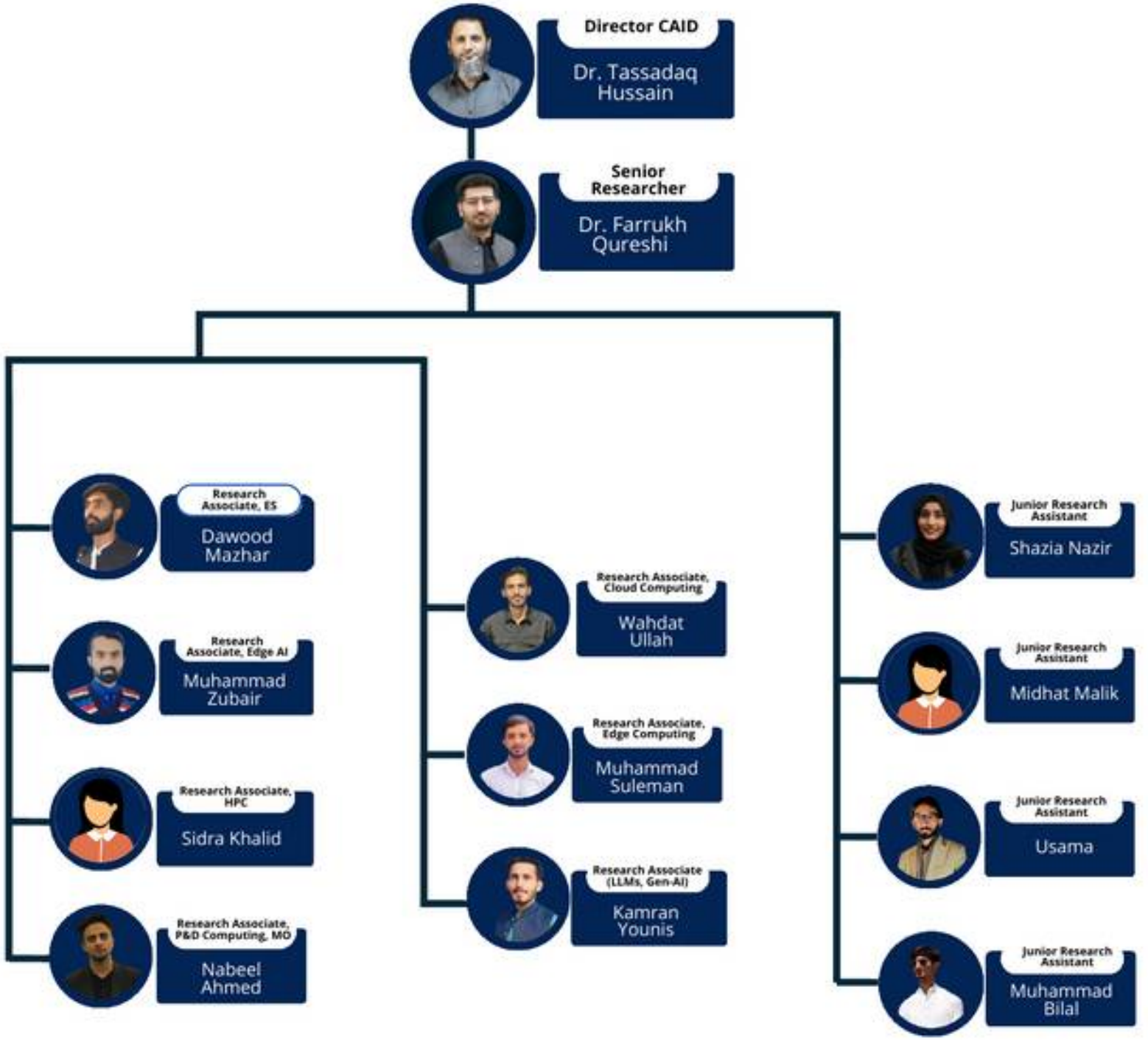
Summer School on Supercomputing & AI for Tech Entrepreneurs
29-31 August 2025 Namal University Mianwali

Supercomputing and AI for Entrepreneurial Innovation

Prof. Dr. Tassadaq Hussain
Specialization: Supercomputing and Artificial Intelligence
Director Centre for AI and BigData
Affiliated Member: Barcelona Supercomputing Centre

- **Team and Speaker Introduction**
- Objectives of this Event

School Team


Director CAID
Dr. Tassadaq Hussain
Senior Researcher
Dr. Farrukh Qureshi
Research Associate, ES
Dawood Mazhar
Research Associate, Edge AI
Muhammad Zubair
Research Associate, HPC
Sidra Khalid
Research Associate, P&D Computing, MO
Nabeel Ahmed
Research Associate, Cloud Computing
Wahdat Ullah
Research Associate, Edge Computing
Muhammad Suleman
Research Associate (LLMs, Gen-AI)
Kamran Younis
Junior Research Assistant
Shazia Nazir
Junior Research Assistant
Midhat Malik
Junior Research Assistant
Usama
Junior Research Assistant
Muhammad Bilal

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:

20+ 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

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

• Development & Commercialization

70+ 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
Centro Nacional de Supercomputación

UVHC
UNIVERSITÉ DE VALENCIENNES ET DU HAINAUT - CAMBRÉSIS

NEW ZEALAND COLLEGE OF CHIROPRACTIC
graduating hands, hearts & minds

PAKISTAN SUPERCOMPUTING

EntrepreneurialPark
Research Innovation Commercialization

Foot Analytic

ComputingPark

Int’l Projects

- Design Ultra Low Cost Display Camera Interface for Mobile Baseband XGold Chip
  (Infineon Techonogies, 200 million single chip)

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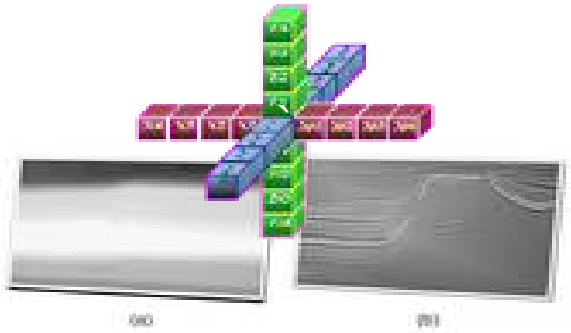

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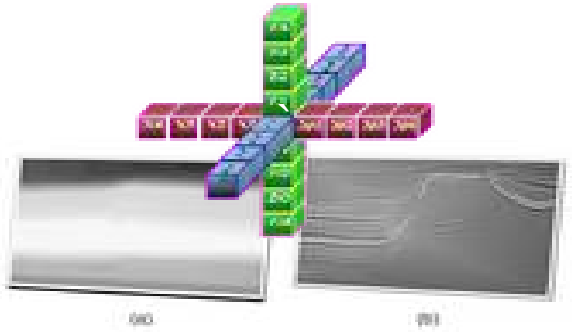
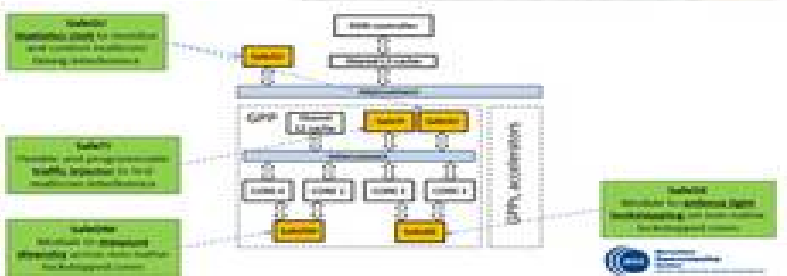


- Open source European full-stack ecosystem based on a new RISC-V CPU
  (Barcelona Supercomputing Center)



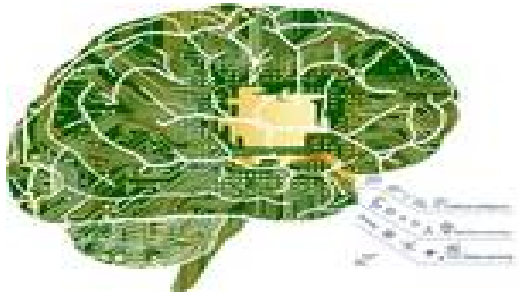
- Speaker Introduction
- **About Event**

Previous Summer School on

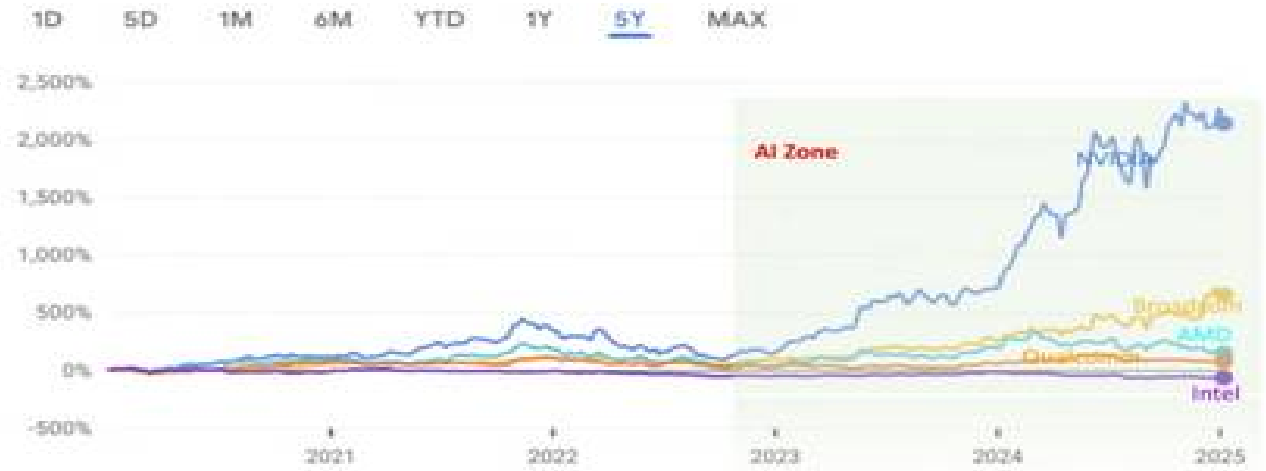
Organized Five Schools:
a) "Supercomputing for AI and Big Data Applications."
b) "Full Stack Ecosystem for Processor-Based Chip Design."
c) Supercomputing and Parallel Programming
Sessions 60, delivered by 25 trainers,
12 international experts
25 national experts
Participation 350+
80 professionals from various sectors
Towards International Recognition (PRACE)

Why the Supercomputing and AI ?

- 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)
- HPC is the only solution to store big-data and process the AI.

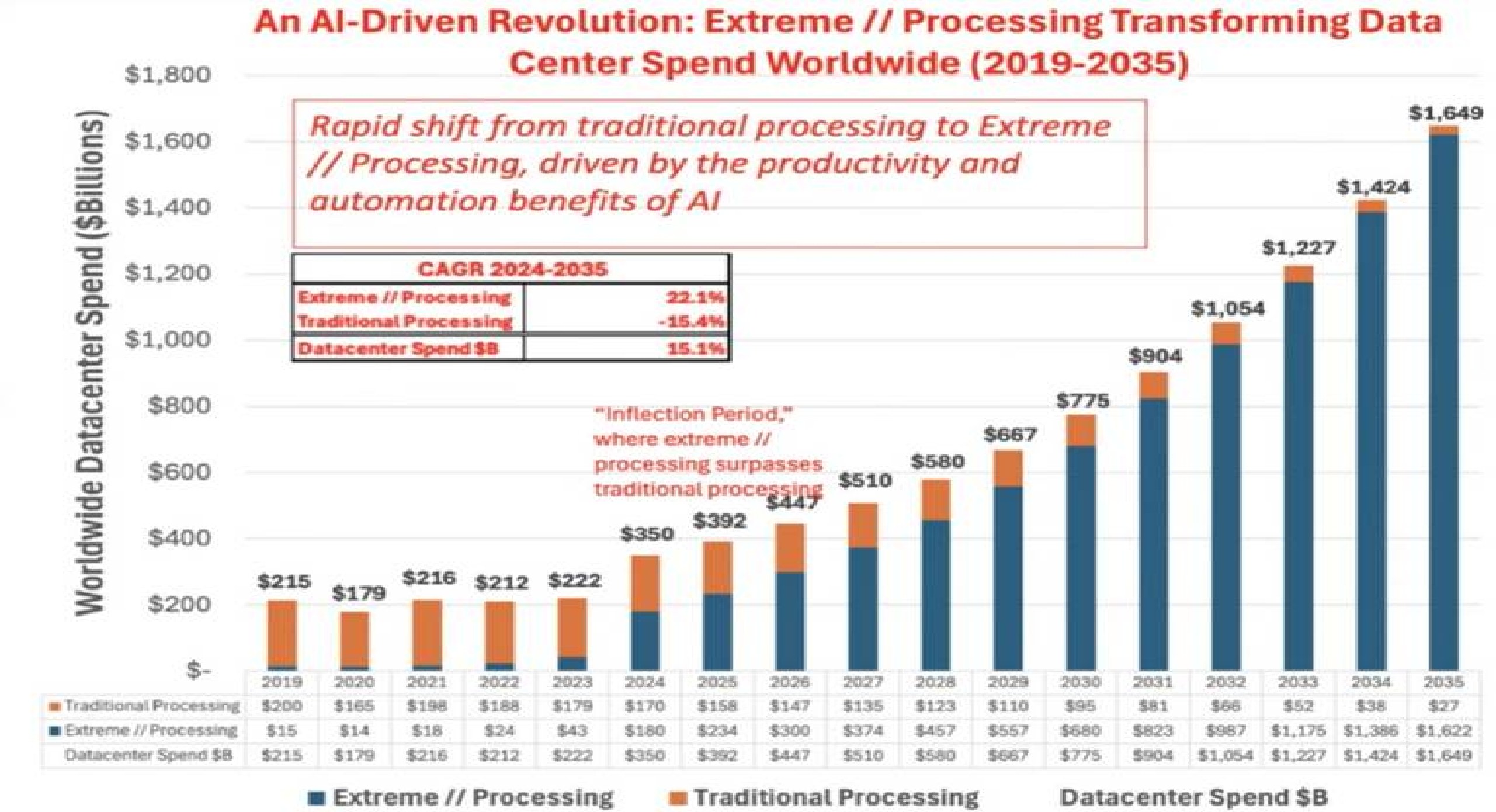


Secure
Affordable
Programmable
Customize-able
Indigenous



NVIDIA Corp	$136.66	+$130.55	↑ 2,136.66%
Broadcom Inc	$225.09	+$195.17	↑ 652.31%
Advanced Micro D...	$116.53	+$68.36	↑ 141.91%
Qualcomm Inc	$157.74	+$67.48	↑ 74.76%

An AI-Driven Revolution: Extreme // Processing Transforming Data Center Spend Worldwide (2019-2035)



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Traditional Processing	$200	$165	$198	$188	$179	$170	$158	$147	$135	$123	$110	$95	$81	$66	$52	$38	$27
Extreme // Processing	$15	$14	$18	$24	$43	$180	$234	$300	$374	$457	$557	$680	$823	$987	$1,175	$1,386	$1,622
Datacenter Spend $B	$215	$179	$216	$212	$222	$350	$392	$447	$510	$580	$667	$775	$904	$1,054	$1,227	$1,424	$1,649

Objectives

Educate , Collaborate and Accelerate

The goal of this school is to foster **interdisciplinary collaboration** and **teamwork across departments** within the **University** through the exploration of Artificial Intelligence and **Indigenous Development.**

by:

Leveraging the collective expertise and resources, challenges and opportunities

for:

Advancing research, education, and societal impact.

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

School Talks

1) From Edge to Bare-Metal: HPC Hardware and Software Architectures for AI Product Development
2) HPC vs Cloud-Native AI Application Deployment Approaches, Strengths, and Hybrid Strategies
3) Think Parallel: The Art of Parallel Programming
4) Scaling AI: Software to Silicon
5) Large Vision Models: Importance, Real-World Demand, and Challenges
6) Building Large Language Models for Local and Regional Applications
7) Ethernet at the Core: Enabling Next Gen AI and HPC System
8) Developing AI Applications for Local Communities and Industrial Challenges
9) Barcelona Supercomputing: The OmpSs Programming Model (ONLINE)

Agenda

- **Entrepreneurship & the Academia–Industry Gap**
- Technology Transfer: From Lab to Market
- AI-Specific Technology Transfer
- AI Ventures: Opportunities & Challenges
- Supercomputing: Enabler of AI Innovation
- Namal Centre for AI & Big Data and Supercomputing Facility

Role of Science, Technology in Sustainable Development at **Entrepreneurial Institutes**

Science: Systematically explores the **natural world** to **generate knowledge** through the **scientific method.**

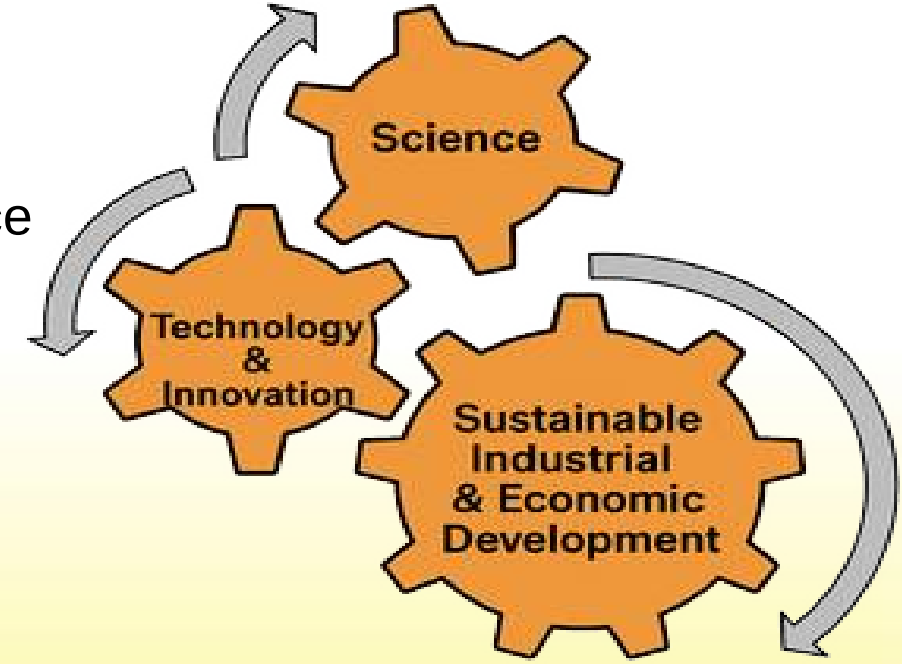
Research: Creative and **systematic** work undertaken to increase the stock of **knowledge**.

Technology: Application of **scientific knowledge** and **principles** to design and develop tools, systems, and devices **that solve real-world problems**.

Innovation: Creating new method, process, device or product.

