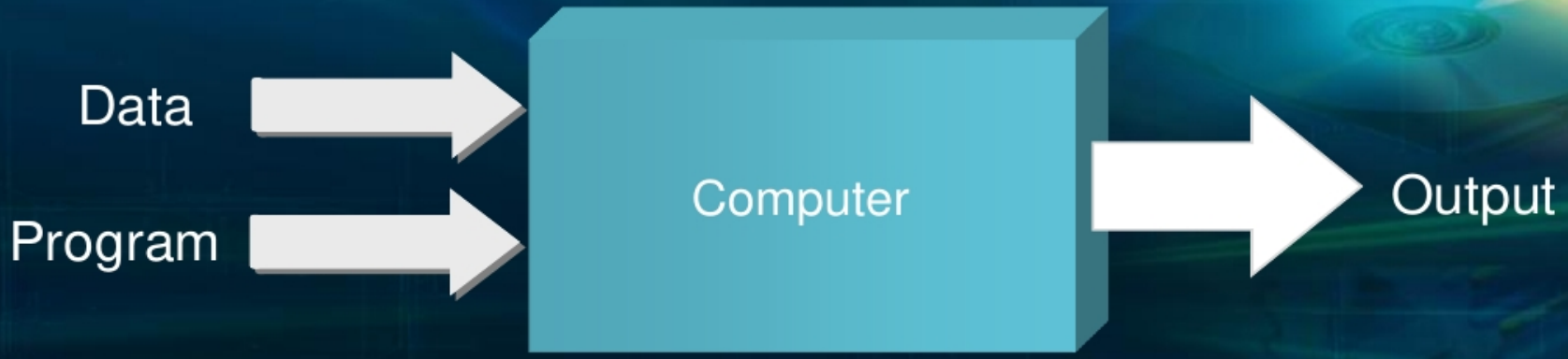
Definition: A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E. T. Mitchell (1997). Machine Learning

*If a computer program can improve how it performs a certain tasks based on past experience then you can say it has learned*

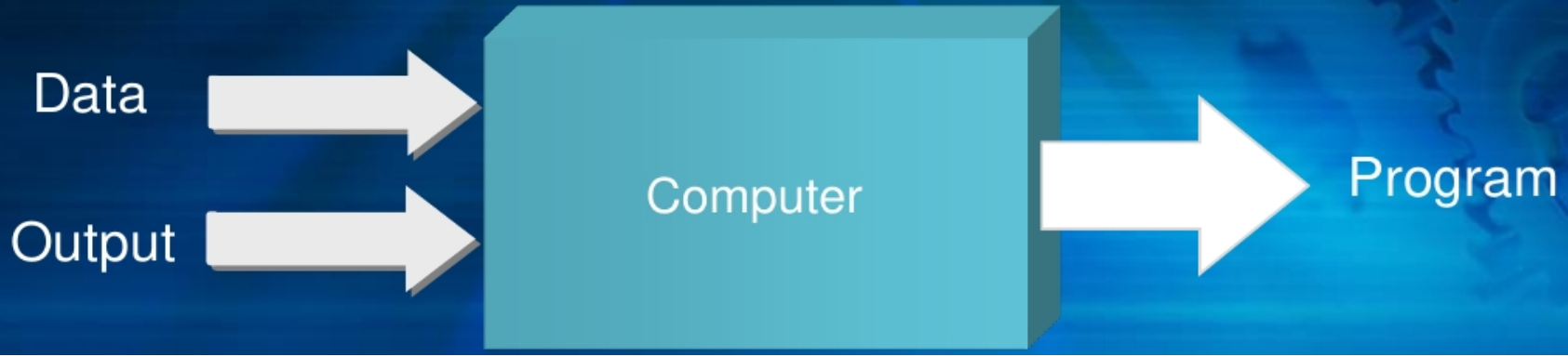
***Machine learning teaches computers to do what comes naturally to humans and animals: learn from experience***

# Computers Program Themselves

- **Traditional Programming**




- **Machine Learning**



# The Machine Learning Framework

$$y = f(x)$$

f(  ) = “apple”

f(  ) = “tomato”

f(  ) = “cow”

