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Artificial Intelligence & Big Data Application to D&D

Dr. Himanshu Upadhyay
Applied Research Center
Florida International University



Projects



- Cyber Threat Automation and Monitoring (CTAM) - Monitoring Mission threats using Advanced Cyber Analytics with Machine Learning, Deep Learning and Big Data on Artificial Intelligence Platform (Funding Agency – TRMC/DOD)
- Structural Health Monitoring of Nuclear Facility with Integrated Big Data Framework and Deep Learning (Funding Agency – DOE-EM)
- Condition Based Preventive Maintenance of Nuclear Flow Loop with Big data Analytics (Funding Agency – NSF)



Projects



- Health Monitoring with IoT Wearable Devices using Machine Learning and Edge Computing (Funding Agency – NSF/ASSIST)
- Critical Technology and Intelligence Studies Workforce Development Program (Funding Agency – DOD/DIA)
- Artificial Intelligence & Big Data Track in Electrical & Computer Engineering



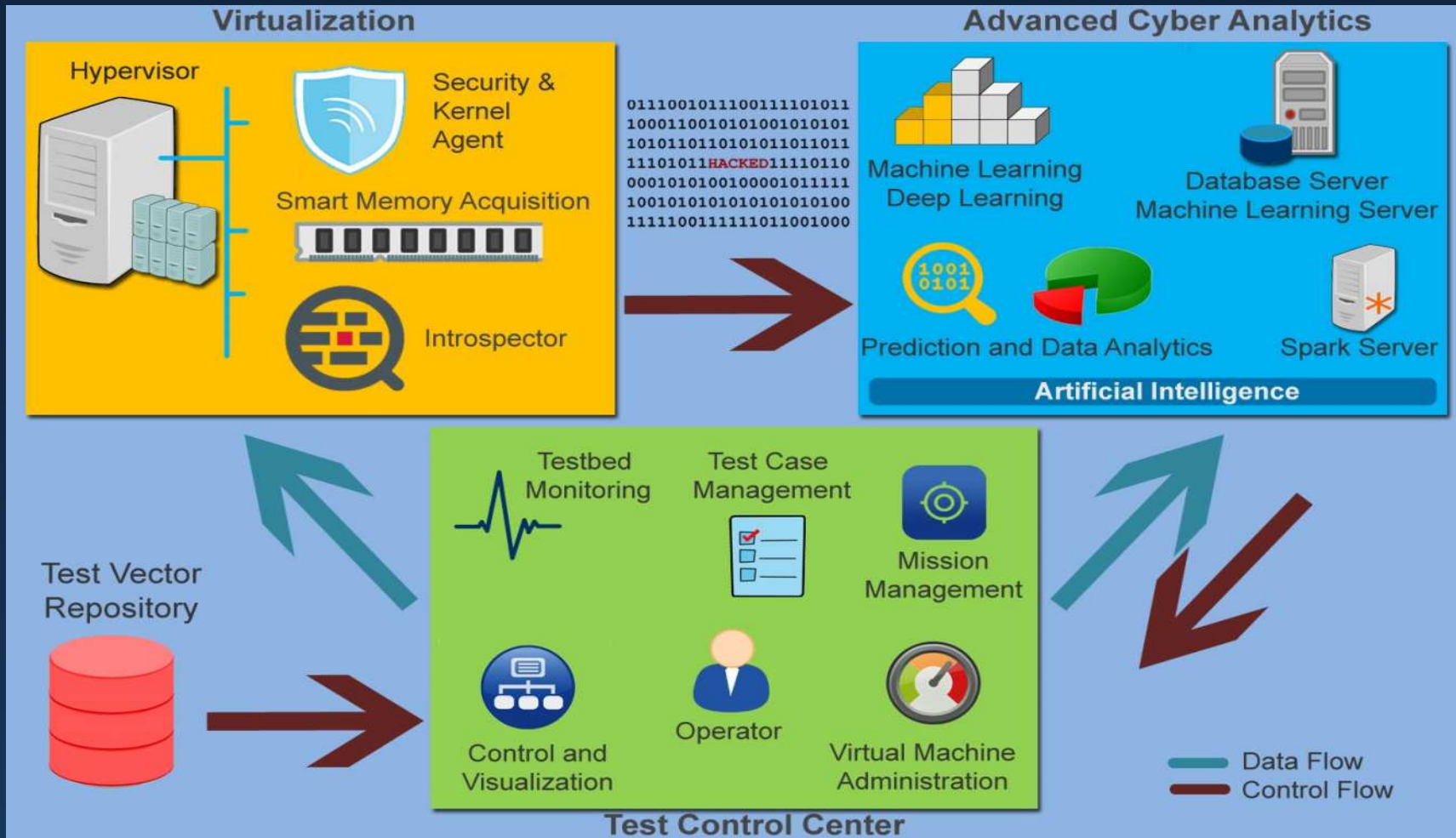
Cyber Threat Automation and Monitoring (CTAM) Overview