Commercial Application: An application/product/process/service that is salable, can generate profit and marketable.

Sustainable Development: National initiative built on **local economies, industrial need** and unique assets to address their individual **challenges** and provide **quantifiable** real-world **benefits**.



Technology Transfer

- The process of moving knowledge, research results, or innovations from universities, research institutes, or laboratories into the marketplace to create products, services, or startups.

Academia-Industry: Status and Gaps

1st Generation University

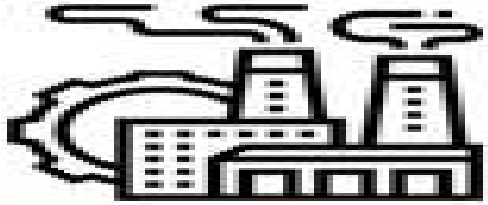
Goals:
Teaching and
Transfer of Knowledge

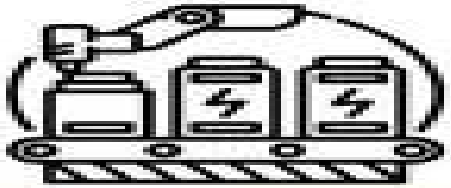
2nd Generation University

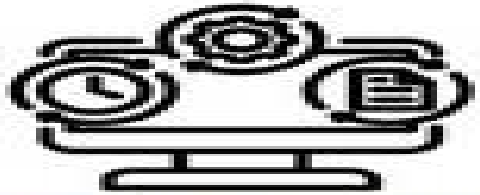
Goals:
Teaching +
Research and Innovation

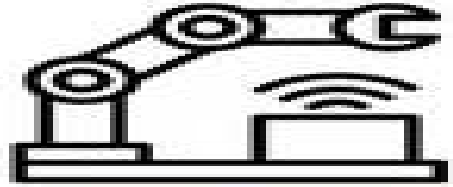
3rd Generation University

Goals:
Teaching + Research +
Innovation as path of industrial, economic and social development





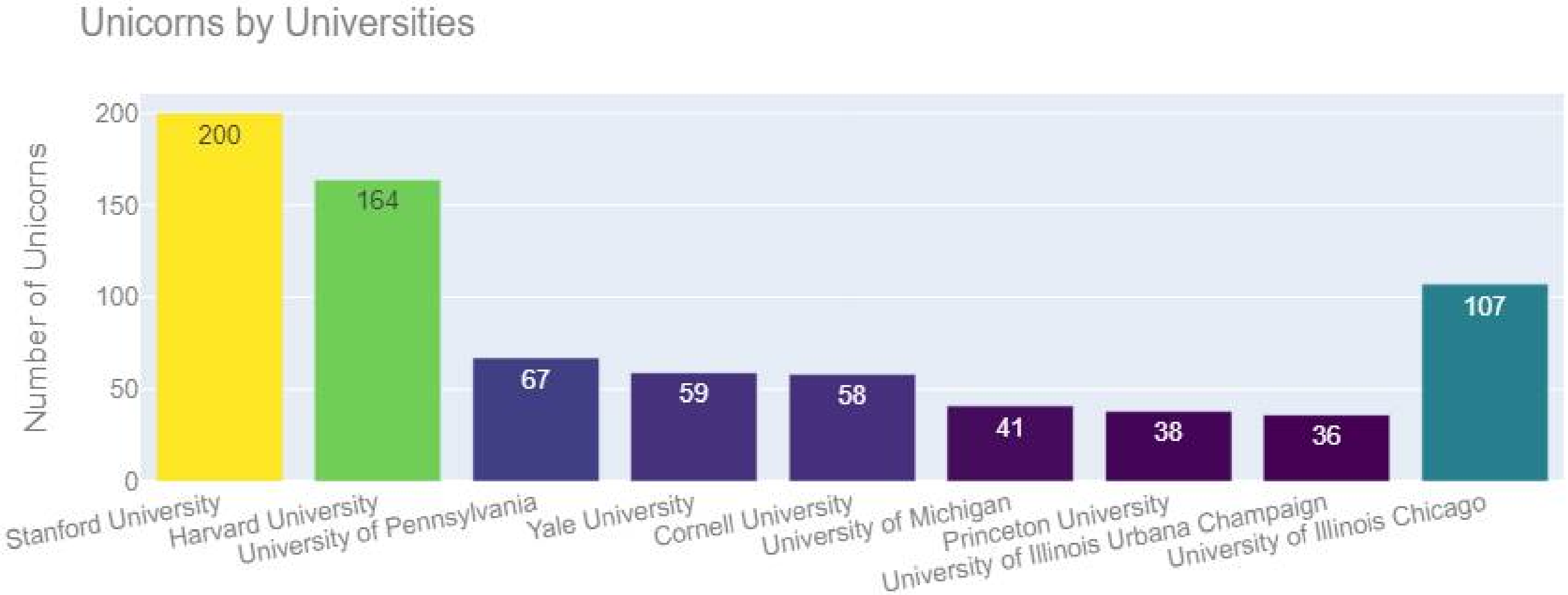




1st	2nd	3rd	4th
35 – 40 %	40 – 45 %	10 – 15 %	2 – 5 %
Mechanization, Water Power, Steam Power	Mass Production, Electricity	Computer and Automation	Cyber Physical Systems
Brick Kilns, Handlooms, Flour Mills, Gur units, Blacksmith shops.	Textiles, Cement, Fertilizer, Steel, Pharmaceuticals, Food Processing	Assembly Lines, Packaging, CNC Manufacturing, Industrial Automation	Software & IT , fintech, healthtech, R&D labs, smart agriculture startups

Global Unicorn Produced by 3G Universities

1,260 Unicorns, more than 90% are 4IR based



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- AI Ventures: Opportunities & Challenges
- Supercomputing: Enabler of AI Innovation
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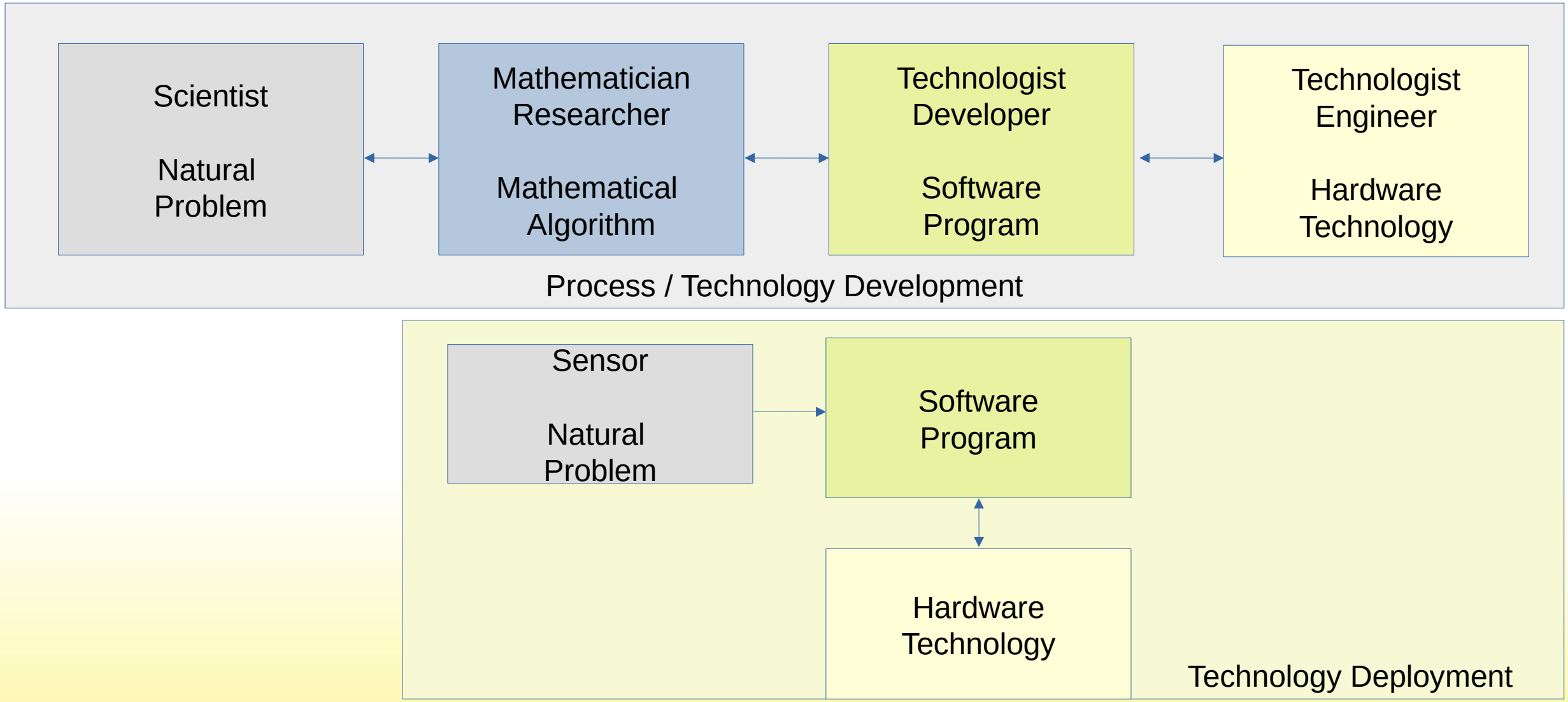
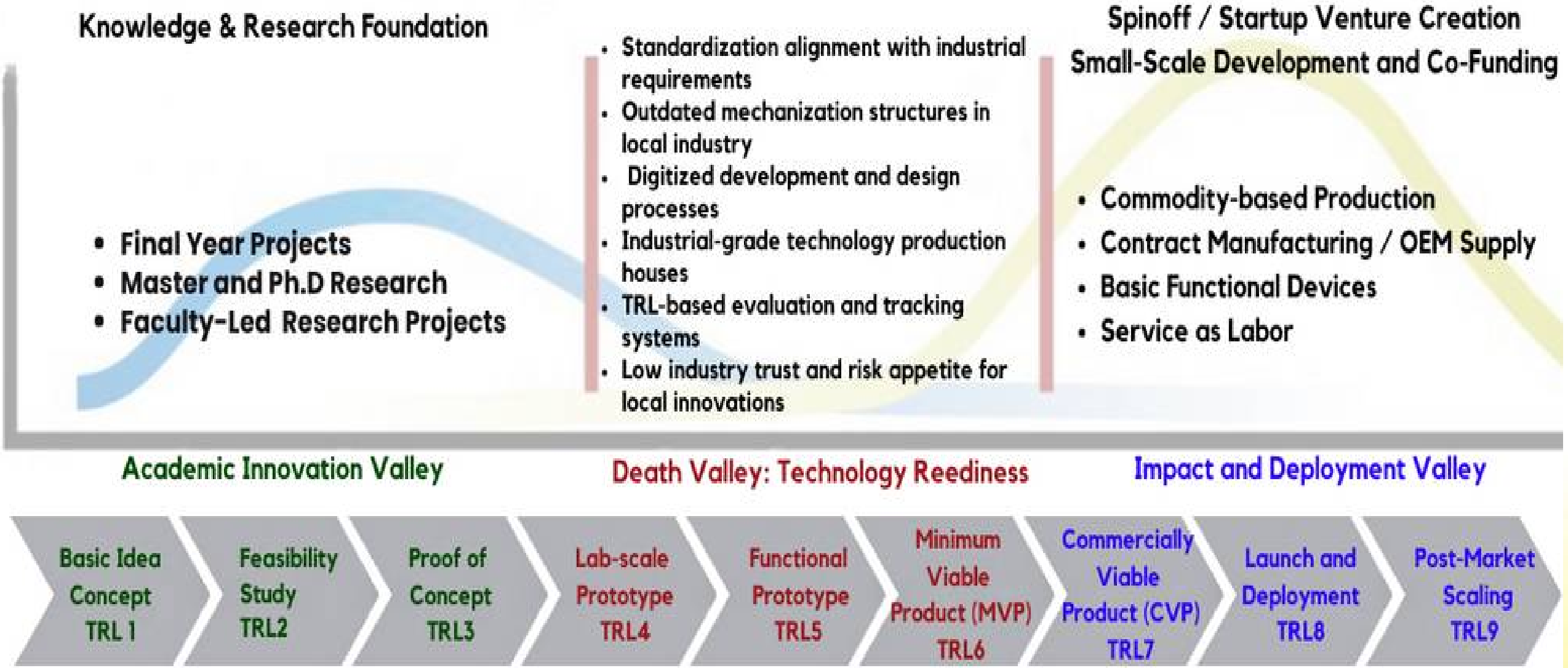
Conventional Technology Transfer Cycle



Academia-Industry and Tech Transfer



Why Technology Transfer Fails

- Lack of Technology Standards Compliance
- Regulatory & Legal Barriers
- Weak Technology Readiness Level (TRL)
- Intellectual Property (IP) & Licensing Issues
- **Non-availability of Indigenous Technology Production House**

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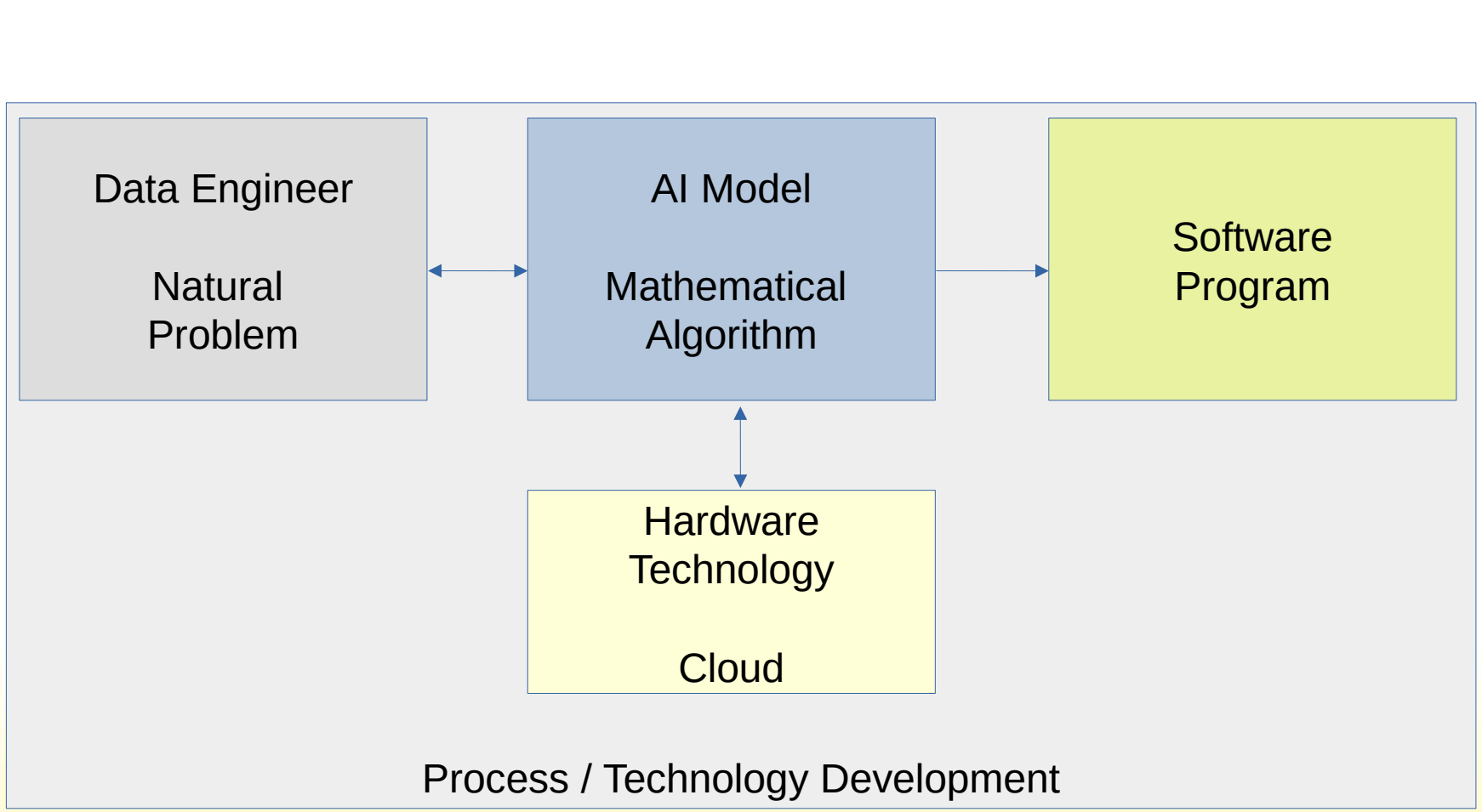
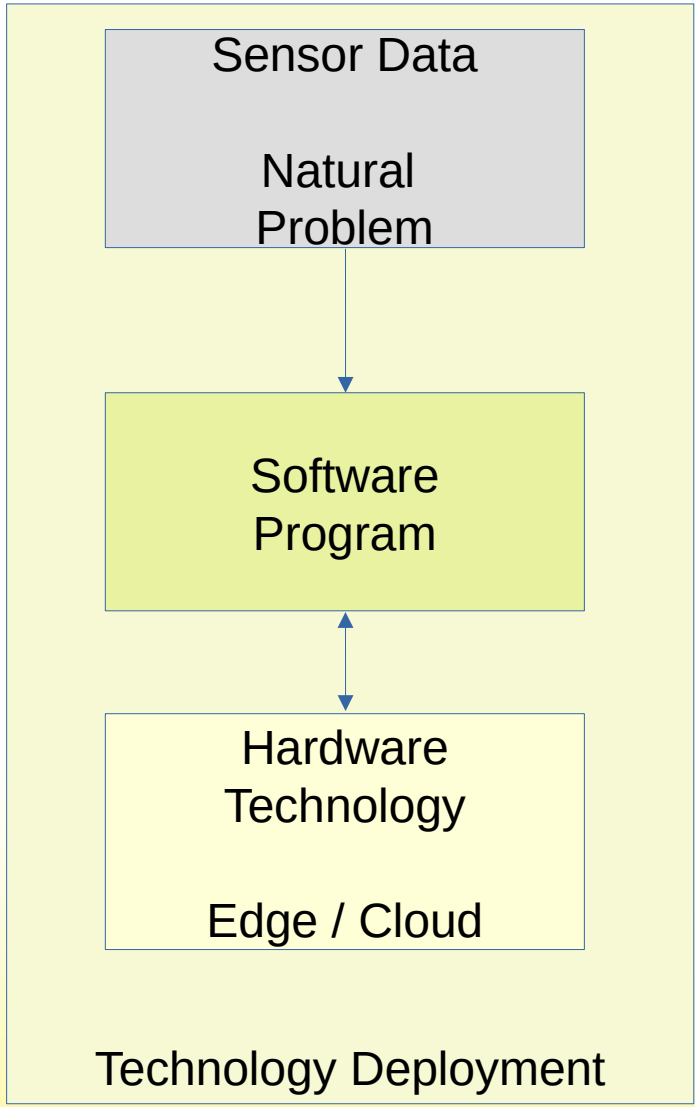
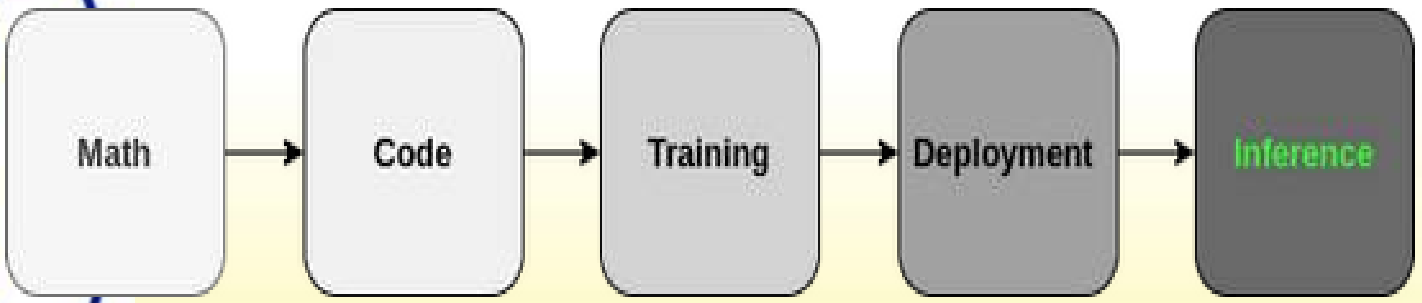
AI based Technology Development Cycle





Why AI Technology Transfer Fails

- Non-Standardized Data Collection & Data Engineering
- Limited AI Model Engineering Skills
- Lack of Indigenous HPC Technologies
- Weak Integration with Industry Use Cases
- Data Privacy and Policy Gaps



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Why AI Venture?