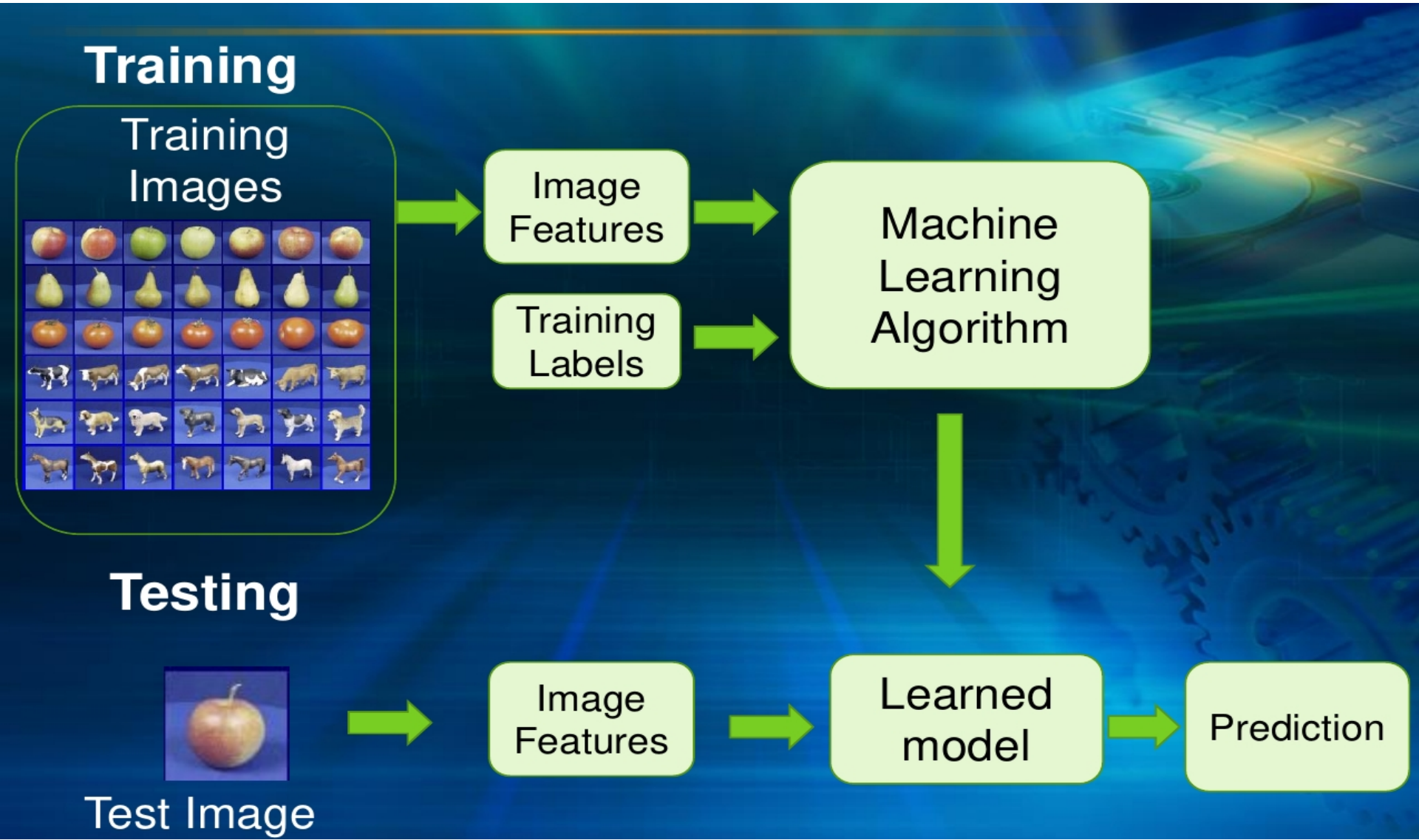
Output

Image Feature

Prediction Function

- **Training:** given a *training set* of labeled examples $\{(x_1, y_1), \ldots, (x_N, y_N)\}$, estimate the prediction function $f$ by minimizing the prediction error on the training set
- **Testing:** apply $f$ to a never before seen *test example* $x$ and output the predicted value $y = f(x)$

# Steps:


Training
Training Images
Image Features
Training Labels
Machine Learning Algorithm
Testing
Test Image
Image Features
Learned model
Prediction

# What is AI? : Conventional Method

Inputs (x) = Algorithm = Decisions

Inputs (x) = Program = Outputs (y)