- CTAM is a Cyberspace Test Technology for T & E purposes to monitor and analyze behavior during cyber attacks and also the impact on the current mission
- CTAM is based on fine-grained introspection of kernel data structures, data collection and advanced cyber analytics using Artificial Intelligence (Machine Learning / Deep Learning and Big Data techniques)
- CTAM consists of three platforms:
 - Virtualization
 - Advanced Cyber Analytics
 - Test Control Center



CTAM System Diagram



Structural Health Monitoring of Nuclear Facility with Integrated Big Data Framework and Deep Learning



- This research focuses on the development and optimization of machine learning/deep learning algorithms to find anomalies in the data collected from various camera/LiDAR images received from the ARC's Outdoor Technology Testing & Demonstration Facility built for nuclear decommissioning research
- Image dataset is used to establish a baseline and the deep learning algorithms are applied to build models and perform prediction for Classification & Anomaly Detection

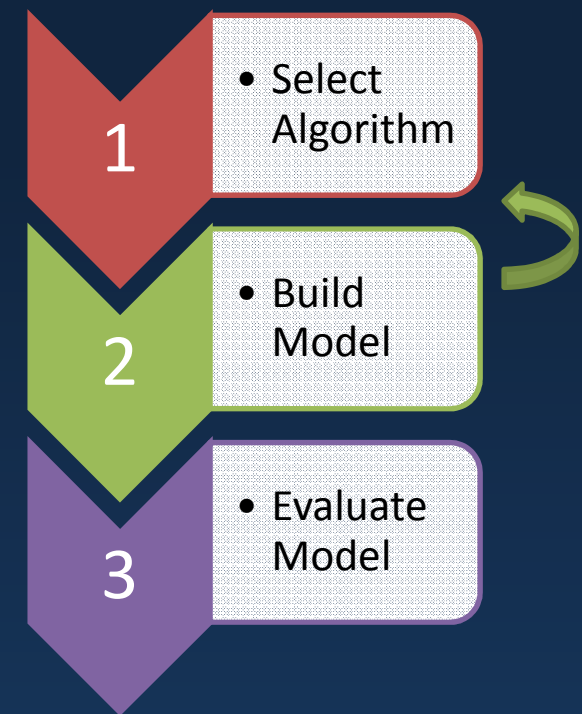
Structural Health Monitoring of Nuclear Facility with Integrated Big Data Framework and Deep Learning



Image classification, a topic of pattern recognition in computer vision, is an approach of classification based on contextual information in images.

Data Analysis is a three step process:

1. Select algorithm - Modeling starts with selecting an algorithm.
 - Image Classification
2. Build model – Construct model with the data.
 - Load the data
 - Create neural network layers
 - Train / Test model
 - Iterative process – Multiple epochs
3. Evaluate – Validate the model with new data samples.
 - Is data missing to capture complete model?