- Rising youth unemployment
- Local problems demand local solutions
- Why AI entrepreneurship ?

Simple ROI

$$\text{ROI} = \left(\frac{\text{Net Profit from AI}}{\text{Total Cost of AI Development}} \right) \times 100$$

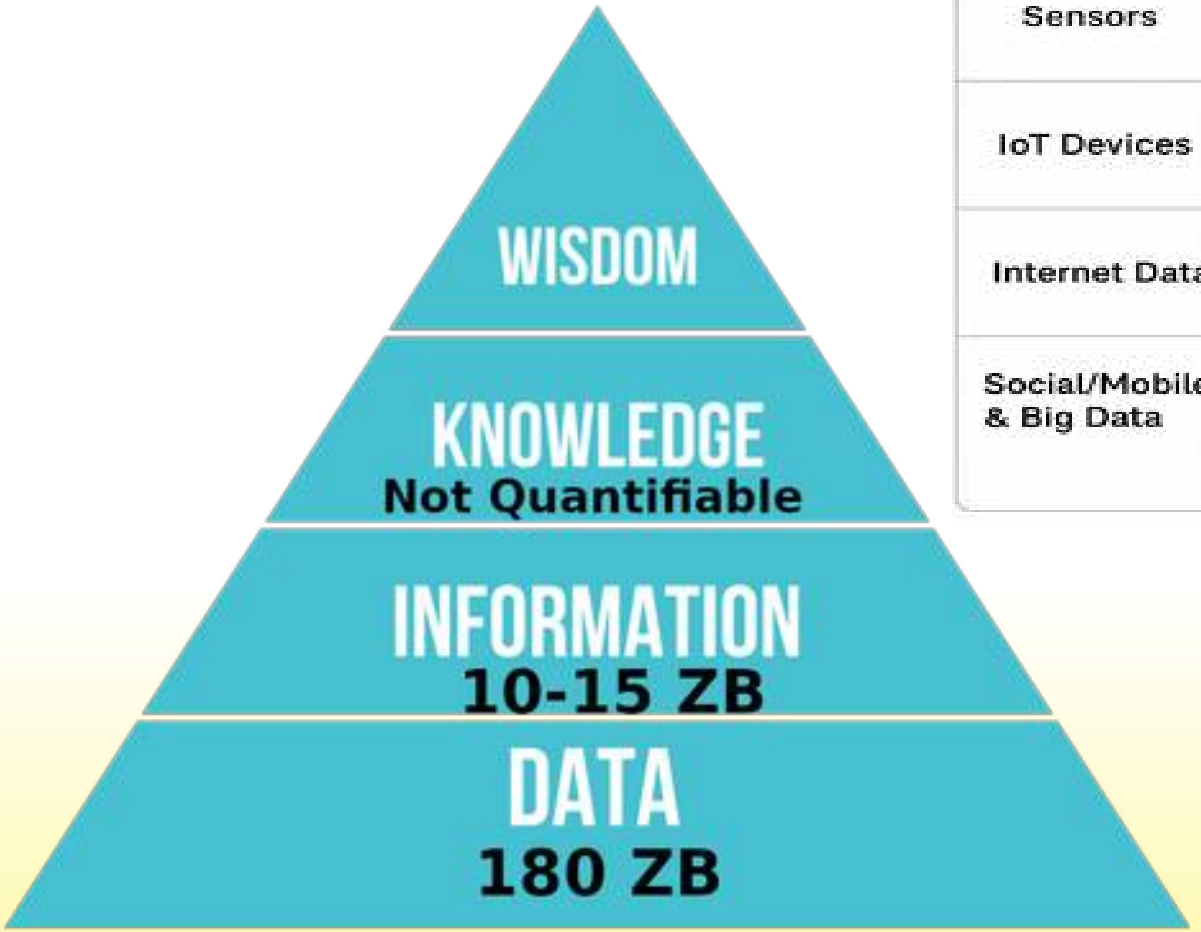
What AI Ventures Truly Need: Data, Models, and Compute Power

- Data Explosion
- AI Model Growth & Evolution
- Processing Limitation & Supercomputing Need

The Evolution of Computing: From Hardware Foundations to Supercomputing Power

- **Microprocessors (Proprietary Era):** Revolutionized automation and digital control, laying the foundation for modern computing.
- GCC (GNU Compiler Collection): Transformed software development by introducing open-source compilers.
- Linux: Made open-source operating systems mainstream, reshaping the computing industry.
- **Open-Source Internet & Networking Protocols (TCP/IP, DNS, HTTP, 5G): Enabled global digital connectivity.**
- **Mathematical Models, Development Frameworks, and Open Datasets: Are revolutionizing AI and computational intellectuality.**
- **Cloud Computing: Democratized access to computing resources, making them available on demand.**
- **Supercomputing: Pushed the boundaries of scalable performance, powering advanced research and innovation.**

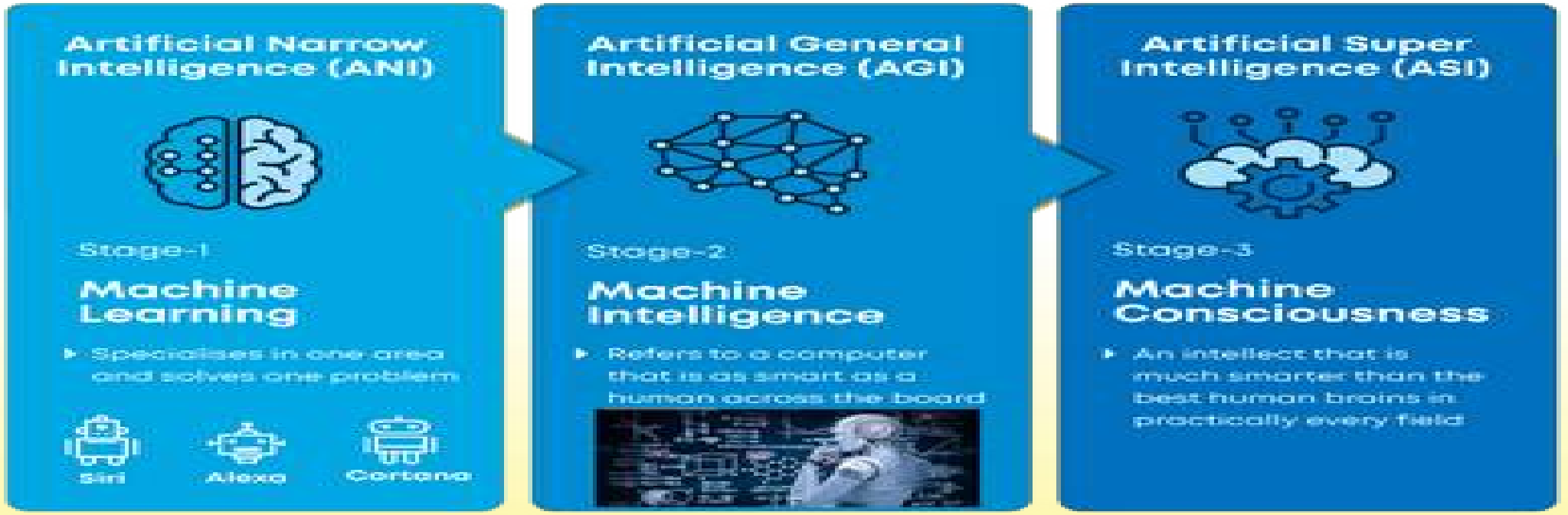
Data Types and Sources



Source	Technology Layer	Examples	Avg, Data Generated per Day (per device/system)	Global Devices/ Sources (approx.)	Computing Domain
Sensors	Embedded Systems	Cameras, accelemeters	1 KB – 10 MB	100+ billion sensors	Embedded Computing
IoT Devices	Edge Devices	Smart meters, home assists wearabies	100 MB – 10 GB	15–20 billion IoT devices	Cloud Computing
Internet Data	Web & Cloud APIs	E-commerce logs, web scraping	10 GB – 1 TB (per plahorem)	5+ billion websites, billlons of services	Cloud Computing
Social/Mobile & Big Data	Social/ Mobile & Big Data	Social media mobile apps GPS	10 TB – 1 PB (large platforms)	6.9 billion smartphones; 4.9 billion social users	High-Performance-Supercomputing

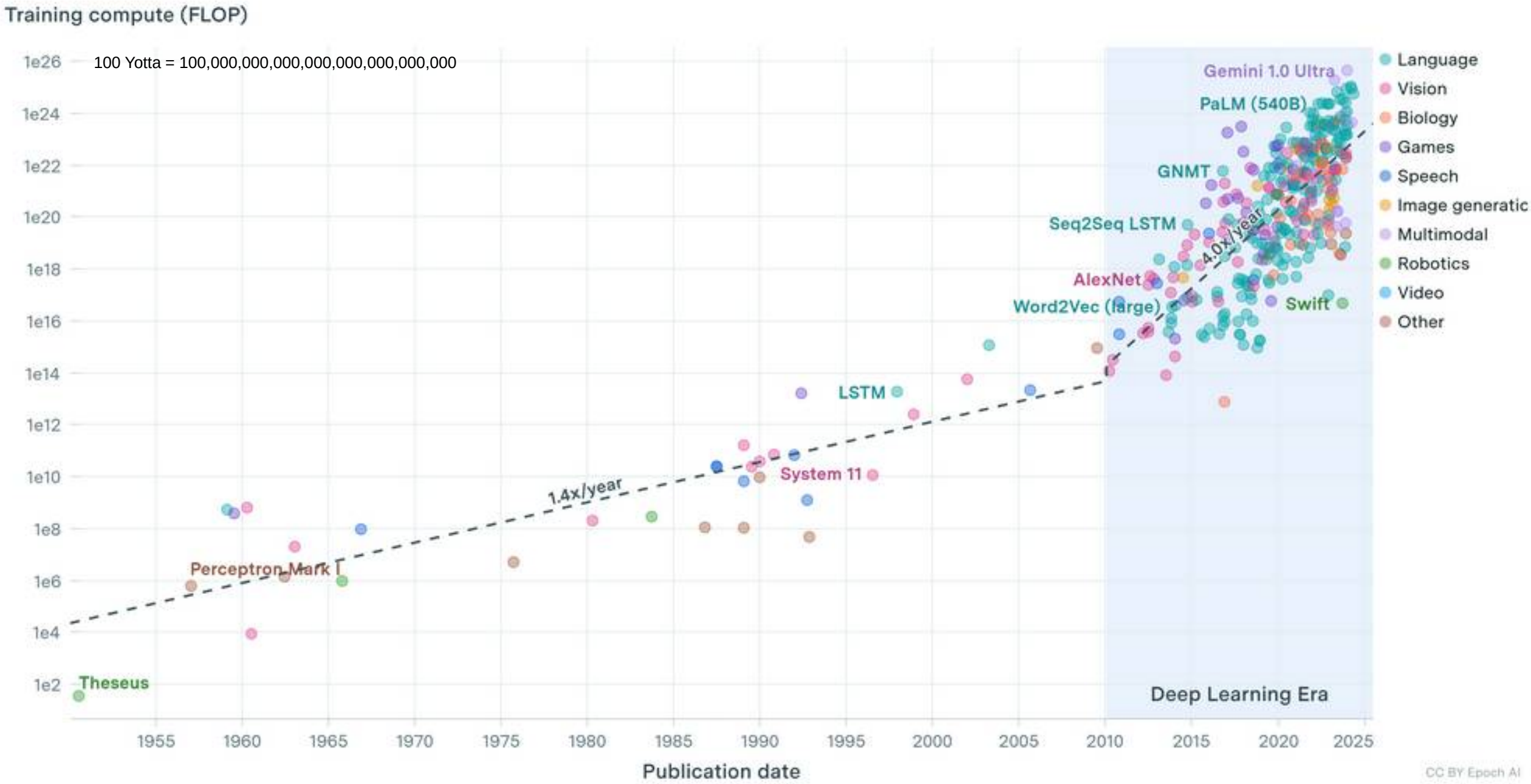
Intelligent Algorithms

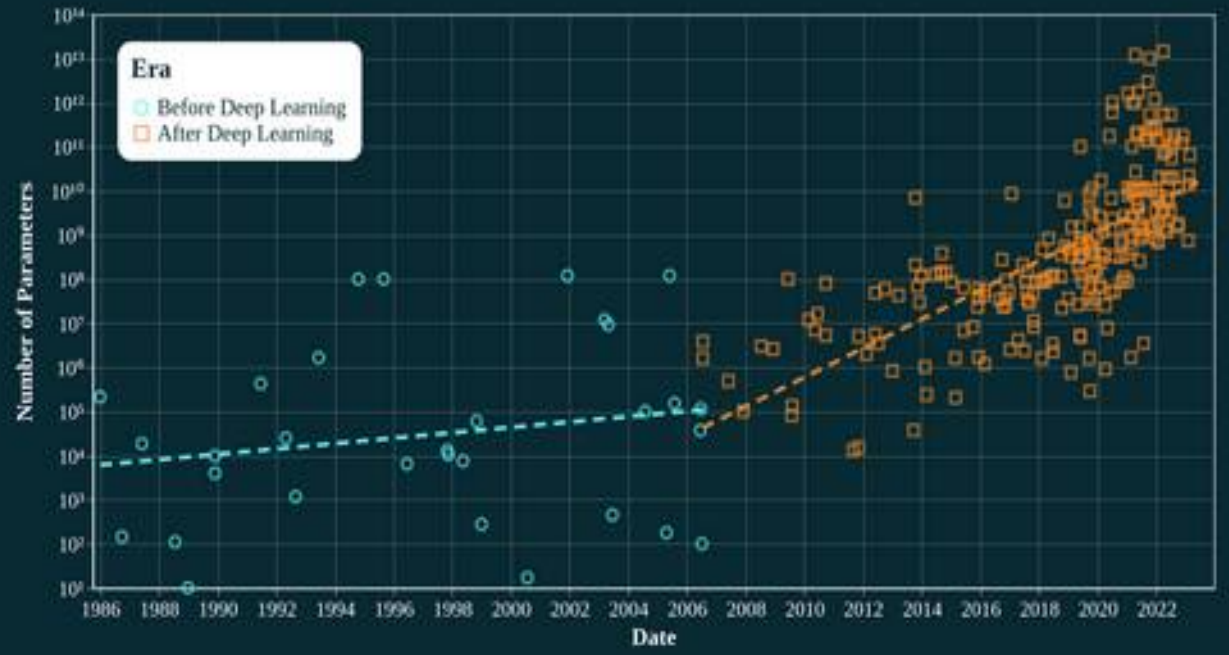
- **Performance**
  - **Execution Time**
  - **Accuracy** “The accuracy of the model is inherently tied to the quality, diversity, and representativeness of the data used for training and evaluation."
  - **Scalability** “Methods that scale with computation are the future of Artificial Intelligence”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