Pre-Processing

**Features Extractions**

Classification

```
#include <opencv.hpp>
void main ( )
{
cv::Mat image = cv::imread
```

a

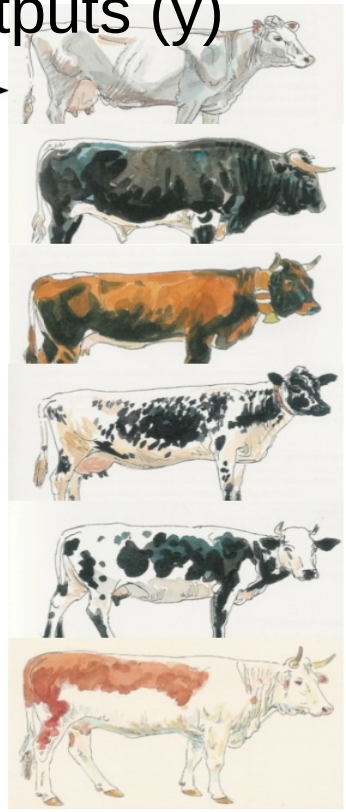
b

c

d

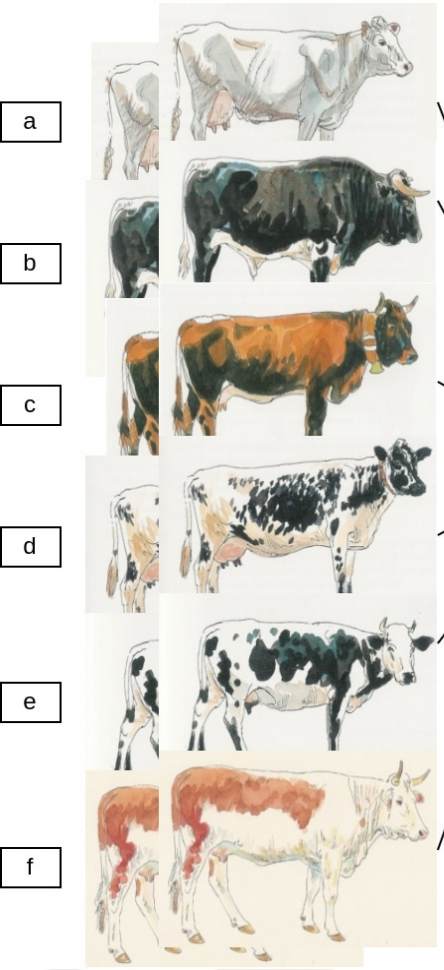
e

f

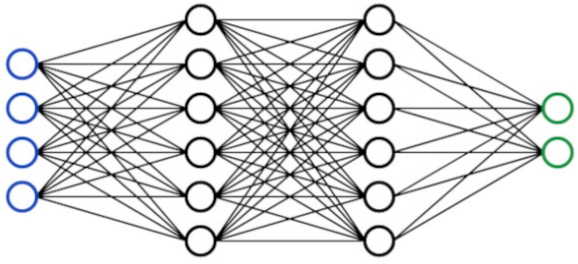


# What is AI?

(Labeled) Outputs (y) = F (x) (AI Model) => **Program**



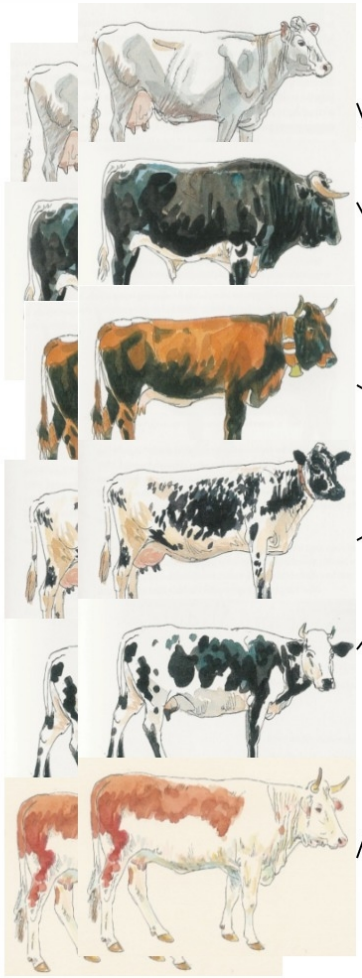

Edges => Objects => Shapes



**Parameters** =>
(Weights, Biases, AF, Embedding, Hyper-parameters)

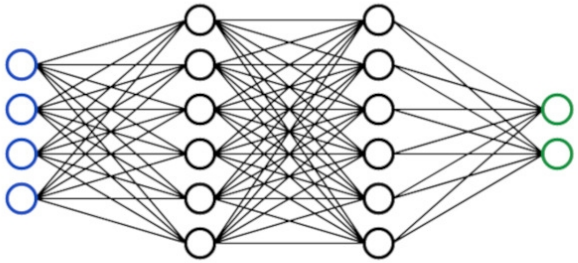
# What is AI?

