ARTIFICIAL INTELLIGENCE & MACHINE LEARNING WORK BENCH

ARTIFICIAL INTELLIGENCE & MACHINE LEARNING LAB

ABOUT THE LABORATORY

From predictive analytics to natural language processing, from computer vision to autonomous systems, the potential applications of AI and ML are boundless. However, harnessing this potential necessitates not only theoretical understanding but also practical experimentation and application.

Hence, we Propose this Laboratory that will give Students and Industrial Infrastructure to nurture their Skill sets that are highly relevant to the current and future job market.

AI is best learned through hands-on experience and experimentation. A well-equipped AI lab provides students with access to cutting-edge hardware and software tools, allowing them to gain practical experience in developing and implementing AI algorithms and systems.
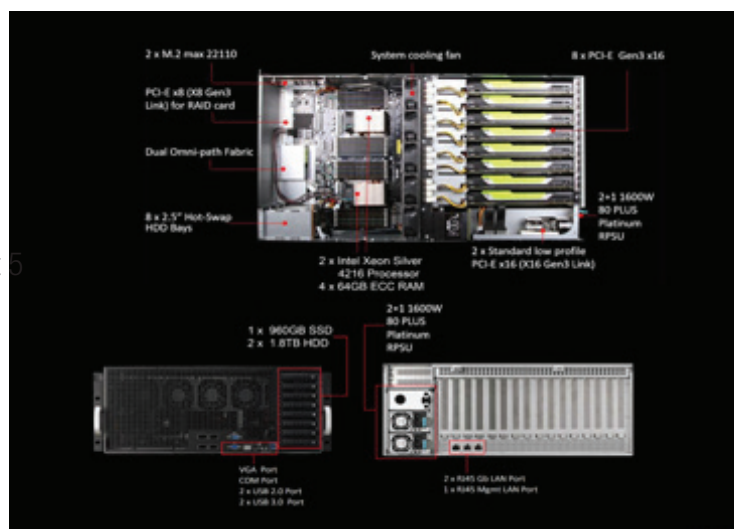
Opportunities in Research: The Proposed Laboratory Facility will enable faculty and students to conduct research in various subfields of AI, such as machine learning, natural language processing, computer vision, and robotics.

Sl. No.	Item	Qty

1	Artificial Intelligence and Machine Learning Laboratory Set-up with AI-DL-ML Software Libraries / Tools and OS
	   - High Performance Computing Server with Required OS installed, Software
	     Libraries and Tools
		01

2	Artificial Intelligence on Embedded System Platform for Edge Computing
	   - High end Embedded System with required Software to deploy AI
	   - Different Types of Cameras like Thermal Camera , Night Vision Camera, IP
	     Camera (Wireless), 3D Stereo camera for various applications
		01

3	Artificial Intelligence on VLSI Platform for Edge Computing
	   - High end FPGA Development Board with required Software &
	     Accessories to deploy AI
		01

4	Industrial Implementation of Artificial Intelligence in Video Analytics
	   - High End Workstation
	   - Core Vision Platform Software
	   - Various Software Engines like Face Recognition, Advanced Intrusion Detection,
	     People Counting
	   - Router
	   - IP Cameras and NVR
		01

5	Artificial Intelligence in Robotics (Robotic Operating System)
	   - Robotic Arm
	   - Autonomous Robotic Car
	   - Software and Accessories
		01

6	Instructor Training Module	01

HPC MACHINE SPECIFICATION

- Server Chassis supporting GPU
- CPU: 2 x Intel® Xeon® Silver 4216 Processor
- GPU: 2 x NVIDIA® RTX A5000
- RAM: 256GB DDR4 ECC
- STORAGE:
- 1.92 TB SATA SSD for Operating System
- 2 x Enterprise Class 2 TB SATA SSD with Raid support
- Gigabit Ethernet card
- Redundant Power supply
- Monitor
- USB Mouse, USB Keyboard

SOFTWARE LIBRARIES

- **Included OS :** Ubuntu Operating System
- **Software Libraries :**
  Essentials Utilities: CUDA, cuDNN, TensorRT
- **Machine Learning :**
  vowpal wabbit, XGBoost,
  Numpy, Scikit, Pandas, other relevant Python libraries
- **Deep Learning :**
  NVidia DIGITS,
  Tensor Flow,
  Caffe, Caffe2,
  PyTorch, Theano
- **Dataset :**
  Image Net, CIFAR-10, KITTI Pre-Loaded for development