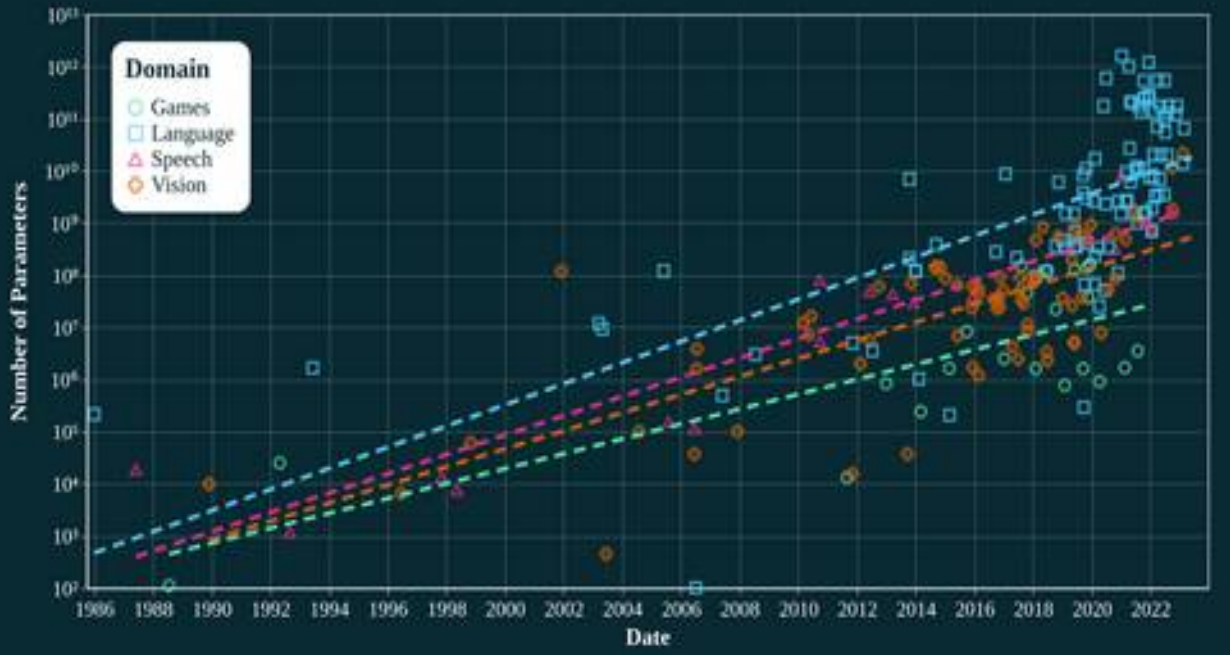


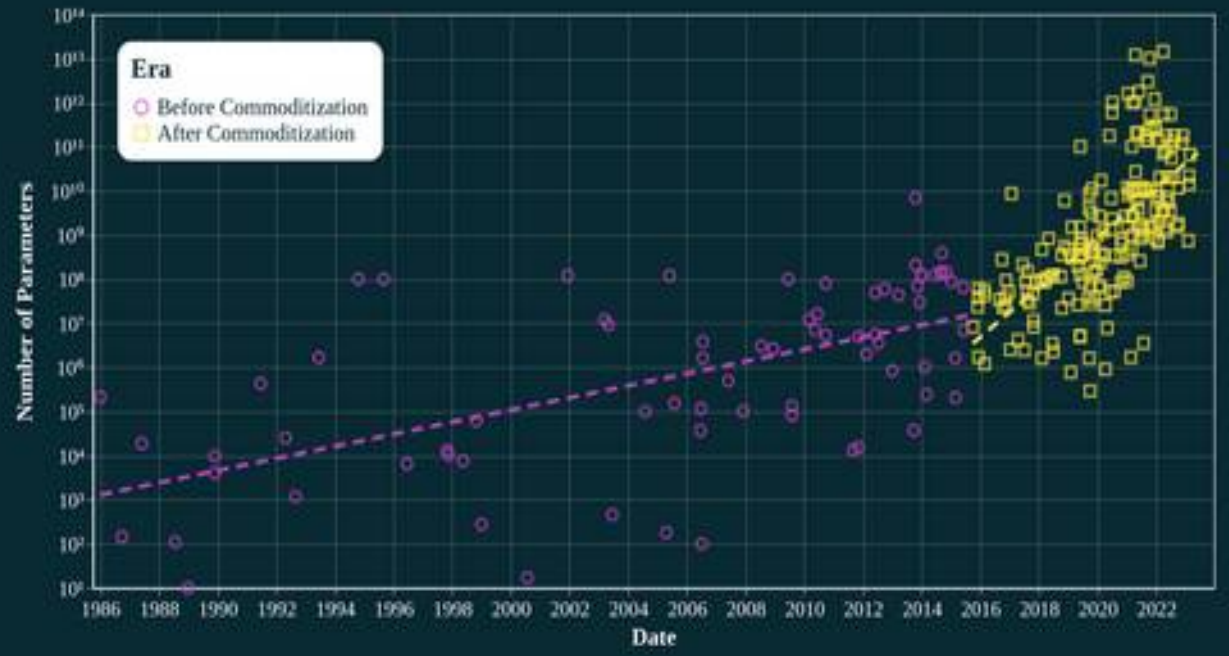
Notable AI models

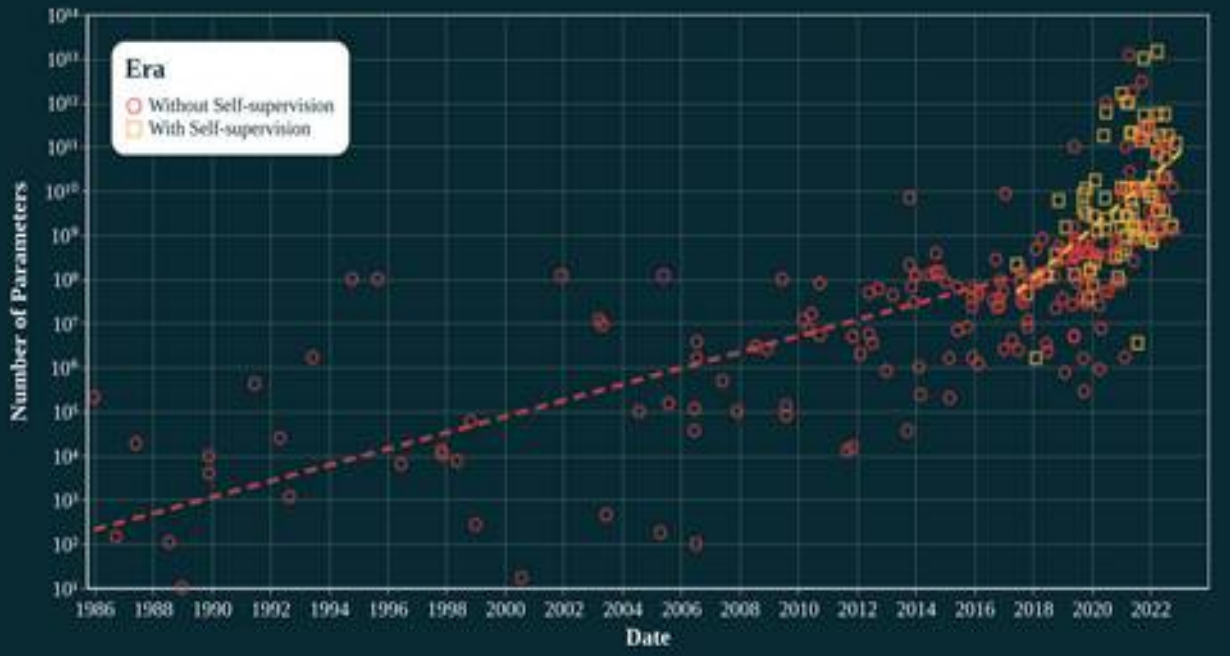
EPOCH AI



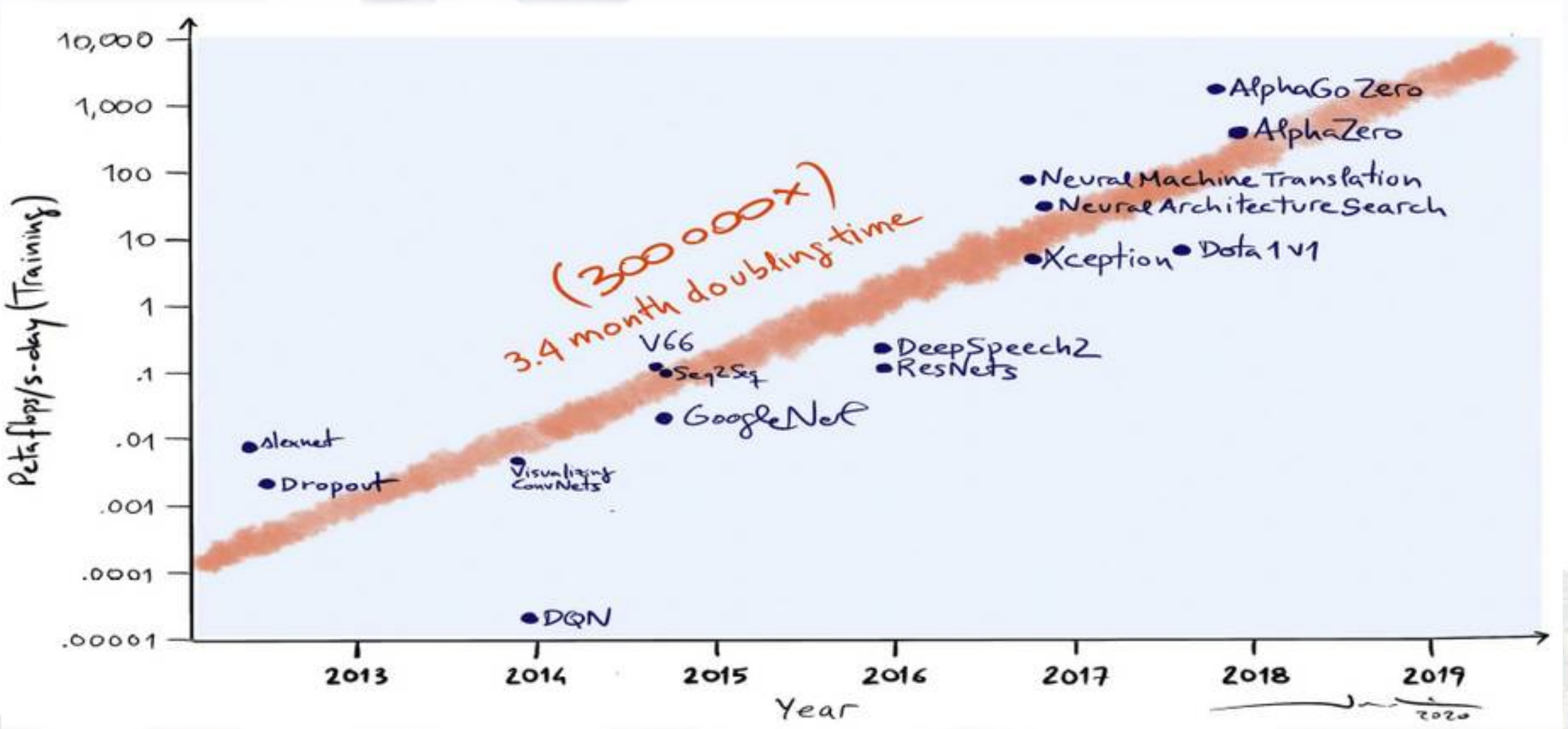

Era
Before Deep Learning
After Deep Learning
Number of Parameters
Date


Domain
Games
Language
Speech
Vision
Number of Parameters
Date

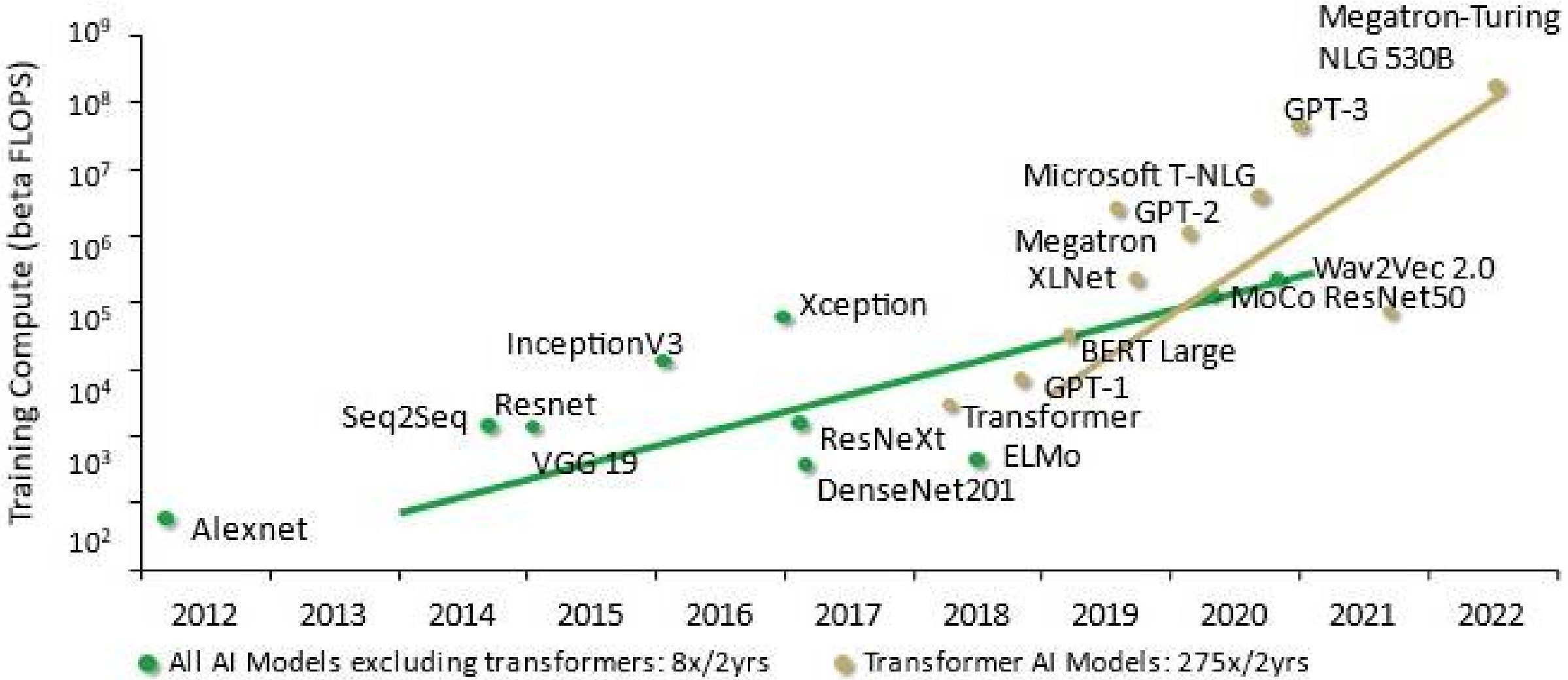

Era
Before Commoditization
After Commoditization
Number of Parameters
Date


Era
Without Self-supervision
With Self-supervision
Number of Parameters
Date

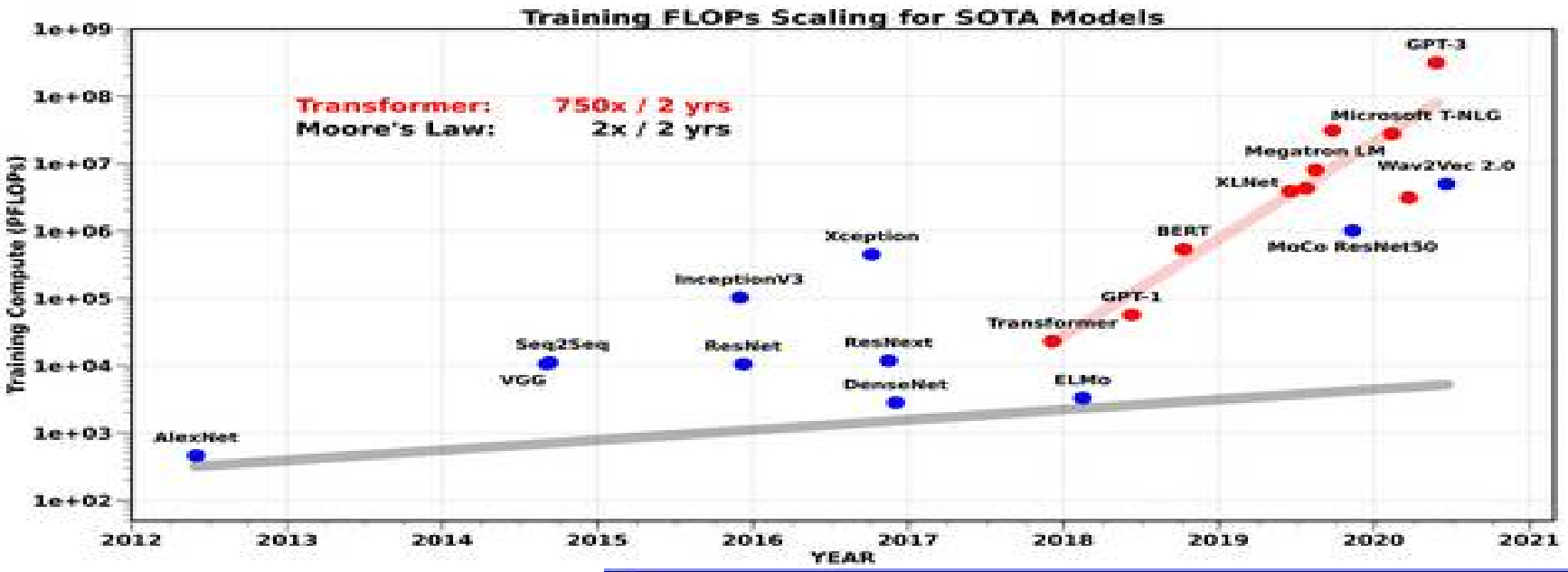
AI Computational Requirements

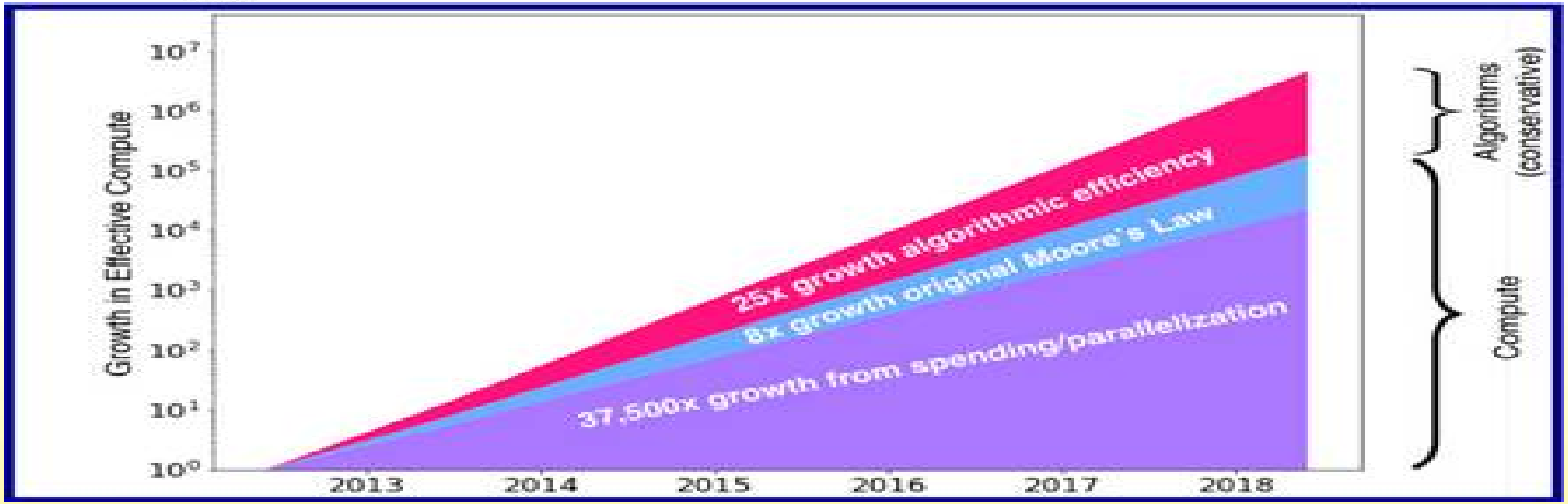


https://towardsdatascience.com/artificial-intelligence-is-a-supercomputing-problem-4b0edbc2888d


Training Compute (beta FLOPS)
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
Megatron-Turing NLG 530B
GPT-3
Microsoft T-NLG
GPT-2
Megatron
XLNet
Wav2Vec 2.0
MoCo ResNet50
Xception
InceptionV3
BERT Large
GPT-1
Seq2Seq
Resnet
Transformer
ResNeXt
ELMo
VGG 19
DenseNet201
Alexnet
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
All AI Models excluding transformers: 8x/2yrs
Transformer AI Models: 275x/2yrs