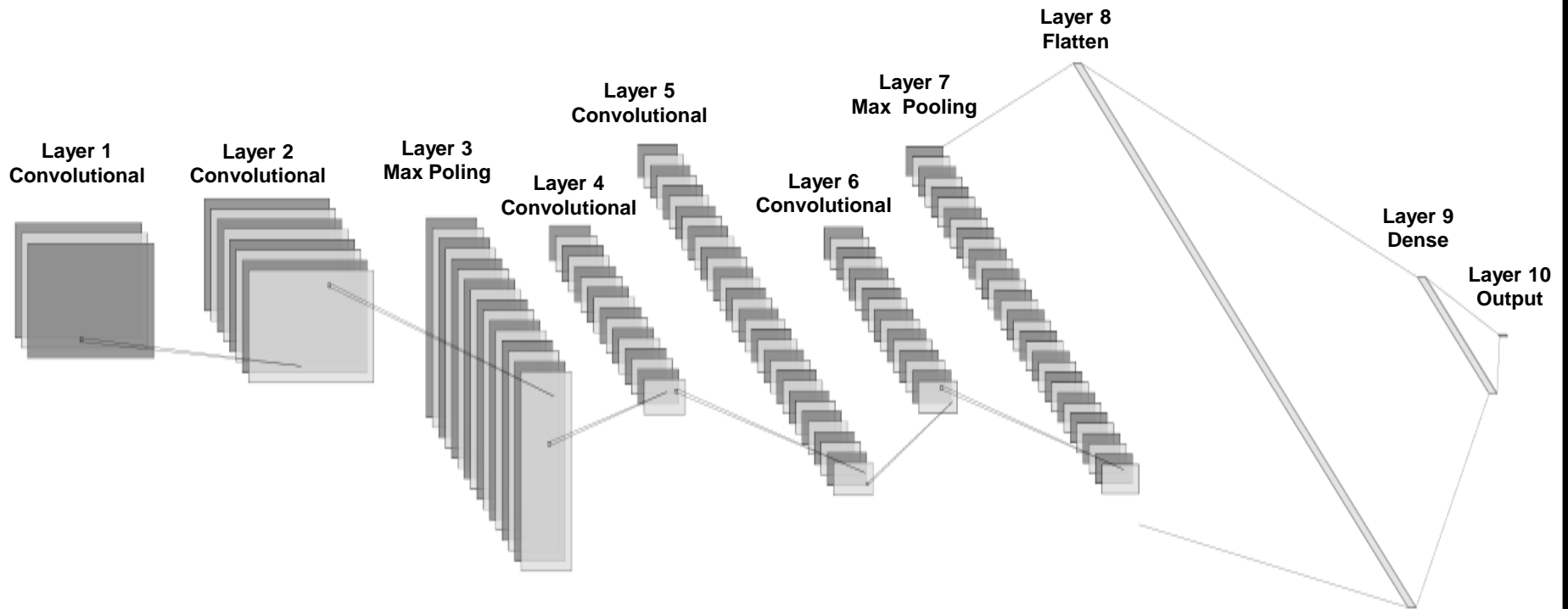


Baseline Model Development and Categorization



- The baseline was created from images collected from the outdoor test facility.
- A total of **16,000** images were collected.
 - **8,000** images were classified as “baseline” (all sections containing “CL” tag).
 - **8,000** images were classified as “deteriorated”.

Deep Convolutional Neural Network - Architecture



A total of 10 layers each with multiple hidden neurons was created to achieve a model accuracy of 96.87%

Deep Convolutional Neural Network Layers



1. Convolution Layer (Layer 1, 2, 4, 5, 6):
 - Convolution layers are the core building blocks of the Neural Network.
 - Most of the computation is performed at this layer.
2. Max Pooling Layer (Layer 3, 7):
 - Progressively reduce the spatial size to reduce the amount of features and computation in the network.
3. Dense Layer (Layer 9):
 - It's a linear operation in which every input is connected to every output by a weight.
 - This layer sees the entire spatial dimension of the previous layer.
4. Output Layer (Layer 10):
 - This is the final layer in the model and it is the one responsible for deciding the category/classification of an image.