Inputs (y) = F (x) (AI Model) => **Program**



Reward

Edges => Objects => Shapes



**Parameters** =>
(Weights, Biases, AF, Embedding, Hyper-parameters)

# Real-Life Problems

Data

Label Data

Features

Solvers

Classification

Follow:

For Meeting => Contact RA First

Plan you meeting => Better to Have Few Slides

Meeting Starts with => Previous Meeting Targets

Make Notes during Meeting

Conclude you Meeting with Future Meeting Targets

Avoid:

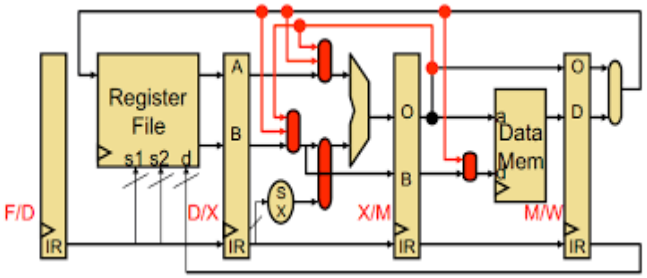
- Unstructured Meetings and discussion

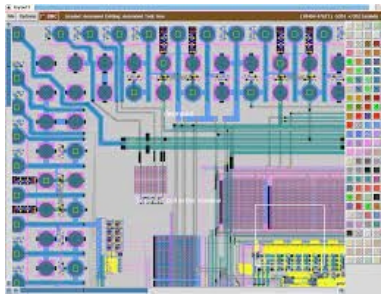
Broken References

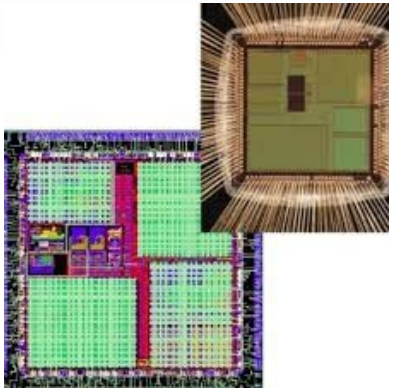
Showing Errors messages as prove of your work or ...

# Microelectronics Solutions for AI Compute Capability

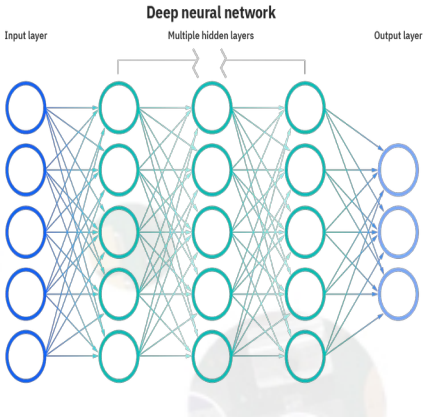
- **OpenSource Full-Stack Ecosystem for RISC-V Processor System**