AI Computation and Computing





https://arxiv.org/pdf/2005.04305.pdf

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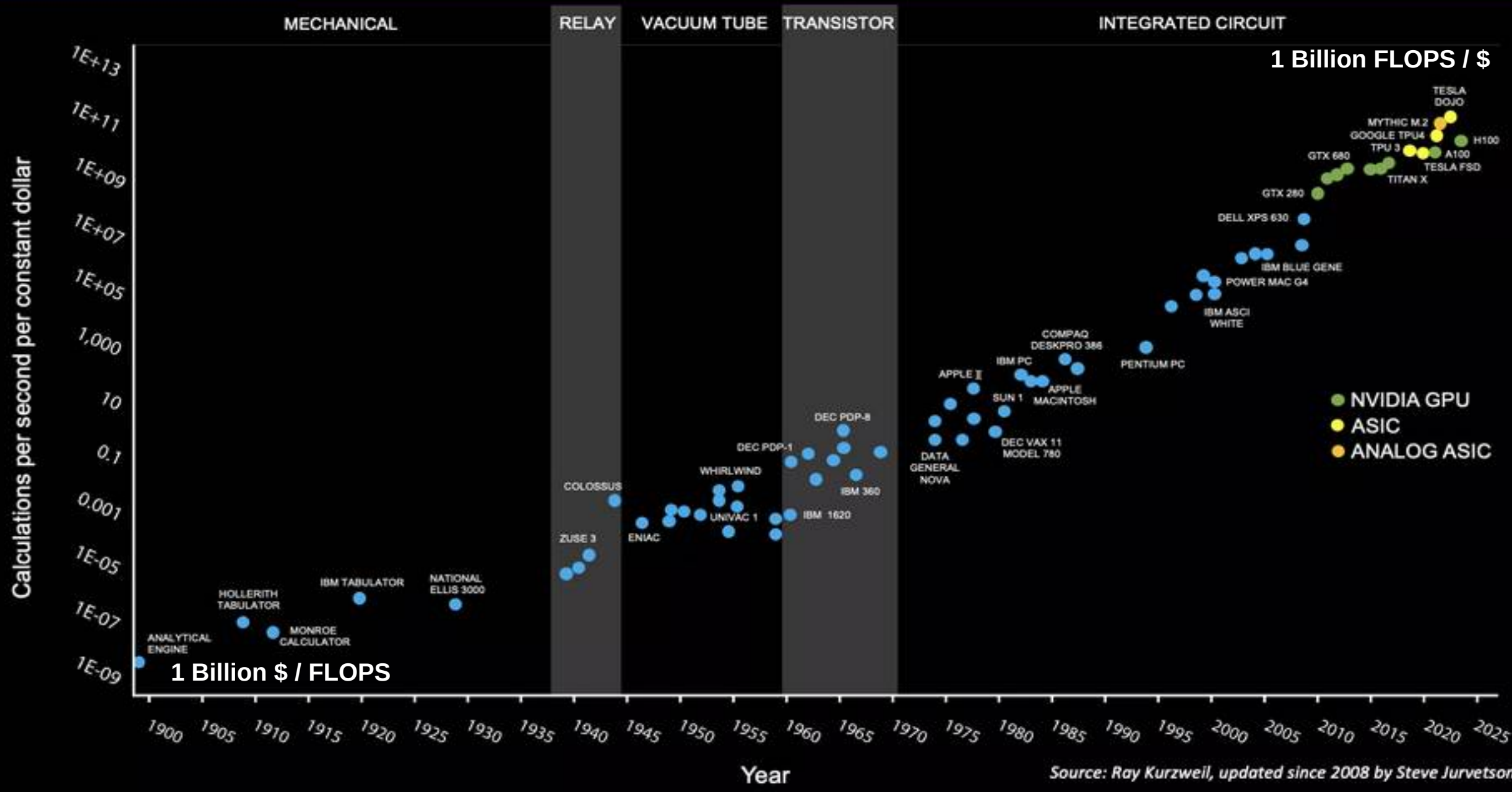
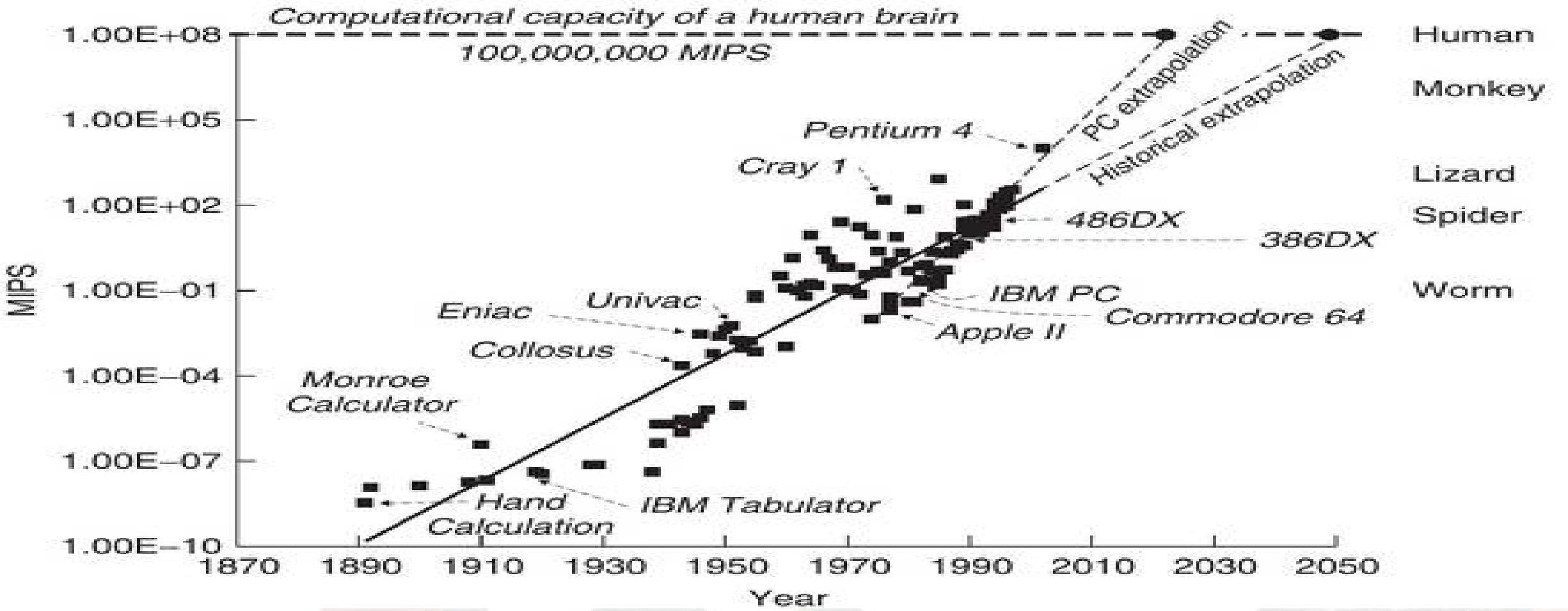
125 YEARS OF MOORE'S LAW



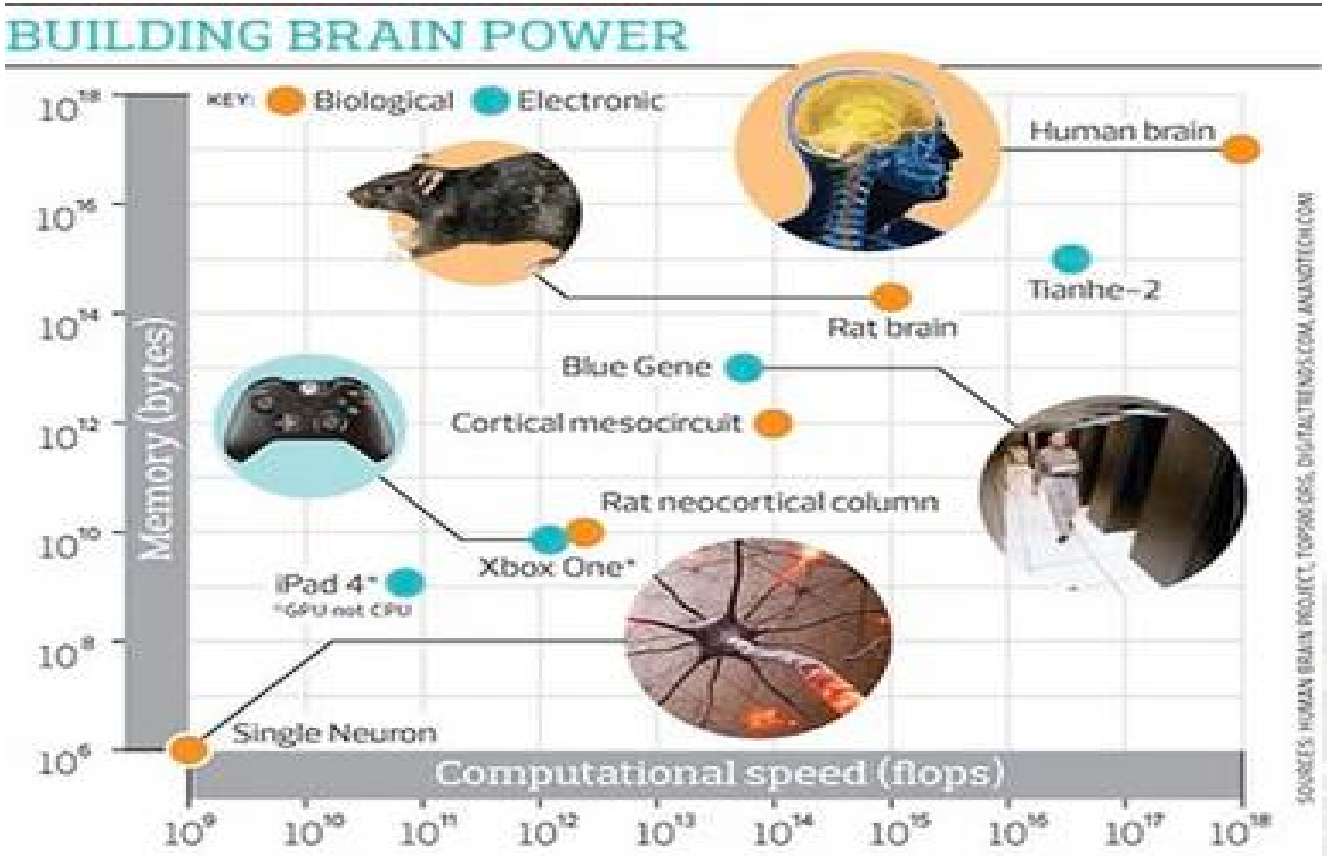
Human Computational Capabilities and HPC



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 Capability

- Perform around 1 exaFLOP (10^{18} FLOP/s) with just ~20 watts of power.
- The adult human brain's memory capacity is often estimated at approximately ~2.5 petabytes.
- Aurora Supercoputer gives 1.012 exaFLOP (Rmax) @ ~38.7 MW



https://www.theguardian.com

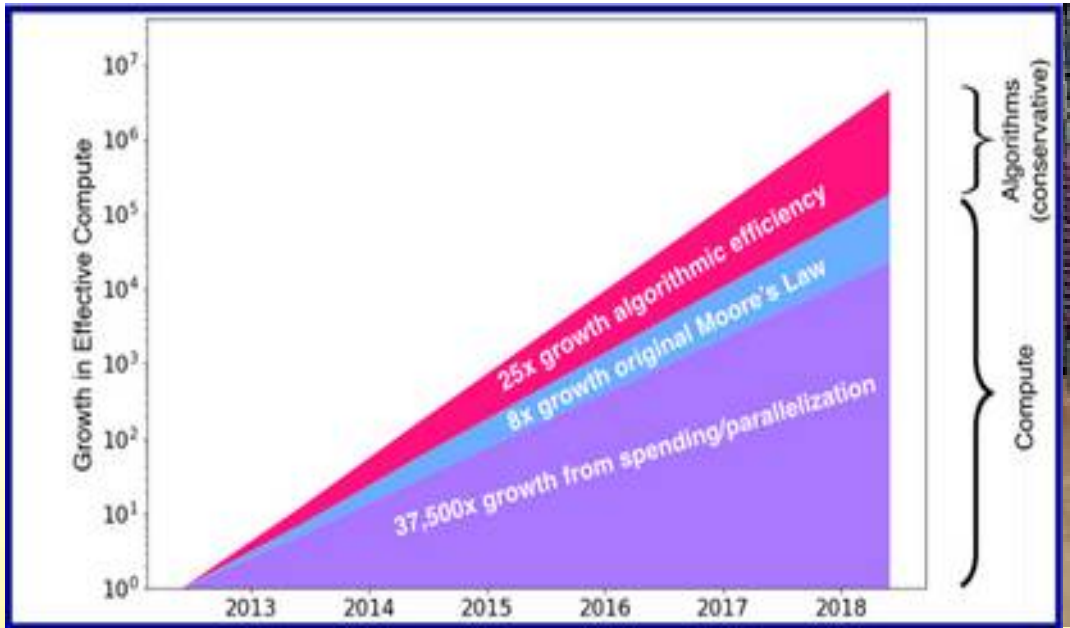
AI Ventures Requirements

- **Training Time**
- **Infrastructure Cost**
- **Power Consumption**
- **Expertise**

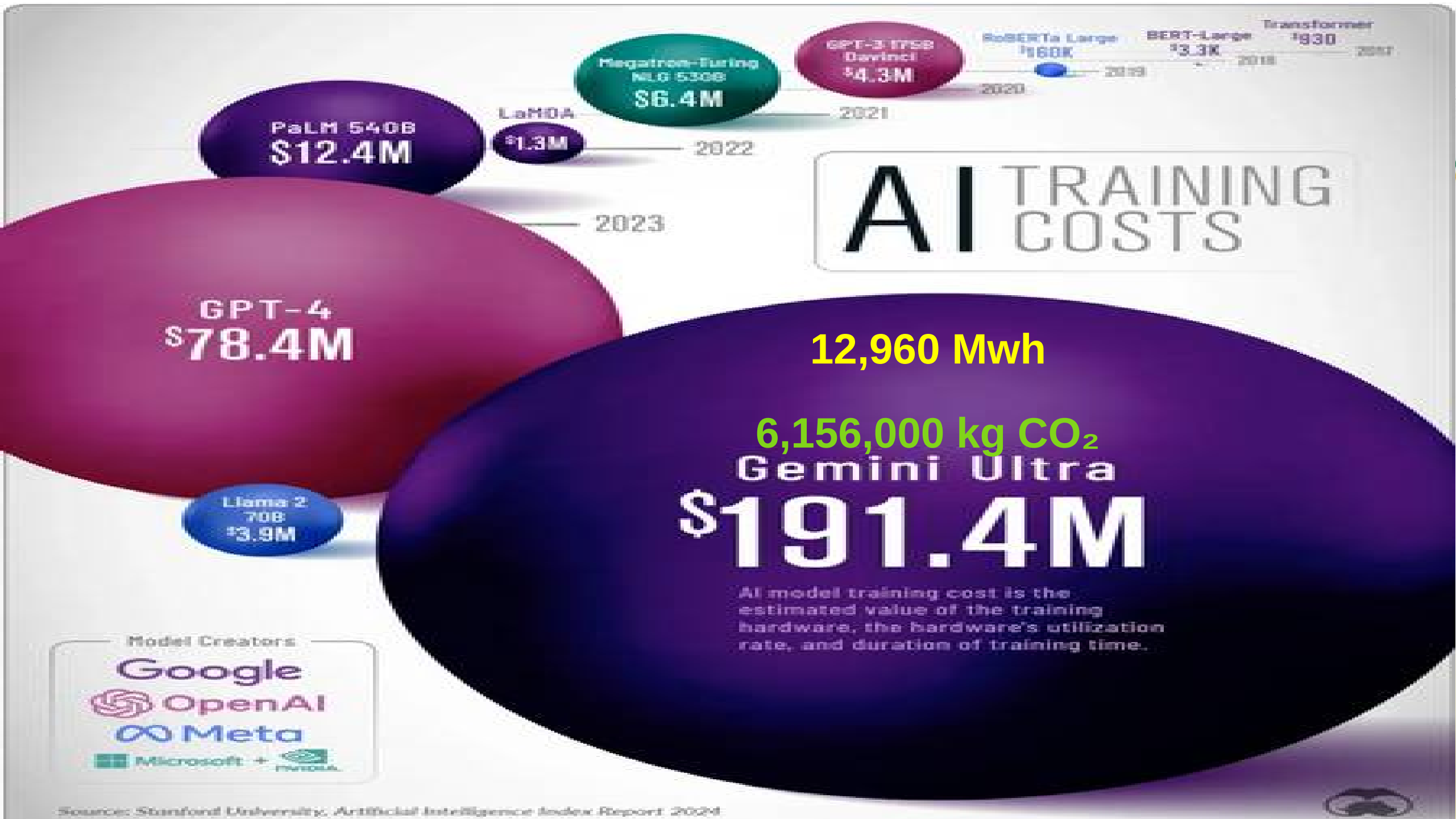
Accelerating AI: From 22 Years to 4 Days

- Google presents a model for Multilingual translation quality with **600 Billion** parameters. The training takes **22 Years on 1TPU**.
- While distributing the training over **2048 TPUs, achived results in 4 days**.

- **Data-Level Parallelism**
- **Model Level Parallelism**
- **Stream Processing**

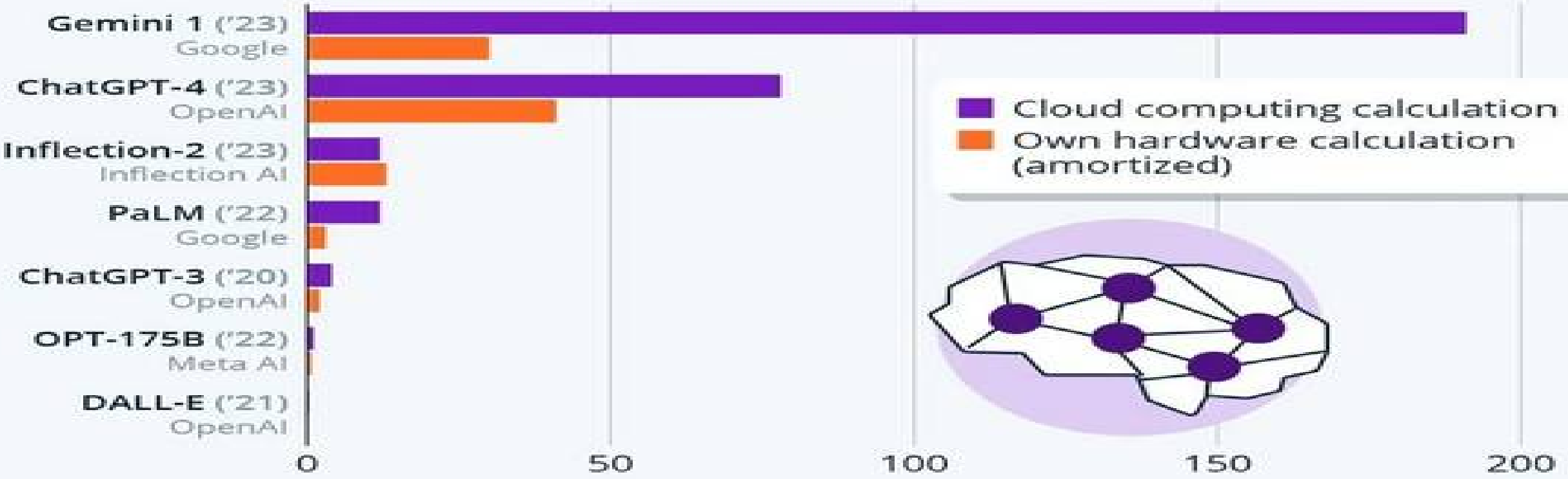


OpenAI GPT-3 paper.