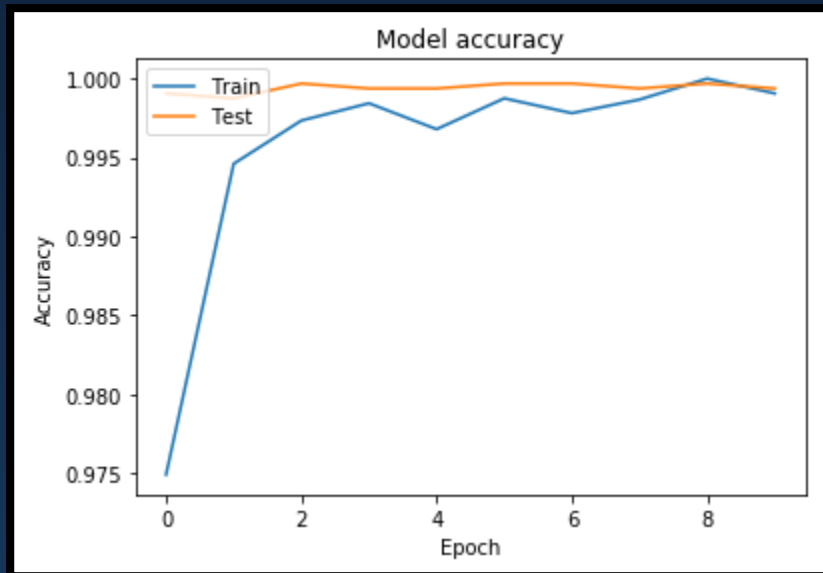


Classification Results

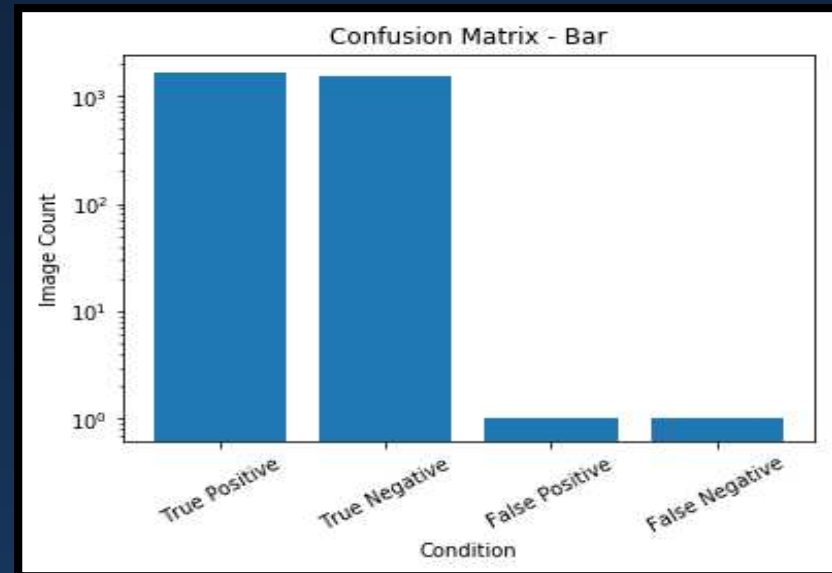
The model developed using then CNN algorithm was able to classify the images with 96.87% accuracy.

- Successfully identified images with the same characteristics (shape and color).
 - Model stabilizes after 10 epochs.