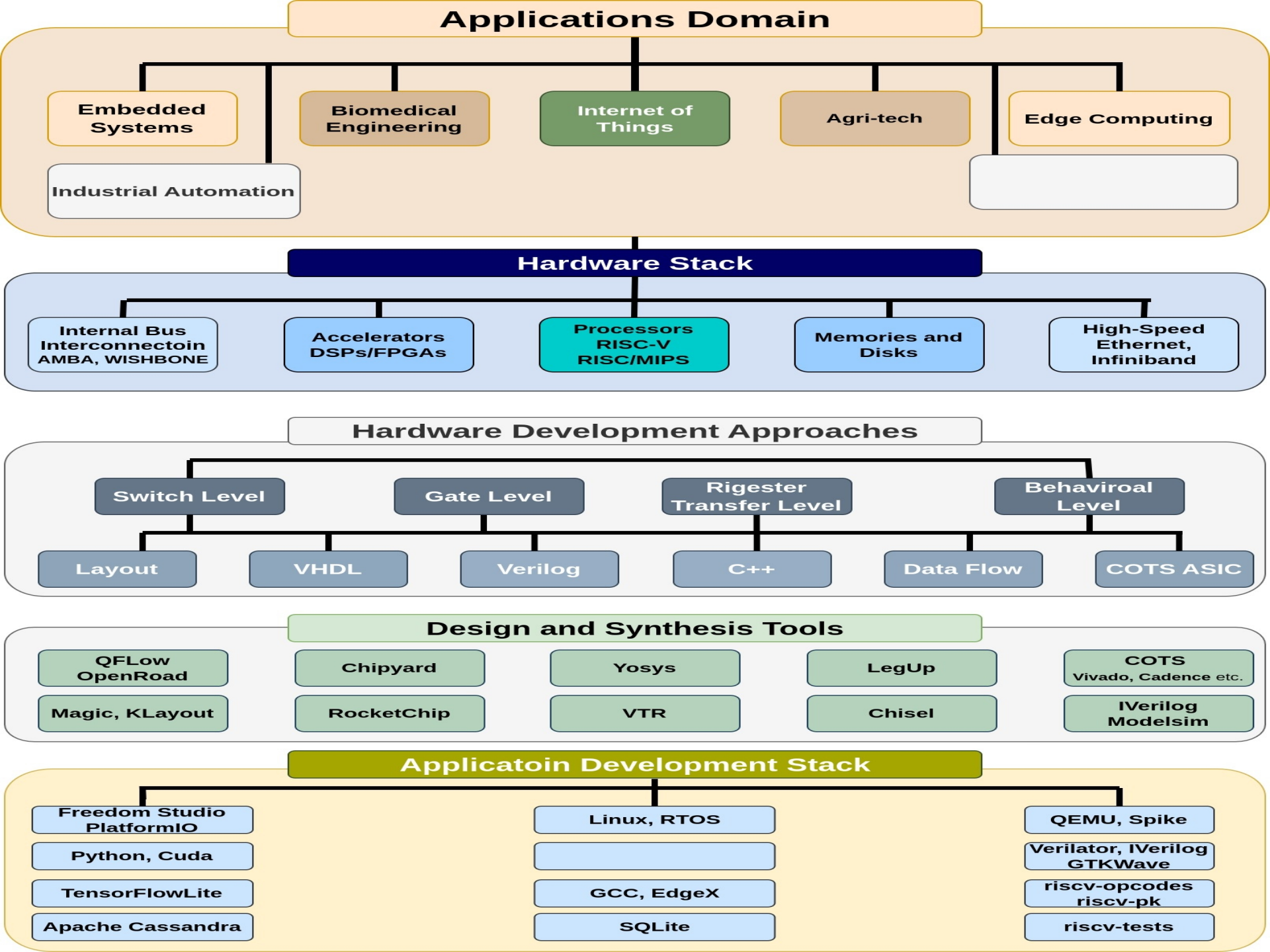


- **Supercomputing for AI and BigData Applications**



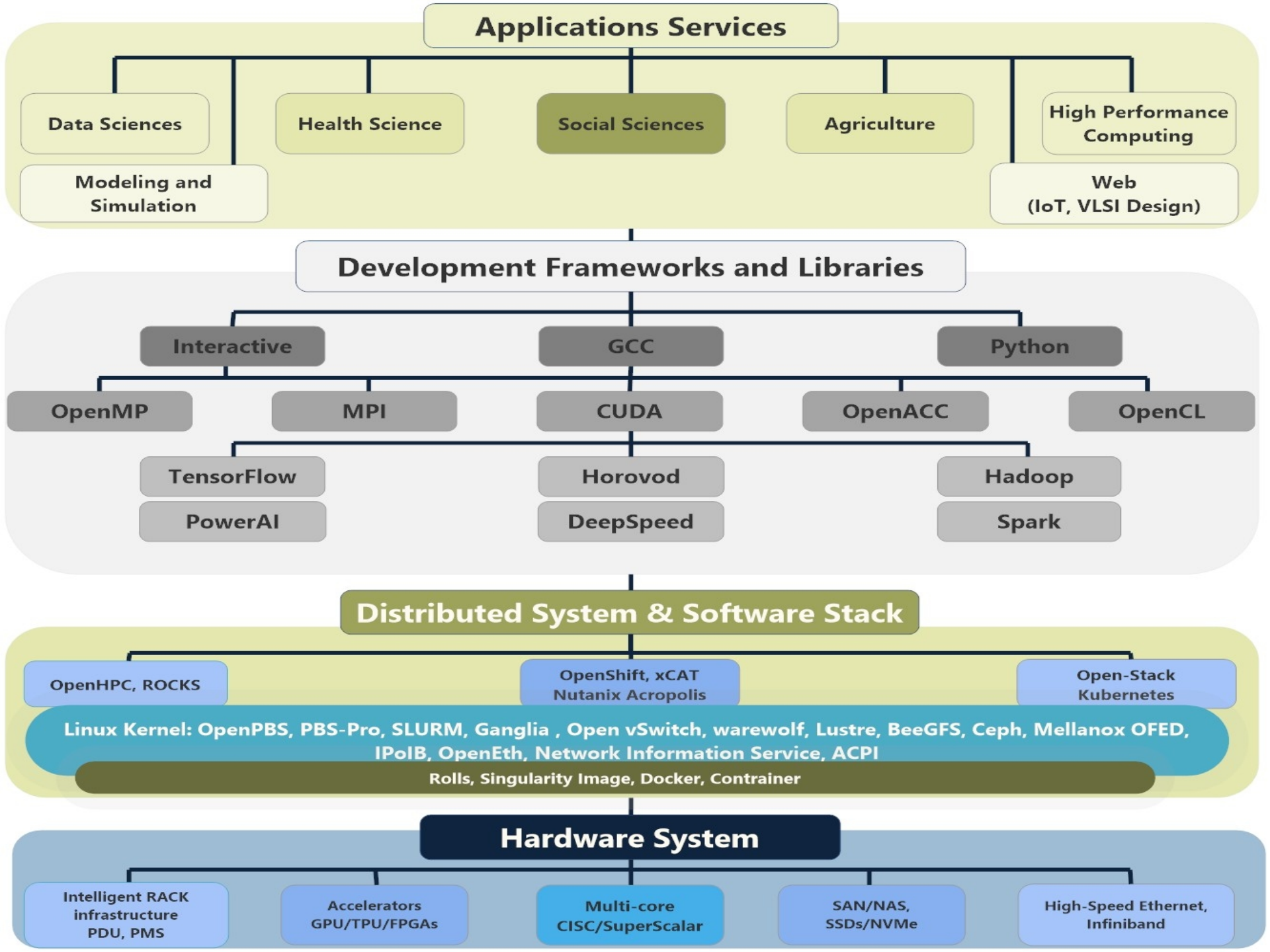

# OpenSource Full-Stack Ecosystem for RISC-V Processor Architecture

- **Hardware Architecture**
  - Low Performance and Low Cost Digital System
  - Uni/Multi Core System on a Chip
- **Single Board Computer**
  - Hardware Software Co-Design
  - High Performance Computing
- **Intelligent and Real-time Applications**
  - Industrial Automation
  - Machine Learning


Applications Domain
Embedded Systems
Biomedical Engineering
Internet of Things
Agri-tech
Edge Computing
Industrial Automation
Hardware Stack
Internal Bus Interconnectoin AMBA, WISHBONE
Accelerators DSPs/FPGAs
Processors RISC-V RISC/MIPS
Memories and Disks
High-Speed Ethernet, Infiniband
Hardware Development Approaches
Switch Level
Gate Level
Rigester Transfer Level
Behaviroal Level
Layout
VHDL
Verilog
C++
Data Flow
COTS ASIC
Design and Synthesis Tools
QFLow OpenRoad
Chipyard
Yosys
LegUp
COTS Vivado, Cadence etc.
Magic, KLayout
RocketChip
VTR
Chisel
IVerilog Modelsim
Applicatoin Development Stack
Freedom Studio PlatformIO
Linux, RTOS
QEMU, Spike
Python, Cuda
Verilator, IVerilog GTKWave
TensorFlowLite
GCC, EdgeX
riscv-opcodes riscv-pk
Apache Cassandra
SQLite
riscv-tests