Transformer
$930
2017
BERT-Large
$3.3K
2018
RoBERTa Large
$160K
2019
GPT-3 175B Davinci
$4.3M
2020
Megatron-Turing NLG 530B
$6.4M
2021
LaMDA
$1.3M
2022
PaLM 540B
$12.4M
2023
AI TRAINING COSTS
GPT-4
$78.4M
Llama 2 70B
$3.9M
12,960 Mwh
6,156,000 kg CO_2
Gemini Ultra
$191.4M
AI model training cost is the estimated value of the training hardware, the hardware's utilization rate, and duration of training time.
Model Creators
Google
OpenAI
Meta
Microsoft + NVIDIA
Source: Stanford University, Artificial Intelligence Index Report 2024

The Extreme Cost Of Training AI Models

Estimated cost of training selected AI models (in million U.S. dollars), by different calculation models

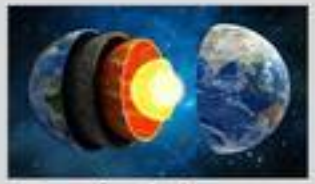


Rounded numbers. Excludes staff salaries that can make up 29-49% of final cost (including equity)

Source: Epoch AI

Ecosystem of AI Ventures

Life Science



Earth Science

Social Science

Science

Data

175 ZByte @2025

80%
Data-Sciences

AI

100 ExaFLOPS
@2020

87.04 B$

234.6 B$ @2025

Computing

Top500 List
8 PetaFLOPS
@2022

uProcessor
100 B$ @2020

30% Cell Phone
20% Embedded
App
50 Servers, PCs etc.

Digital Industrial Age
5.5 Trillion $ Revenue@2021

Agenda

- Entrepreneurship & the Academia–Industry Gap
- Technology Transfer: From Lab to Market
- AI-Specific Technology Transfer
- AI Ventures: Opportunities & Challenges
- Supercomputing: Enabler of AI Innovation
- **Namal Centre for AI & Big Data and Supercomputing Facility**

Namal Centre for AI and BigData:

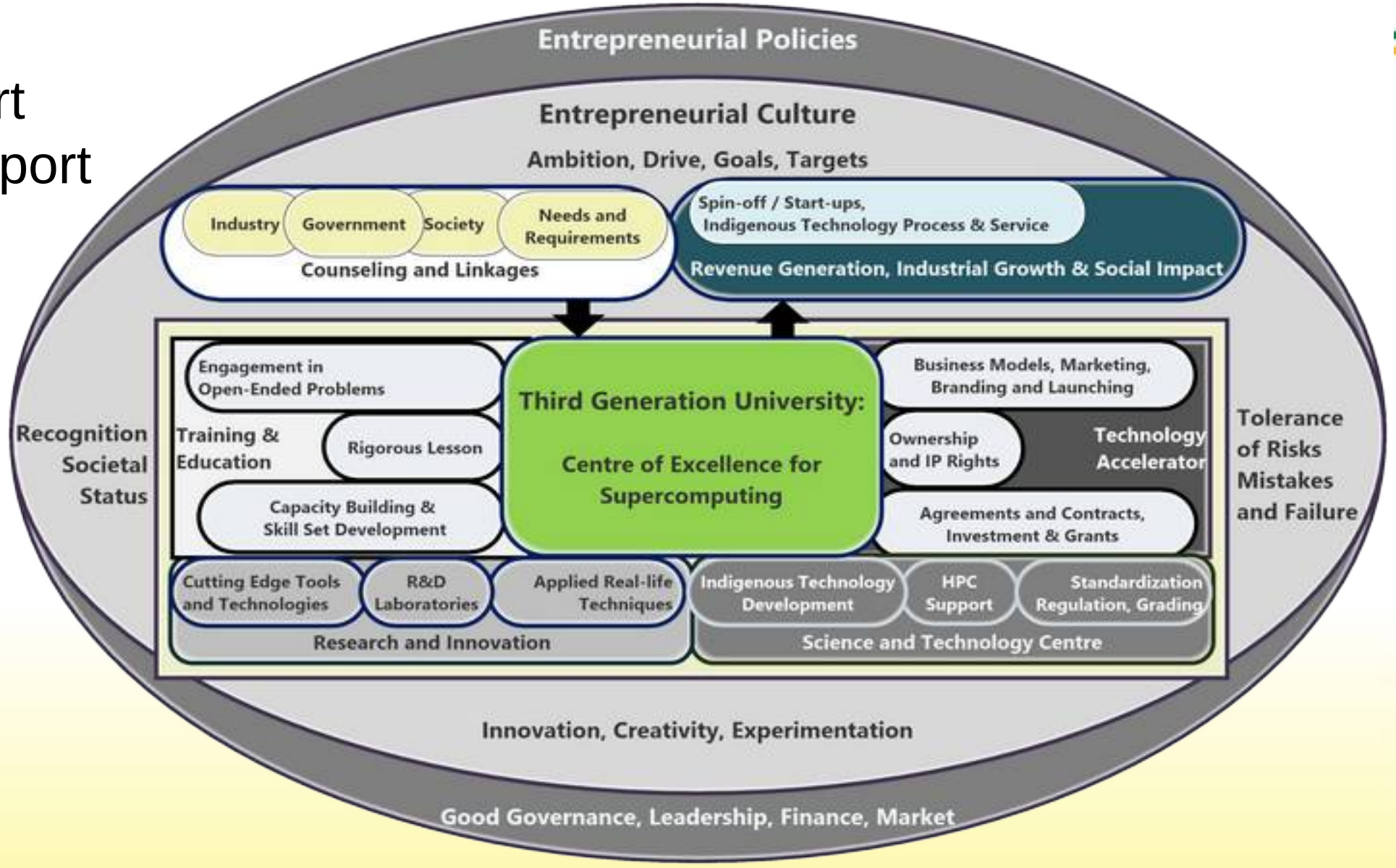
To become a center of **academic excellence** for **national uplift** and **development**

Vision: To produce **indigenous** smart **technologies** and empower **talent** for **local impact** and **sustainable national growth.**

Mission: To develop indigenous smart digital solutions for multidisciplinary local problems and to produce trainers, innovators, technologists, and entrepreneurs.

Namal's Role in AI Tech Transfer

- Advisory Support
- Technology Support



Advisory Support

- IP Project guidelines at the time of POC
- Standardized, scalable architecture (APIs, security, programmability, adaptability)
- Technology Readiness Assessment tools
- Linkages with Industrial Partners & Tech Transfer Offices

Technological Support

- **Data & Infrastructure**
  - Data Management & Storage
  - Data Streaming & Ingestion
  - Architecture Design
  - Software Architecture
- **Development Support**
  - Software Development Tools & Guidance
  - Parallel Programming Support
  - Real-time Computing Support
- **Deployment Environments**
  - Edge Computing
  - Cloud Deployment
  - Bare-Metal Execution Support

Science and Technology Center

- **Supercomputing Centre of Excellence (Pakistan's Leading)**
  - 1.1 Peta FLOPS Supercompitng Facility (20 Nodes)

Institute	Peak Performance	Power Consumption	Technologies Used	Manufacturer
Namal, PakSupercomputer	1.1 PFLOPS	25 KW	Intel Xeon, GPU acceleration, Fast Eathernet	Custom-build
NUST, Islamabad [27]	650 TFLOPS	N/A	Intel Xeon, NVIDIA GPUs, Infiniband	HPE
UCERD, Islamabad	113 TFLOPS	N/A	AMD EPYC, NVIDIA GPUs, Fast Ethernet	Dell
PAK-IAST Haripure [28]	91 TFLOPS	N/A	Intel Xeon, NVIDIA GPUs, InfiniBand	Lenovo
KUST, Kohat	0.416 TFLOPS	N/A	Intel Xeon, basic networking	Custom-built
COMSATS, Islamabad	0.158 TFLOPS	N/A	Intel Cores, NVIDIA GPUs, standard network	HP
CIIT, Islamabad	0.05 TFLOPS	N/A	Intel processors	Custom-built
UoM, Malakand	NA	N/A	Intel processors	Custom-built
GIK Institute [29]	N/A	N/A	N/A	N/A
KRL	N/A	N/A	N/A	N/A
UET Lahore	N/A	N/A	N/A	N/A
NED Karachi	N/A	N/A	N/A	N/A

International IET Conference on Energy, Power, Environment, Control and Computing (ICEPECC 2025)
Journal Supercomputing Frontiers and Innovations (Submitted)

Visit us: ssh username@hpc.pakistansupercomputing.com

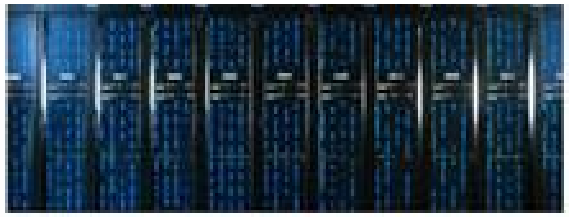
Pakistan's Number One High Performance Computing Facility:

The hardware architecture includes: 20 Nodes, 1600 Processor Core, 5 Tera Byte Main Memory, 40 TeraByte SSD, 10 Gigabit Fast Ethernet, Low Latency Switch, 40 4070TI GPU for Distributed Acceleration. The Supercomputer is build on Rocky Linux 9.4 and features an advanced software stack including RoCE-enabled networking, Lustre parallel file system, Slurm workload manager, distributed AI and parallel programming models, with Grafana and Prometheus for real-time monitoring, and Ansible for automated deployment and management.

HPC and AI Bridging Entrepreneurial Innovation

Knowledge & Idea Generation Research Foundation

- Industrially Co-Supervised Final Year Projects
- Graduate Research for Local Challenges
- Faculty Innovation Fellowships



- Indigenous HPC Infrastructure
- Open Source AI Toolchains
- TRL-based Technology Grading
- Standards Compliance & Certification
- Industrial Benchmarking & Risk Analysis

Productization and Socioeconomic Deployment

- Startups and Spin-Offs
- Public-Sector & SME Adoption
- Technology Transfer Agreements
- Jobs and Local Enterprise Creation

Academic Innovation Valley

Technology Maturation Valley

Impact and Deployment Valley

TRL1	TRL2	TRL3	TRL4	TRL5	TRL6	TRL7	TRL8	TRL9
Problem Farming Smart Soltuions Ideatization	Data Digitization, Acquisition, & Early Analysis	AI Solution Proof of Concept	Model Validation Integrated in Lab Settings	Field-Ready System Standardization Benchmarking	Minimum Viable Product (MVP)	CVP: Pilot Deployment in Operational Settings	System with Compliance and Scaling Support	Scaled Deployment and Monetization

Supercomputing as a Service

- **Dedicated HPC Access**
- **Software Application and Technology Development Support**
  - Parallel Distributed and Scalable Technology
- **Cloud Hosting**
- **Startup Mentorship**
  - Standardization, Licensing, Regulation, Commercialization

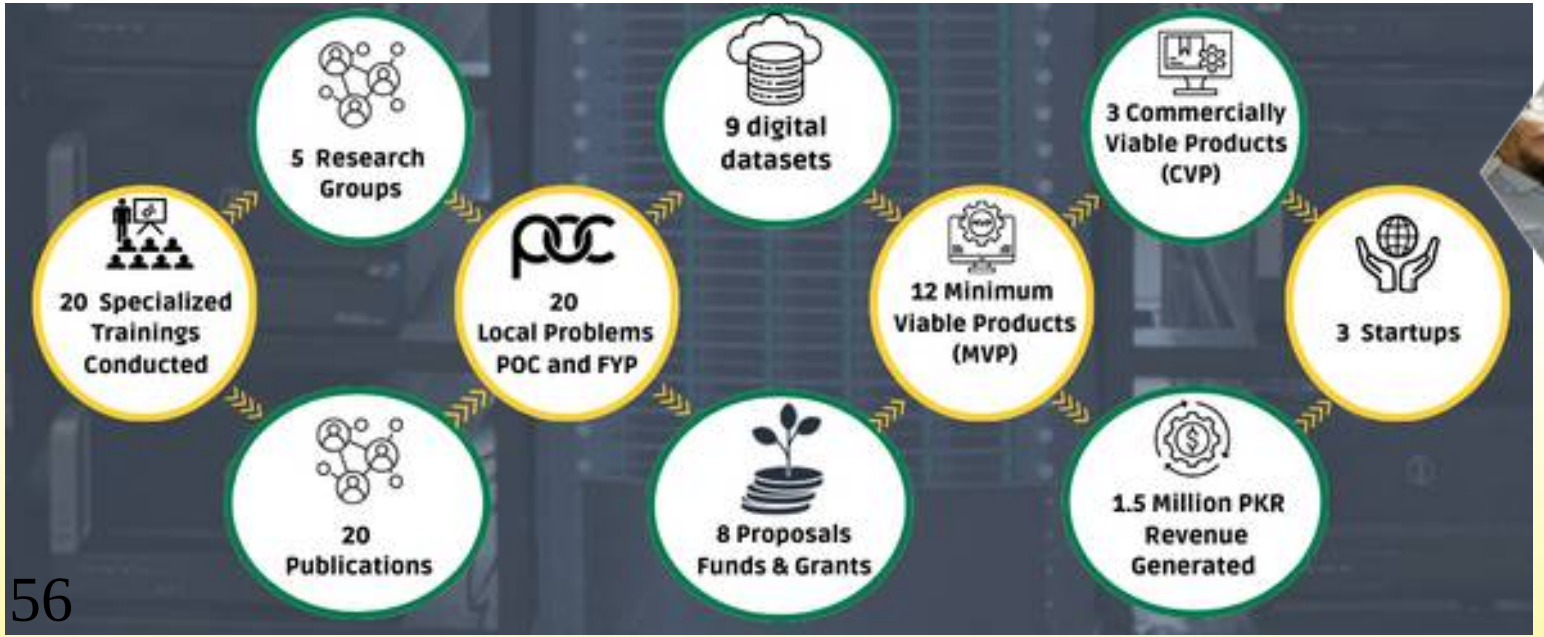
Feature (CPU)	AWS EC2 t3.medium	Namal HPC Single Node
CPU	2 vCPU	4 Cores
System RAM	4 GB	4 GB
Storage (SSD)	Min. 8 GB (separate cost)	30 GB
Network	Up to 5 Gbps	10 Gbps
Cost Per Hour	**$ 0.045 (Rs. 13) / hour**	**Rs. 7 / hour**

Feature (GP-GPU)	AWS EC2 g5.xlarge	Namal HPC Single Node
CPU	4 vCPU	10 Cores
System RAM	16 GB	16 GB
Storage (SSD)	250 GB	250 GB
GPU	NVIDIA A10G	NVIDIA 4070 Ti
GPU VRAM	24 GB	12 GB
Network	Up to 10Gbps	10 Gbps
Cost Per Hour	**$ 1.21 (Rs. 340) / hour**	**150 / hour**
Feature (Cluster)	**AWS Eq. (20 x g5.8xlarge)**	**Namal HPC (Full Cluster)**
Total Compute Nodes	20	20
CPU	640 (32 x 20)	1600 (80 x 20)
System RAM	2560 GB (128Gb x 20)	2560 GB (128GB x 20)
Storage (SSD)	18 TB	40 GB
GPU	20 x NVIDIA A10G	20 x NVIDIA RTX 4070 Ti
GPU VRAM	480 GB	240 GB
Network	Up to 10Gbps	40 Gbps
Cost Per Hour	**$ 50 (Rs. 14,000) / hour**	**Rs. 5000/ hour**

Science and Technology Center

Ready to provide end-to-end design, development, and support services for software applications and technology platforms across:

- **Data centers**
- **Chip clusters**
- **Cloud computing**
- **High Performance Computing**



Demos: Supercomputing System

- Applications
  - Cricket Analyzer
  - CV Analyzer
  - **Rice Analyzer**
  - **Sugarcane Analyzer**
  - Soil Analyzer
  - Bacterial Colony Identifier
- Technologies
  - PakSupercomputer
  - PakASIC
  - Rice Sorting Machine
  - Foot Weight Distribution System
  - VR AR for Rehabilitation
  - RISCV Processor
  - BLDC Motor Controller

SOIL ANALYZER

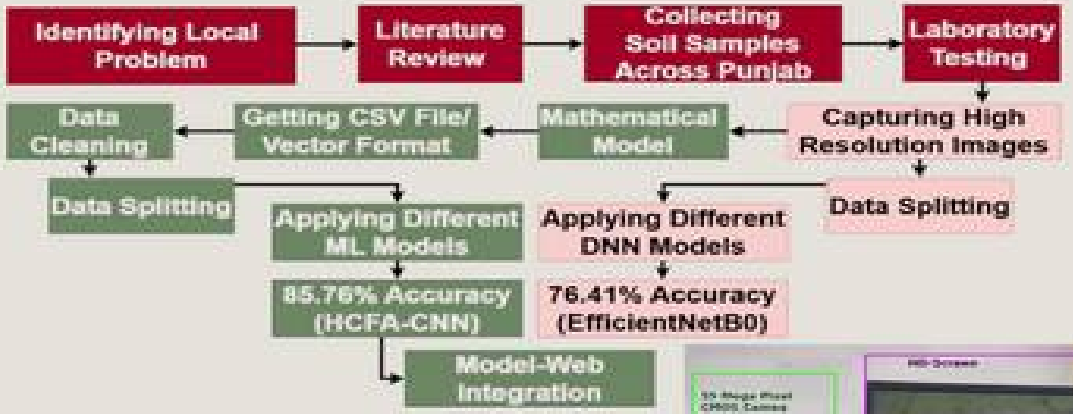
A Smart Visual Features based Soil Classification System

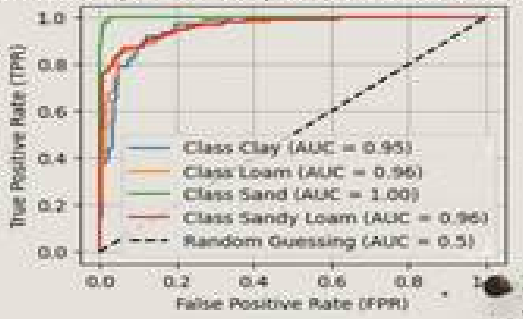
IMPORTANCE

Accurate and timely soil analysis is vital for sustainable agriculture in Pakistan. Traditional lab methods are costly and slow, limiting large-scale assessments. Soil Analyzer leverages mathematical model, machine learning and computer vision for fast, cost-effective soil classification.