Model Accuracy



Confusion Matrix



Results - Classification of Wall Images



Sample Baseline Images



Input image feed to CNN model for Classification



Model Prediction = "Baseline"
94.35% probability



Model Prediction = "Degraded"
98.23% probability



Model Prediction = "Baseline"
87.63% probability



Model Prediction = "Degraded"
98.7% probability

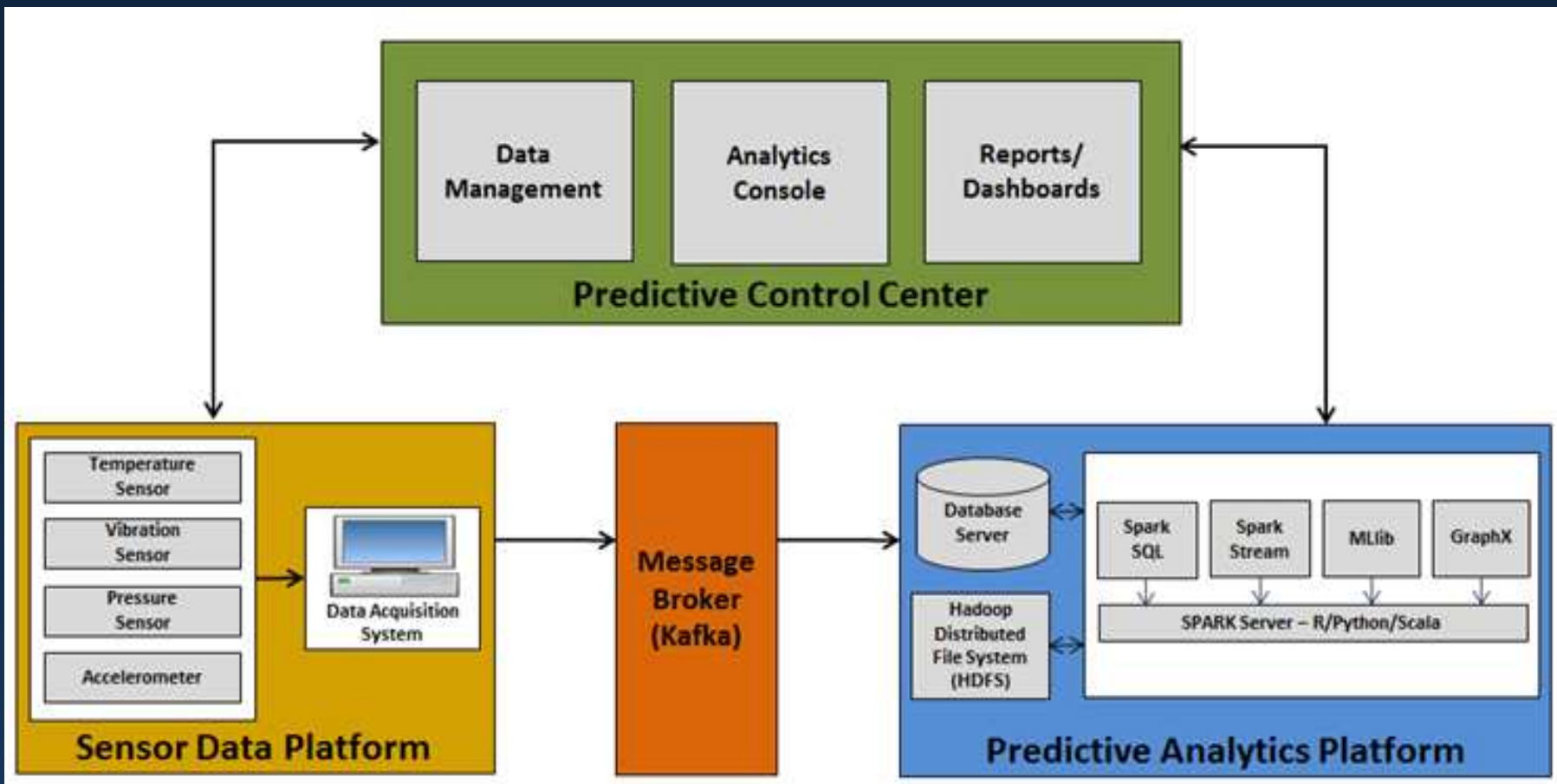
Condition Based Preventive Maintenance of Nuclear Flow Loop with Big Data Analytics



- This research focuses on the development of Predictive Analytics Platform for predictive maintenance of the nuclear power plant equipment.
- Analyzing the big data generated by various sensors installed on nuclear power plant equipment for predicting equipment failures based on condition rather than periodicity.
- Analyzing continuous stream of data generated by temperature, pressure, vibration sensors from nuclear flow loop in real-time using SPARK framework.