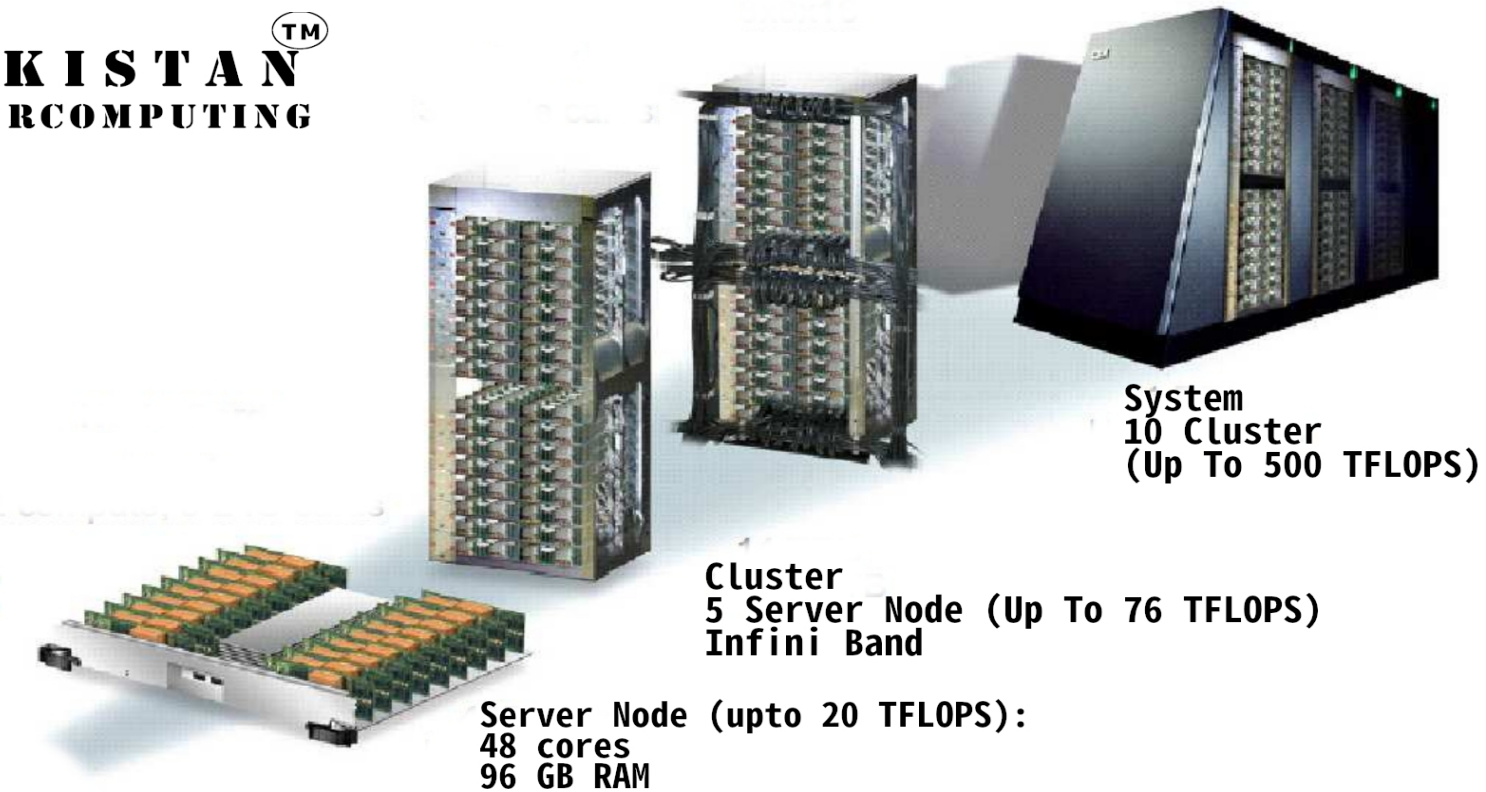
# Supercomputing Platform for AI and BigData Applications

- **Bare-Metal and Containerized Cluster Infrastructure:**
  - Distributed Hardware Interfacing, Network Configuration and Distributed Computing Software Deployment
- **Data Center and Cloud Infrastructure:**
  - Storage systems, networking equipment, and software configuration
- **AI Applications for Scientific and Engineering Problems**
  - Distributed AI applications for multi-node bare-metal system
- **HPC Application Parallel Programming**
  - Heterogeneous multi-node parallel processing using parallel programming models