SALIENT FEATURES

- Uses visual-micro-features based mathematical model, machine learning and computer vision for rapid soil classification.
- Employs Hand-Crafted Feature Augmented Convolutional Neural Network (HCFA-CNN) to analyze soil morphology, structure, texture and color.
- Achieves 85.76% classification accuracy, reducing dependency on expensive lab tests.
- Provides a cost-effective, scalable and efficient solution for soil assessment.
- Supports multi-user access and automated analysis, improving agricultural decision-making.





RICE ANALYZER

AI-Powered Rice Classification System

IMPORTANCE

The Rice Analyzer addresses critical challenges in Pakistan's rice export market by providing accurate classification of Basmati rice varieties. Its significance lies in preventing variety mixing, ensuring export quality standards, and strengthening Pakistan's position in the global rice market through an accessible cloud platform that achieves 95.13% accuracy in variety identification.

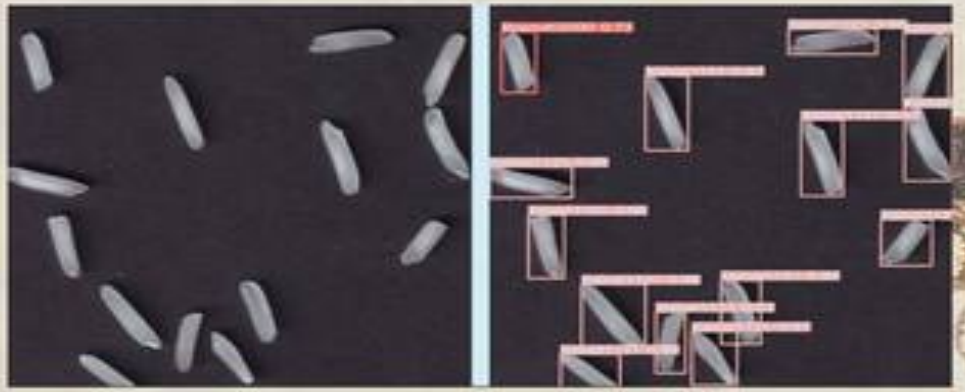
SALIENT FEATURES

Rice Analyzer uses a computer vision model that captures detailed characteristics of rice grains. The application analyzes four key aspects of each grain:

- Physical measurements (length, width, shape)
- Surface texture and structure
- Color properties (intensity, shade variations)
- Distinctive patterns unique to each variety

These features help differentiate between Basmati 2000, Sella 1509, Kainat 1121, and Sella Basmati 1121 varieties with exceptional precision.

VISUALS



COW ANALYZER

Visual Features Based Smart Breed Identification Application

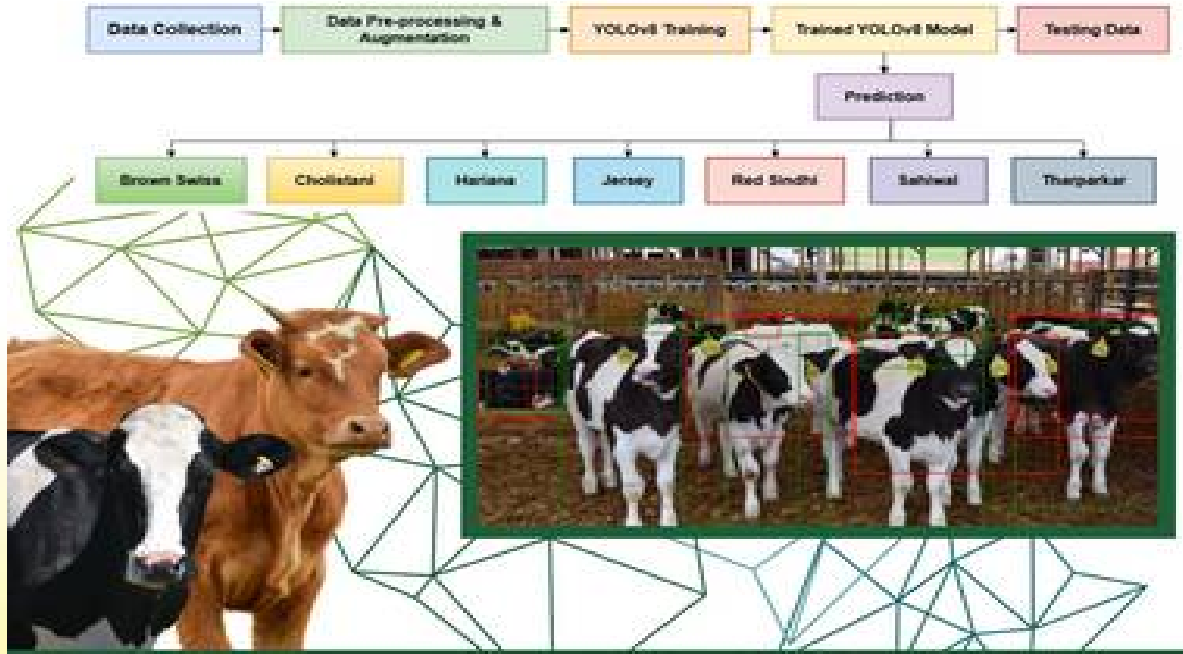
Importance

Pakistan's economy and food security heavily depend on livestock, contributing 60.1% to agricultural value addition and 11.5% to GDP [1]. A 1% increase in dairy output boosts agricultural GDP by 0.36%, highlighting the sector's critical role. To enhance livestock management, a fast, accurate, and AI-powered solution is needed to visually classify Pakistani cattle breeds. This will improve breed identification, optimize productivity, and support sustainable growth in the livestock industry.

Salient Features

- CowAnalyzer performs feature engineering on 10 Pakistani cow breeds.
- It utilizes a large vision model to identify phototypical features of each breed.
- The application is deployed on the PakSupercomputing cloud and is accessible via both mobile and web applications.
- It accurately classifies 10 cow breeds with an accuracy of 79%.

Working Flow



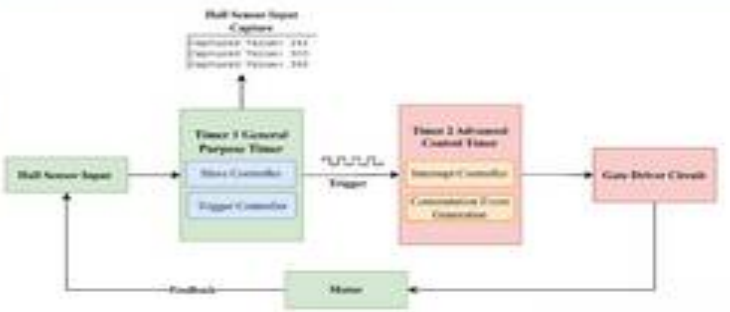
AN ENERGY EFFICIENT & LOW-COST RISC-V BASED BLDC MOTOR CONTROLLER

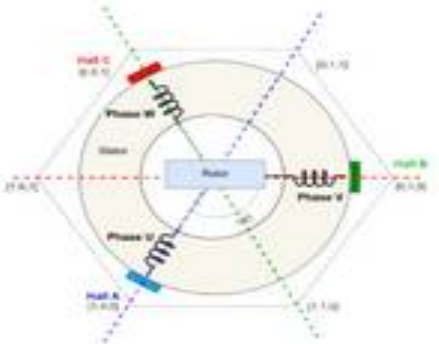
IMPORTANCE

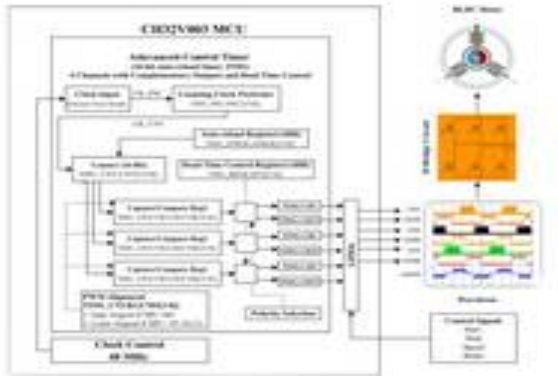
BLDC motors are widely used for their high efficiency reliability and lesser maintenance issues, but existing controllers struggle to provide balance in power consumption, control features and cost-effectiveness. This study develops an energy-efficient BLDC motor controller using a RISC-V processor with low-level control speed and position feedback, optimizing power usage while maintaining precise motor control.

SALIENT FEATURES

- Utilizes a low-cost 48MHz RISC-V processor for improved energy efficiency, affordability and advanced motor control.
- Optimized power consumption while maintaining precise speed and torque control.
- Implements low level programmed control algorithms for better performance.
- Evaluated based on power efficiency, speed control accuracy, and torque response.
- Outperforms existing programmed motor controllers, ensuring reliable and efficient motor operation.



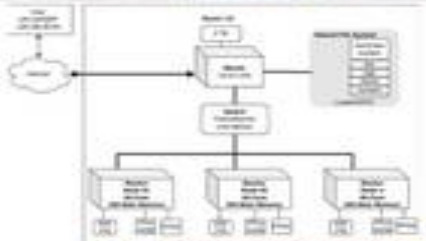


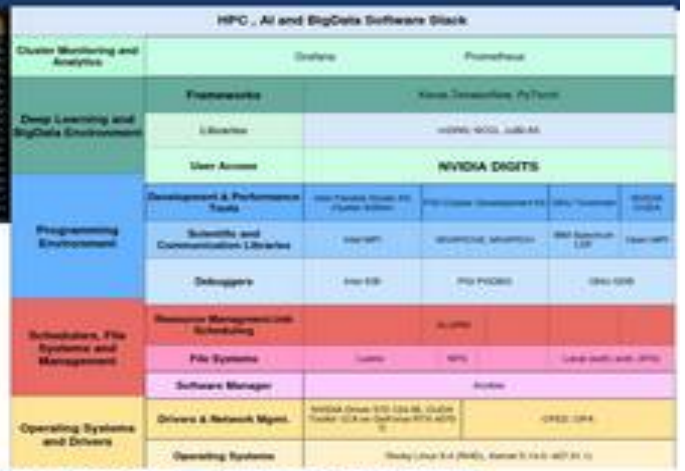


PAKSUPERCOMPUTER: SCALABLE HETEROGENEOUS SUPERCOMPUTING SYSTEM AND ELASTIC PROGRAM MODEL

Pakistan's Number One High Performance Computing Facility:
The hardware architecture includes: 20 Nodes, 1600 Processor Core, 5 Tera Byte Main Memory, 40 TeraByte SSD, 10 Gigabit Fast Ethernet, Low Latency Switch, 40 4070TI GPU for Distributed Acceleration.
The Supercomputer is build on Rocky Linux 9.4 and features an advanced software stack including RoCE-enabled networking, Lustre parallel file system, Slurm workload manager, distributed AI and parallel programming models, with Grafana and Prometheus for real-time monitoring, and Ansible for automated deployment and management.

- Offers hands-on training on HPC, parallel programming, and distributed AI models.
- Facilitates the development, testing, and deployment of large-scale parallel and distributed applications.
- Optimized for compute-intensive domains including AI, Big Data analytics, scientific simulations, and industrial automation.
- Built for scalable workloads using RoCE networking and Lustre parallel file system for high-throughput data access.
- Capable of running modern AI/ML frameworks with multi-GPU, multi-node support for large-scale model training.





Paksupercomputer HPC-as-a-Service (HPCaaS) — Resource Pricing Plans

We offer cutting-edge HPC technology as a service, including support for embedded computing, edge computing, cloud, and bare-metal high-performance systems. Our services also include software application development tailored to real-world industrial challenges, coupled with startup mentoring to drive innovation and commercialization.

Feature (CPU)	AWS EC2 (1 medium)	Nanal HPC Single
CPU	2 vCPU	4 Cores
System RAM	4 GB	4 GB
Storage (SSD)	Min. 8 GB (separate cost)	30 GB
Network	Up to 5 Gbps	10 Gbps
Cost Per Hour	$ 0.045 (Rs. 13) / hour	Rs. 7 / hour
Feature (GP-GPU)	AWS EC2 g5.xlarge	Nanal HPC Single
CPU	4 vCPU	10 Cores
System RAM	16 GB	16 GB
Storage (SSD)	250 GB	250 GB
GPU	NVIDIA A10G	NVIDIA 4070 T
GPU VRAM	24 GB	12 GB
Network	Up to 10Gbps	10 Gbps
Cost Per Hour	$ 1.21 (Rs. 340) / hour	150 / hour

Feature (Cluster)	AWS Eq. (20 x g5.8xlarge)	Nanal HPC (Full Clust
Total Compute Nodes	20	20
CPU	640 (32 x 20)	1600 (80 x 20)
System RAM	2560 GB (128GB x 20)	2560 GB (128GB x 20
Storage (SSD)	16 TB	40 GB
GPU	20 x NVIDIA A10G	20 x NVIDIA RTX 4070
GPU VRAM	480 GB	240 GB
Network	Up to 10Gbps	40 Gbps
Cost Per Hour	$ 30 (Rs. 14,000) / hour	Rs. 5000/ hour

DISTRIBUTED AI CLUSTER

Scalable, Intelligent & Decentralized.
Distributed AI enables scalable, efficient processing of large data and complex tasks by leveraging multiple computing units. It enhances fault tolerance, real-time decision-making, and collaborative intelligence.

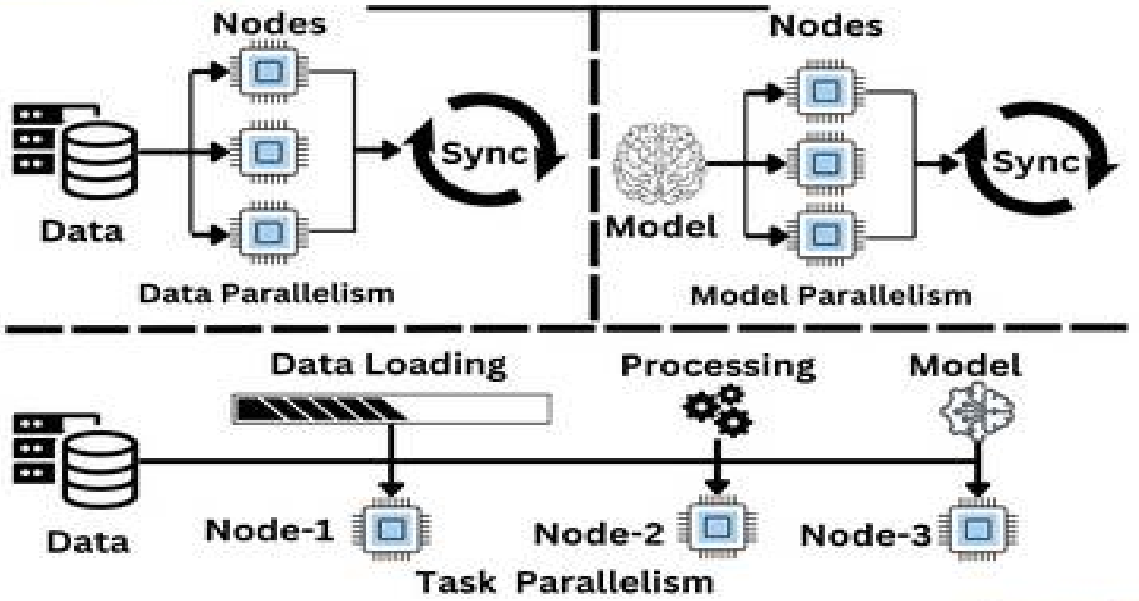
Importance

Global data generation surpassed 120 zettabytes in 2023, with projections doubling by 2025, demanding AI-driven solutions for real-time processing.
With AI workloads exceeding 1 exaFLOP daily, the ever-increasing need for Distributed-AI is crucial to managing complex computations and unlocking actionable insights.

Salient Features

- Multi-node cluster with NVIDIA 4070 Ti GPUs, each delivering 40 TFLOPs FP32, 7680 CUDA cores, and 12GB GDDR6X memory.
- NVLink-enabled high-bandwidth communication for seamless multi-node processing.
- Supports large-scale computer vision models and LLMs with optimized memory and computational resource handling.
- Enables multi-level distributed computing with full support for PyTorch and TensorFlow.

Flow Diagram



HPC CHIP DESIGN CLUSTER

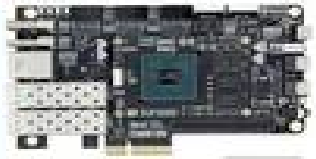
A Free, Open-Source Software Stack Cluster for Digital System Design

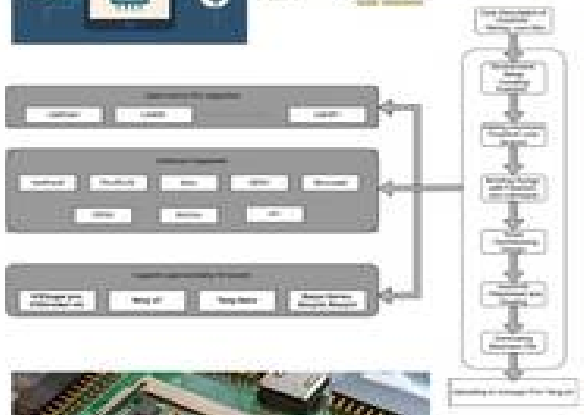
Importance

HPC Chip Design Cluster provides free, open-source software stack-basedfor digital system design, programming and verification. It enables chip design, verification, simulation, and programming using high-performance computing (HPC) and cloud platforms with global accessibility. Provides cost-effective solution for innovation in processor architectures, embedded systems, digital system design, verification and prototyping.

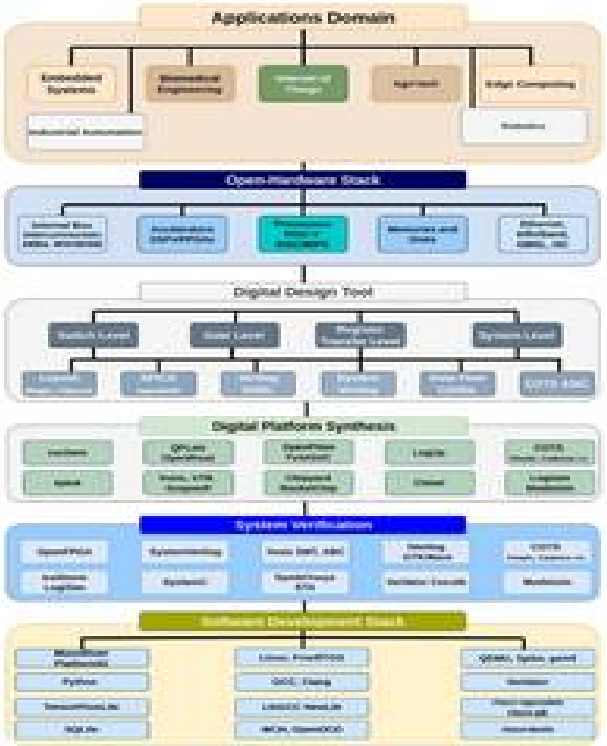
Salient Features

- Free, open-source software stack for **embedded system programming, digital system design, computer architecture, FPGA and VLSI chip design, verification, and simulation.**
- Supports RISC-V, FPGA frameworks, and cloud-based platforms for efficient development.
- Uses HPC clusters to support multi-user collaboration and resource optimization.
- Structured workflow includes modeling, verification, synthesis, and FPGA deployment.
- Promotes scalable and cost-effective digital system development while reducing reliance on proprietary tools.