Condition Based Preventive Maintenance of Nuclear Flow Loop with Big Data Analytics - Architecture

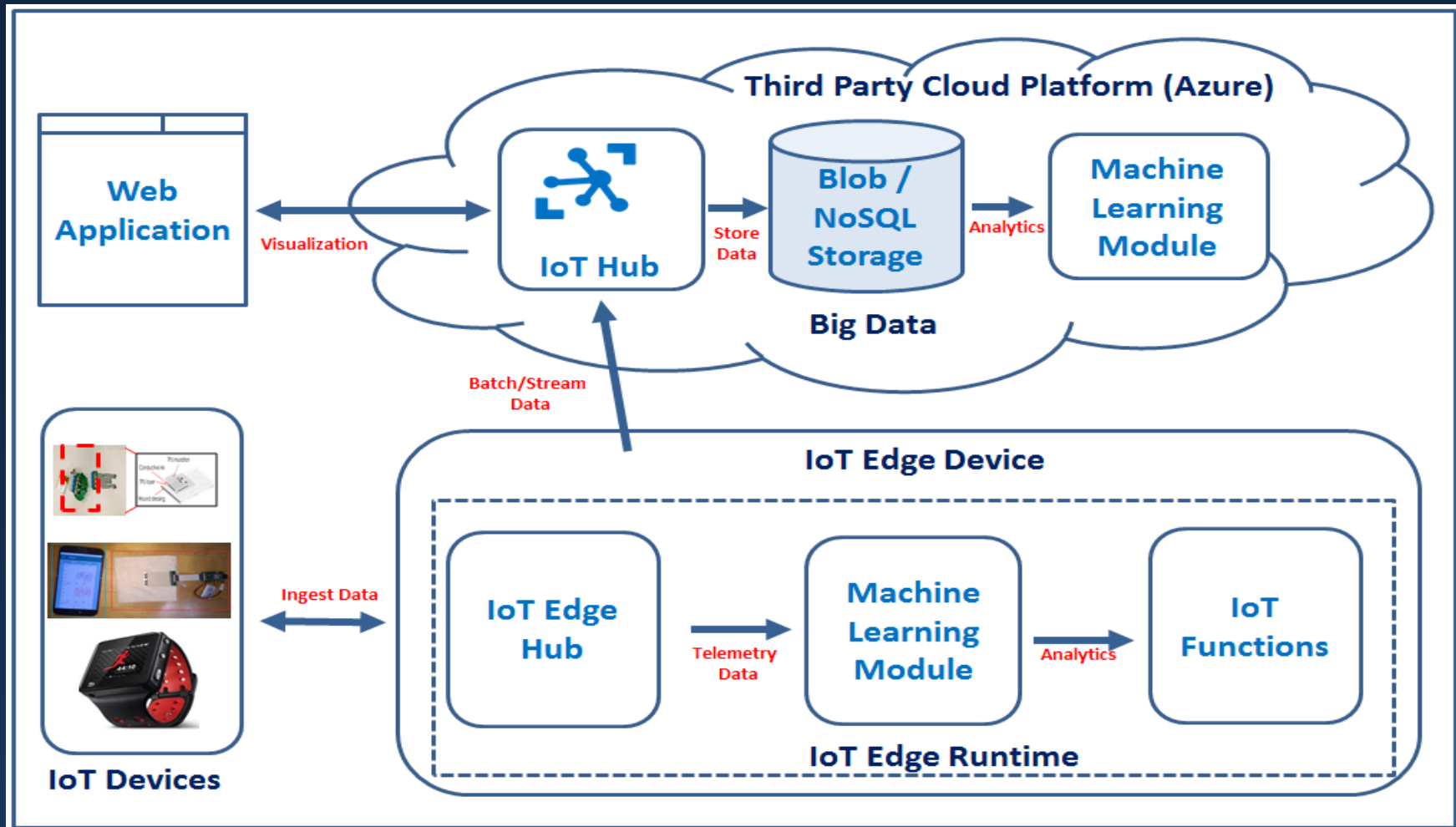


Health Monitoring with IoT Wearable Devices using Machine Learning and Edge Computing