ARTIFICIAL INTELLIGENCE ON EMBEDDED PLATFORM

Embedded Module :
Inference Application Hardware
- 8-core Arm® Cortex®-A78AE v8.2
- 1024 Ampere GPU @ 918 with 64 Tensor Cores
- Dual Deep Learning Accelerator
- (DLA) engines
- Vision Accelerator
- 16 GB LPDDR5
- MIPI CSI-2 lanes
- UART, SPI, I2C, I2S, CAN, GPIOs

Research Areas:
- Machine Vision
- Robotics
- Deep Learning Model Inference
- Machine Learning
- Medical Imaging
- Gaming
- Virtual Reality
- NLP \And Many More

OpenCV
Image Processing

OpenGL
Image Rendering

NVIDIA CUDA
Parallel Computing

NVIDIA VISIONWORKS™
Hardware Accelerated Graphics

Vulkan.
Hardware Accelerated Image Rendering

CAMERA SETUP

Camera Setup:
Camera setup to enhance & implement AI skills for image/vision field.
- Thermal Camera
- 3D-Stereo Camera
- Night Vision Camera
- IP Wireless Camera
- USB Camera

ARTIFICIAL INTELLIGENCE ON VLSI PLATFORM

FPGA Module :

Inference Application Hardware

- Device: Zynq™ UltraScale+™ MPSoC with Thermal cooling solution Active (Fan + Heatsink
- System logic cells: 256K
- Block RAM blocks :144, UltraRAM blocks: 64
- Ethernet interface: One 10/100/1000 Mb/s
- Image sensor processor: OnSemi AP1302 ISP, IAS MIPI sensor interfaces: x2

- Raspberry Pi camera interface x1
- Pmod 12-pin interface x1
- USB3.0/2.0 interface x4
- 13MP Auto Focus RGB Camera Module
- MicroSD card and MicroSD to SD Adapter

INDUSTRIAL IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN VIDEO ANALYTICS

Core Vision Platform Software License-

Includes video search dashboard, real-time alert dashboard, heat map dashboard, smart hash tag, camera health mgmt., outdoor/indoor map, live view, VMS/NVR playback, LDAP,
privacy protection, cluster/federation, false detection report, detail extraction, smartphone AP

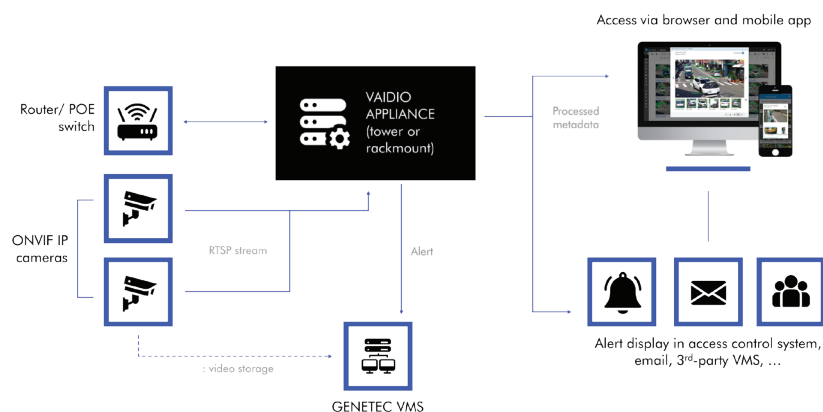**SOFTWARE ENGINES**

Advanced Intrusion Detection Engine

Intrusion Detection (ID) software license per channel- Includes multiple ROIs, "with/without objects" filter

Face Recognition Engine

Face Recognition & Face Search (FRS) software license per channel- Includes Facemask/Emotion detection and a max database of 10,000 FR entries (in all FR lists per server)

People Counting Engine

People Counting and Occupany

ROBOTIC SETUP

This hardware setup includes Robotic Arm and Car which can used to implement AI skills using Embedded GPU Kit & Robotic Operating System (ROS) by building applications.