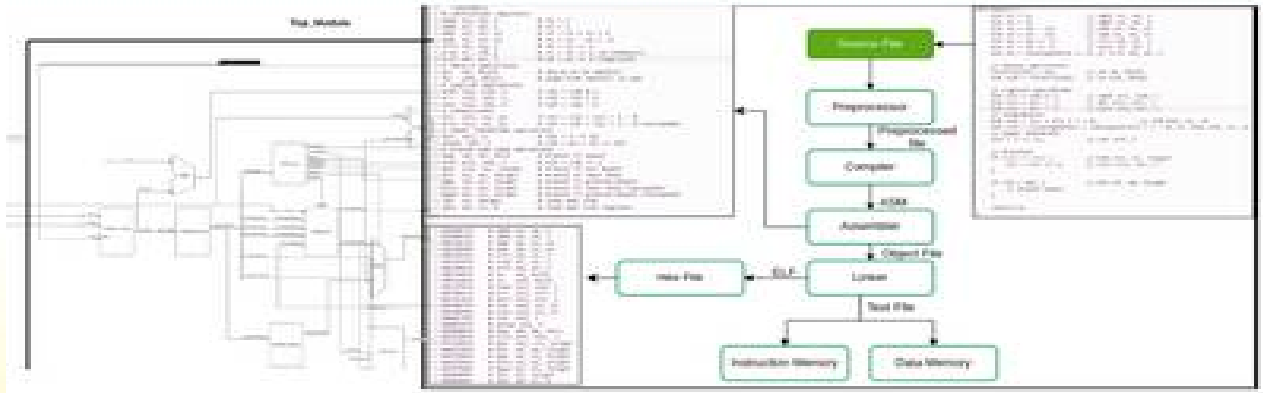
Chip Design Hardware visuals



FPGA BASED RISCV PROCESSOR AND GCC PROGRAMMING TOOLCHAIN

Developed an FPGA-based System-on-Chip (SoC) platform named Namal SoC Architecture, featuring a low-power, low-cost RISC-V-based baseline processor core. This architecture is optimized for resource-constrained embedded applications, offering a practical and scalable solution for real-world industrial use cases.
The Namal SoC integrates a custom RISC-V32I processor core, surrounded by a configurable interconnect bus, on-chip memory, and peripheral control logic, making it highly suitable for application-specific customization. The system is fully programmable using the standard GCC toolchain, allowing seamless integration with existing embedded software workflows. It supports portability across a wide range of FPGAs, from entry-level to mid-tier platforms, which helps in reducing both development cost and time-to-market.

- **Processor Core: Lightweight RISC-V32I ISA compliant core with modular enhancements for performance and power optimization.**
- **Bus Architecture: Processor Local Bus (PLB) and high-speed interconnects for DMA, serial IO, and memory-mapped peripherals.**
- **Memory: On-chip SRAM with future support for external DRAM interfaces.**
- **FPGA Portability: Compatible with various Open FPGA families including Tang, iCE40, Xilinx, Intel.**
- **Toolchain Support: GCC and RISC-V ecosystem compatible; standard linker scripts and startup code provided.**
- **Debug and Monitoring: JTAG-based debug support, performance counters, and testbench simulation environment.**



Feature	Status	Explanation
Integer Operations	✓ Supported	Fully supported in GCC.
Floating-Point (FPU)	✖ Not Supported	Software Supported
Atomic Operations	✖ Not Supported	Not Fully Supported
Threading	⚠ Limited	Not Fully Supported

CV ANALYZER

An Intelligent Application for Automated Resume Analysis and Ranking Using Multi-Model Semantic Processing

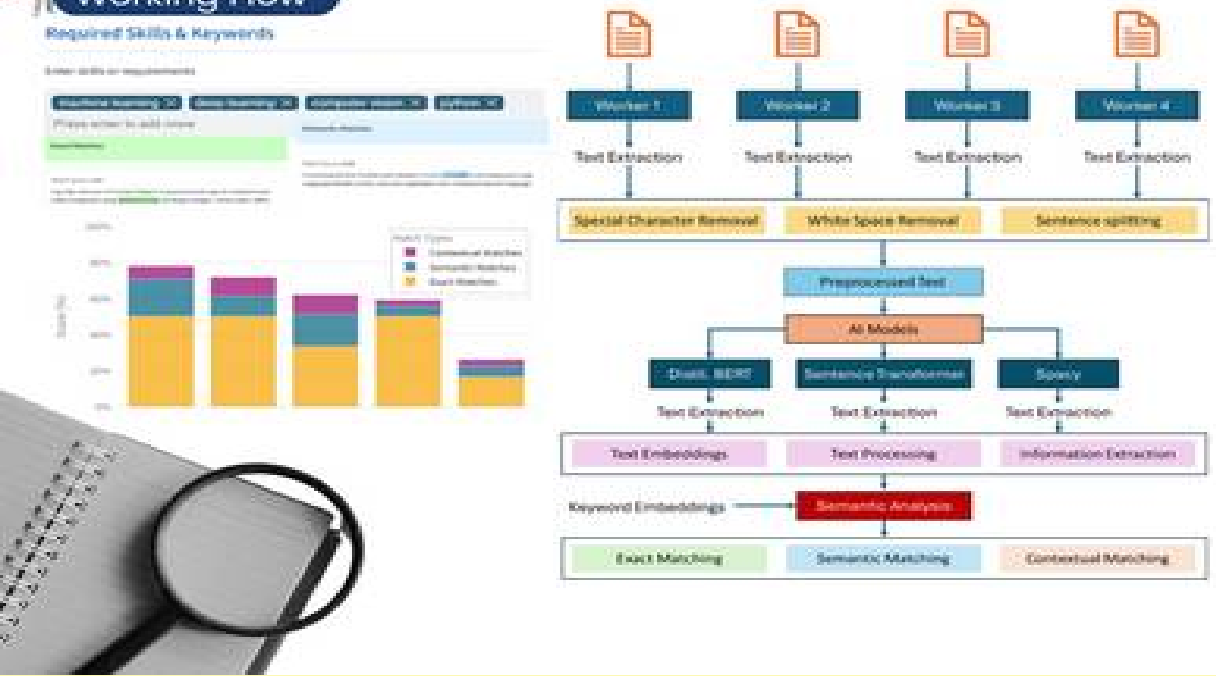
Importance

CV Analyzer revolutionizes the recruitment process by automating resume screening and evaluation. Its significance lies in reducing hiring time by up to 70% while ensuring qualified candidates aren't overlooked, enabling HR professionals to focus on more strategic aspects of recruitment rather than manual screening.

Salient Features

- Utilizes advanced language processing with AI models like DistilBERT, Sentence Transformer, and Spacy.
- Implements a three-tier matching system (exact, semantic, and contextual) for accurate resume analysis.
- Features text preprocessing and extraction for efficient data processing.
- Provides a user-friendly dashboard with visual analytics for easy result interpretation.
- Enhances resume screening efficiency with AI-driven automation.

Working Flow



CRICKET ANALYZER

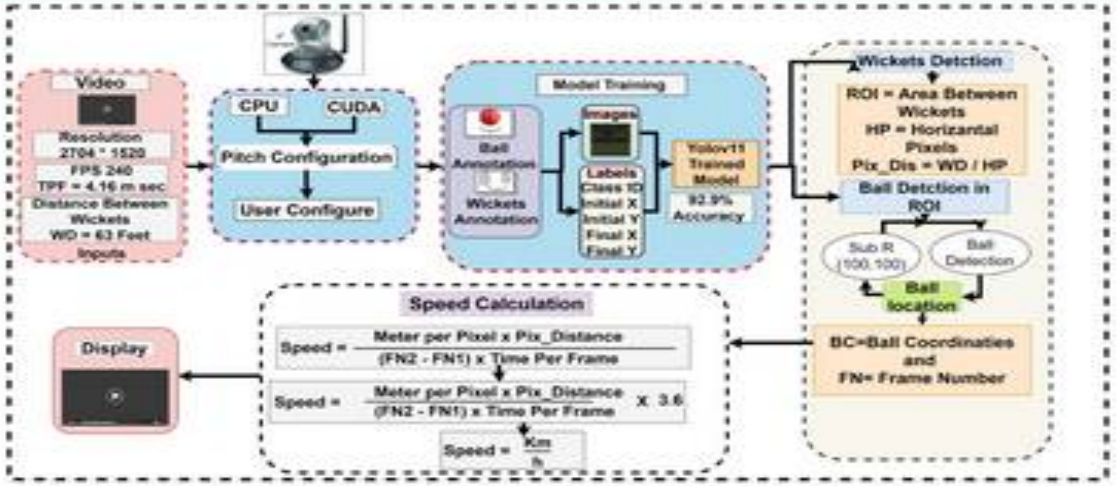
A Smart Camera-Based System for Accurate Ball Speed Detection in Cricket

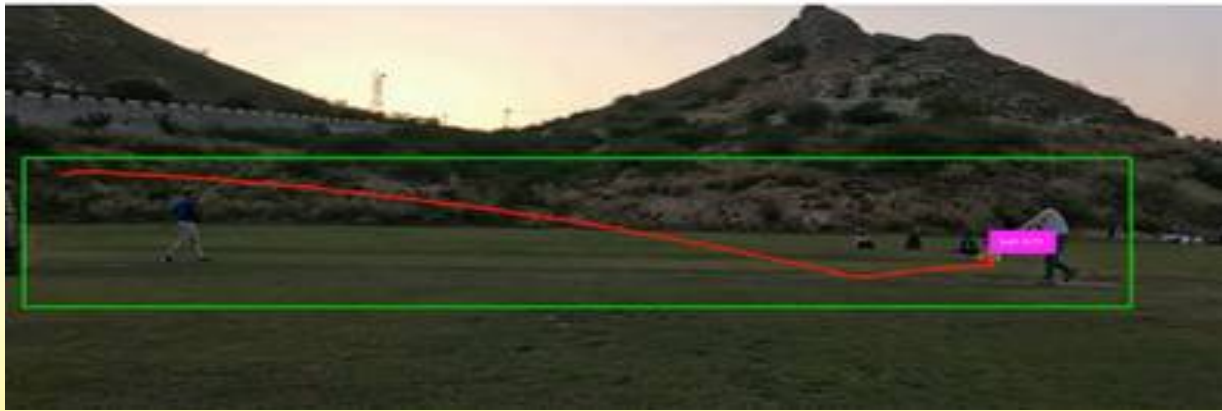
Importance:

Cricket Analyzer provides an AI-powered, real-time solution for accurate ball speed detection, replacing costly radar-based systems with a more affordable and flexible. By leveraging YOLOv11 and high-resolution video input, it ensures precise ball tracking and analysis, making it a valuable tool for professional and amateur cricket. Its integration with a supercomputing-cluster enhances processing speed, enabling scalable and efficient sports analytics.

Salient Features:

- Uses a camera-based system instead of Expensive radar for speed detection.
- Employs Yolov11 for real-time ball detection and speed calculation.
- Runs on Pak supercomputing cluster, ensuring high performance.
- Provides a cost-effective and scalable solution for sports analytics.
- Enhances flexibility and accuracy in cricket ball speed measurement.





FootAnalytics

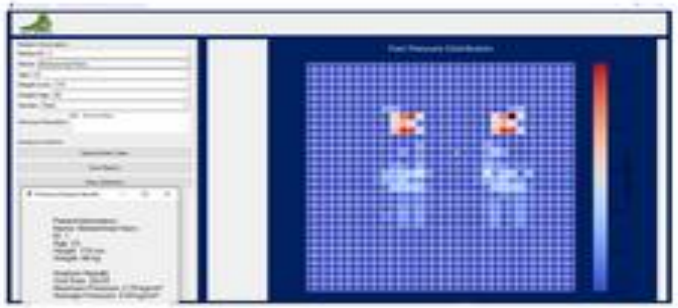
An Intelligent Digital System For Foot-Weight Distribution Analysis

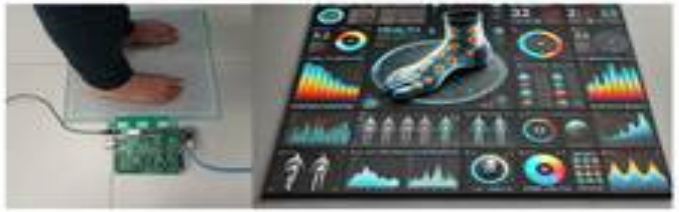
Importance:

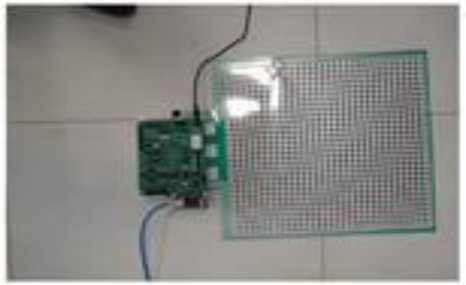
Maintaining proper foot weight distribution is essential for health, posture, and recovery. Uneven weight distribution can cause pain, walking problems, and injuries. This research presents a smart system that uses sensors to measure pressure across the foot. The collected data is analyzed to detect health issues like osteoporosis and prosthetic misalignment. The system aims to improve diagnostics and preventive care effectively.

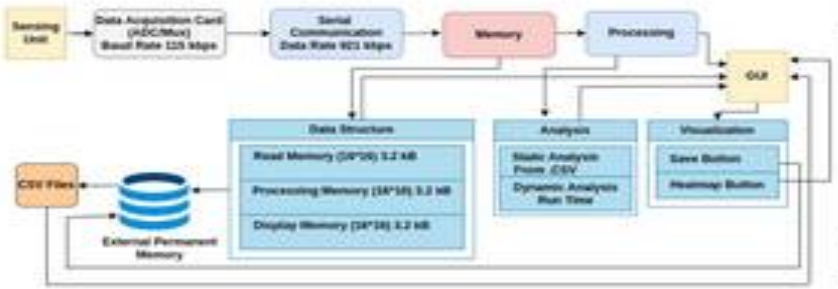
Salient Features:

- Utilizes FSR sensors in a matrix to capture foot pressure data.
- Converts pressure readings into digital signals via a data acquisition module.
- Processes data using statistical and machine learning techniques for analysis.
- Displays results on a user-friendly interface for easy interpretation.
- Assists in identifying health issues and supporting rehabilitation.









AI-POWERED HUMAN-COMPUTER INTERFACE FOR PSYCHOPHYSIOLOGICAL MONITORING AND REHABILITATION

Real-Time Psychophysiological Analysis System.

Introduction

This project develops an AI-driven system for real-time psychophysiological symptom analysis using multi-sensor data. It integrates inputs from ECG, EEG, EMG, respiratory sensors, audio/video, and a thermal camera for comprehensive monitoring. Advanced signal processing and feature extraction enable accurate detection of stress and related symptoms. Machine learning models classify emotional and physiological states with high precision. The scalable system supports early diagnosis and personalized health management.

Salient Feature

- Combines ECG, EEG, EMG, respiratory sensors, thermal camera, and video/audio to analyze physiological and psychological states.
- Utilizes thermal imaging to detect emotional and stress-related changes through facial temperature variations.
- Employs advanced machine learning models to accurately classify and detect psychophysiological symptoms in real-time.
- Provides continuous, non-invasive monitoring with immediate insights into emotional and physical well-being.
- Designed to detect a wide range of psychophysiological conditions, adaptable to various health and wellness applications.

VIRTUAL REALITY BASED TELE-REHABILITATION SYSTEM

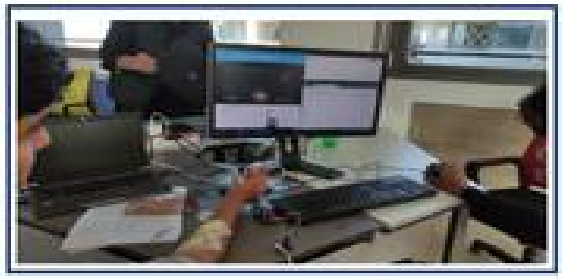
Importance:

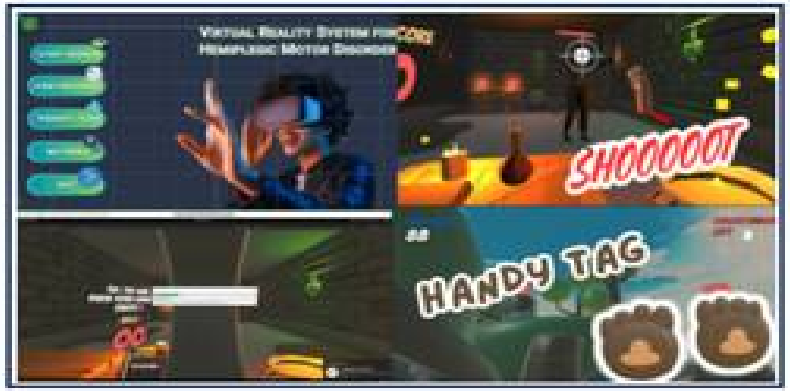
Hemiplegia, a neurological condition caused by stroke, severely impacts motor function. This study explores the potential of Virtual Reality (VR) technology to improve rehabilitation outcomes for patients. The patients participated in rehabilitation sessions using the developed VR tele-rehabilitation.

Salient Features:

- Integrates biofeedback sensors for real-time performance monitoring.
- Utilizes VR-based exercises to improve patient engagement and recovery.
- Gives improvement in upper limb motor function for hemiplegic patients.
- Provides an innovative and interactive approach for tele-rehabilitation therapy.
- Advances the effectiveness of traditional rehabilitation methods.

Visuals





Use of Rehabilitation System

FACE RECOGNITION APPLICATION

Robust Face Recognition System for Identity Verification

Importance

Face recognition is a powerful technology used for identity verification and secure access control. It enables real-time, contactless authentication, making processes such as attendance tracking faster and more efficient. With growing use in surveillance, smart devices, and automated attendance systems, it plays a vital role in modern AI applications.

Salient Features

- Accurate Face Recognition using FaceNet for deep feature-based identity verification.
- Real-Time Attendance System that logs entries automatically through facial recognition.
- Edge and Cloud Deployment support for flexible, scalable implementation.
- Multi-Face Detection and recognition in live video streams for group scenarios.