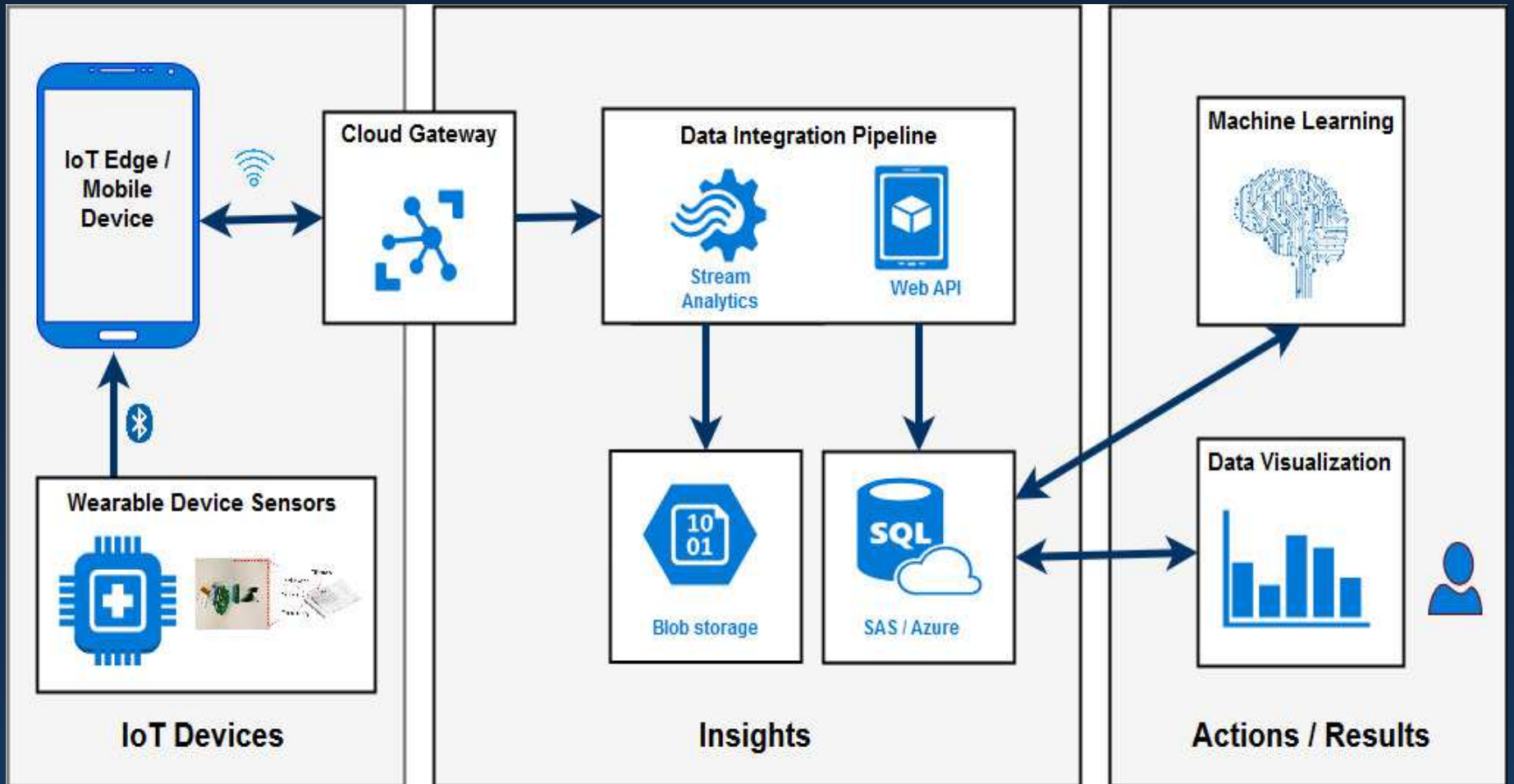


- Research objective is to provide prompt urgent treatment to the patients with IoT technology and Machine Learning
- Patients' health data analysis is performed *at the device level* by developing an offline anomaly detection model and deploying them on the IoT device or gateway
- Processing of the real-time health data is performed at the device level and the anomalous data is sent to the Azure cloud for taking necessary actions