INSTRUCTOR TRAINING MODULE

ADMIN TRAINING:
- Login to AI-DL Machine as Administrator
- Managing User accounts
    - User Creation/Delete
    - Hardware parameter visualization
    - Managing Hardware resources
- Training on Docker/container
    - Checking available Docker Images
    - Adding/managing various Libraries/
    - Software versions in specific docker Images
- Backup/Restore Docker Images
- Backup/Restore user DATA to/from user space to/from server database
- Script based management for ease of operation

USER TRAINING:
- Login to AI-DL Machine as Administrator
- Training on Docker/container
    - Checking available Docker Images
    - How to User Docker Images
    - Check available libraries/ software
    - Running simple example using Digits
    - Running simple example using Jupyter-notebook
    - How to run your own example on AI-DL Machine
- Data Management
    - Transferring DATA to/from AI-DL computing Machine to/from user node machine
    - Manage storage space

ARTIFICIAL INTELLIGENCE &
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LAB TUTORIALS

Artificial Intelligence
- A * Search Algorithm
- Optimization Algorithm - Hill Climb
- Optimization Algorithm - Simulated Annealing
- Optimization Algorithm - Genetic Algorithm
- Implementation of Fuzzy Logic

Machine Learning
- Simple Linear Regression
- Multiple Linear Regression
- Polynomial Regression
- Support Vector Regression
- Decision Tree Regression
- Random Forest Regression
- Logistic Regression
- K-Nearest Neighbors
- Support Vector Machine
- Kernel SVM
- Naïve Bayes
- Decision Tree Classification
- Random Forest Classification
- K-Means Clustering
- Hierarchical Clustering
- Association Rules- Apriori
- Association Rules- Eclat
- Reinforcement Learning- Upper Confidence Bound (UCB)
- Reinforcement Learning- Thompson Sampling
- Natural Language Processing (NLP)
- Dimensionality Reduction- Principal Component Analysis (PCA)
- Dimensionality Reduction- Linear Discriminant Analysis
- Dimensionality Reduction- Kernel PCA
- Model Selection- XG Boost

Deep Learning
- Neural Network - Artificial Neural Network (ANN)
- Neural Network - Convolutional Neural Network (CNN)
- Neural Network - Recurrent Neural Network (RNN)
- Natural Language Processing (NLP) - Part of Speech, Lemmatization and Stemming
- Natural Language Processing (NLP) - Sentiment Analysis

LAB TUTORIALS

- ⚙ Computer Vision - Face Detection & Body Detection
- ⚙ Computer Vision - Face Recognition
- ⚙ Generative AI - Image Generation with Stable Diffusion
- ⚙ Transfer Learning - Feature Extraction
- ⚙ Transfer Learning - Fine Tuning

Hardware Based Experiments

- ⚙ Real-Time Object Detection on Live Camera using YOLOv8n model.
- ⚙ Real-Time Face Detection on Live Camera using the Mediapipe library.
- ⚙ Real-Time Eye Detection on Live Camera using the Mediapipe library.
- ⚙ Real-Time Hand Tracking on Live Camera using the Mediapipe library.
- ⚙ Real-Time Object Tracking based on Colour on Live Camera with the HSV scheme.
- ⚙ Real-Time Multiple Object Tracking based on Colour on Live Camera with the HSV scheme.
- ⚙ Real-Time Object Contours detection based on Colour on Live Camera with the HSV scheme.
- ⚙ Real-Time Face Recognition on Live Camera using the Face Recognition library.
- ⚙ Real-Time Pose Detection on Live Camera using the Mediapipe library.
- ⚙ Real-Time Hand Detection on Live Camera using the Mediapipe library.
- ⚙ Distinguishing between the Right and Left Hands on Live Camera using the Mediapipe library.
- ⚙ Real-Time Gesture Detection on Live Camera using the Mediapipe library.
- ⚙ Storing the Trained Gestures in a pickle file to be uploaded directly on Live Camera using the Mediapipe library.
- ⚙ Real-Time Object Detection based on User prompt on Live Camera.
- ⚙ Implementation of Text Generation with Llama model using LLMs.
- ⚙ Implementation of Text + Vision with Llava model using CLIP vision encoder.
- ⚙ Implementation of Video Analytics on VLSI Platform
- ⚙ Robotics : Simulated ROS Projects provided with certain common experiments that contains node programming and compilation steps which includes publish, service, client and subscribe nodes.