Applications Services
Data Sciences
Health Science
Social Sciences
Agriculture
High Performance Computing
Modeling and Simulation
Web (IoT, VLSI Design)
Development Frameworks and Libraries
Interactive
GCC
Python
OpenMP
MPI
CUDA
OpenACC
OpenCL
TensorFlow
Horovod
Hadoop
PowerAI
DeepSpeed
Spark
Distributed System & Software Stack
OpenHPC, ROCKS
OpenShift, xCAT Nutanix Acropolis
Open-Stack Kubernetes
Linux Kernel: OpenPBS, PBS-Pro, SLURM, Ganglia , Open vSwitch, warewolf, Lustre, BeeGFS, Ceph, Mellanox OFED, IPoIB, OpenEth, Network Information Service, ACPI
Rolls, Singularity Image, Docker, Contrainer
Hardware System
Intelligent RACK infrastructure PDU, PMS
Accelerators GPU/TPU/FPGAs
Multi-core CISC/SuperScalar
SAN/NAS, SSDs/NVMe
High-Speed Ethernet, Infiniband

# Developing Supercomputing for AI

PAKISTAN SUPERCOMPUTING™



System
10 Cluster
(Up To 500 TFLOPS)

Cluster
5 Server Node (Up To 76 TFLOPS)
Infini Band

Server Node (upto 20 TFLOPS):
48 cores
96 GB RAM
1 TB Disk
2 GPUs

CentOS Linux

Chip
4 cores
XEON Processor

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Centro Nacional de Supercomputación

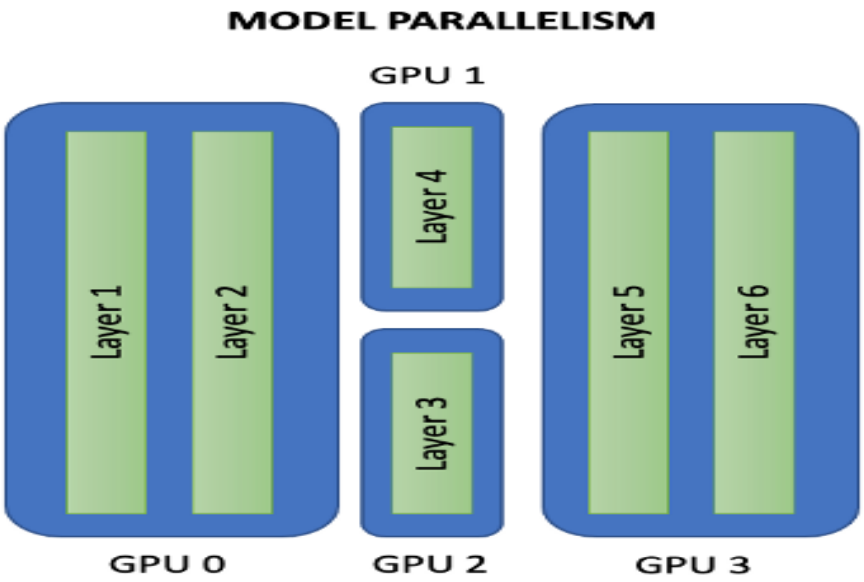
# AI Model Parallelism

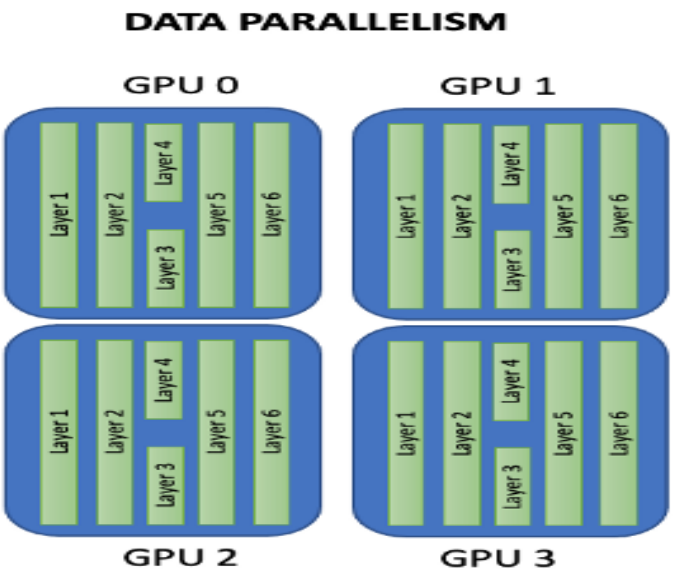
- **Model Parallelism**

  Different layers of the network distributed across different devices

- **Data Parallelism**

  Same model in every one of the GPUs, each processing a separate piece of the data, a separate portion of the mini-batch.



# Visit us

ssh username@10.0.0.153