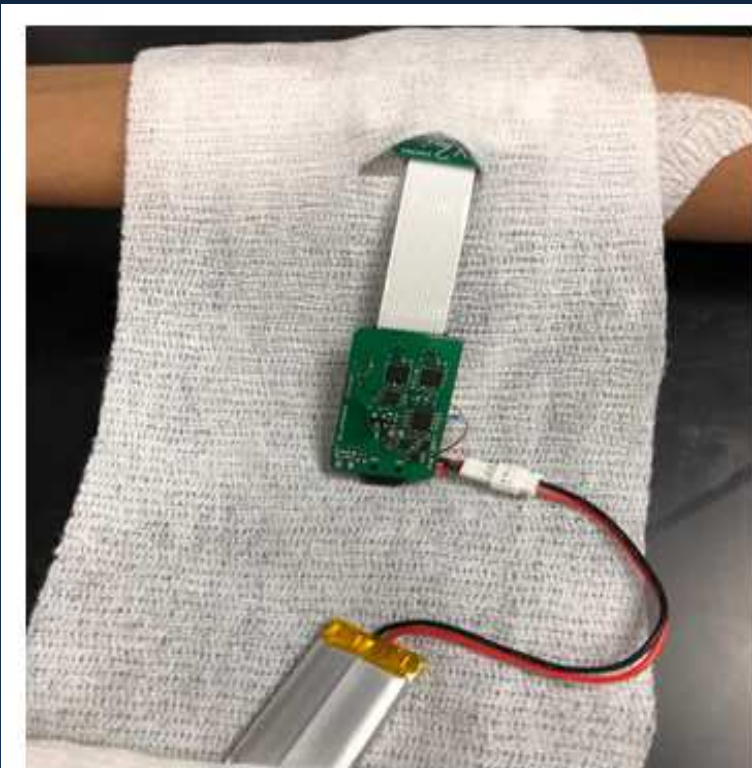
ASSIST Wound Sensor with IoT Edge Pipeline



Health Monitoring with IoT Edge & Machine Learning Architecture



ASSIST Wound Sensor Installation for Clinical Trial



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Intelligence Community—Center for Academic Excellence (IC-CAE) Critical Technology and Intelligence Program



- Defense Intelligence Agency (DIA) has sponsored Critical Technology and Intelligence workforce development program
- Intelligence Fellowship provides opportunities for students to integrate rigorous course work in artificial intelligence, machine learning, deep learning and visualization, with applied research and technical / professional mentorship in pursuit of a career in the U.S. intelligence community



Intelligence Community—Center for Academic Excellence (IC-CAE) Critical Technology and Intelligence Program



- Develop Critical Technology and Intelligence Lab (CTI Lab)
- Certificate/degree track include courses in Critical Technology with focus on Artificial Intelligence, Machine Learning, Data Visualization and Computational Statistics
- Computer Science Analytic Writing and Briefing
- Sponsored Training and Internships for students

Artificial Intelligence & Big Data Track in Electrical & Computer Engineering



- Artificial Intelligence & Big Data is a new track in ECE for students from multiple disciplines to analyze large scale datasets using machine learning, deep learning and big data technologies.
- It will help students to identify and solve complex problems from various domains like Networks, IoT, Sensors, Robotics etc.



Artificial Intelligence & Big Data Track in Electrical & Computer Engineering



Undergraduate Courses	Graduate Courses
<p>CNT 4999: IoT Applied Machine Learning CNT 4998: IoT& Sensor Big Data Analytics CNT 4997: IoT& Sensor Programming with Python CNT 4XXX: Sensor & IoT Data Analysis with Deep learning CNT 4996: IoT& Sensor Data Visualizations CNT 4XXX: Sensor IoT Analytics CNT 4XXX: IoT& Analytics with Cloud Services</p>	<p>CNT 6XXX: Advanced IoT Applied Machine Learning CNT 6990: Advanced IoT& Sensor Big Data Analytics CNT 6XXX: Advanced IoT& Sensor Programming with Python CNT 6XXX: Advanced Sensor & IoT Data Analysis with Deep learning CNT 6XXX: Advanced IoT& Sensor Data Visualizations CNT 6XXX: Advanced IoT& Analytics with Cloud Services 1)CNT 4999: IoT Applied Machine Learning (Summer 2019)</p>

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Q & A



Thank You

