

Intelligent Change Detection System: Autonomous Intelligent Machine Agent Model Development

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Development Outline:

☐ Research Motivations

☐ The Technical Challenge

☐ Net Centric Architecture

- What it is
- Pros
- Cons

☐ Intelligent Change Detection System (ICDS) Architecture

- ICDS Autonomous Trigger (AT)
- Real-Time Intelligent Streaming Distributed Data Architecture
- ICDS Intelligent Machine Agent (IMA) Model

☐ ICDS Component Integration

☐ ICDS IMA Model Development and Test

Research Motivations:

☐ **Maturation of the NAS**

☐ **Net-Centric Environment**

☐ **Data Influx into Ground Control Stations**

☐ **Complex Visual Infrastructures**

☐ **Change Blindness**

☐ **Human and Machine Symbiosis**



The Technical Challenge:

- ☐ **The Next-Gen National Airspace System (NAS) will need to facilitate the emergence of Advanced Air Mobility (AAM).**
- ☐ **An exponential increase in the amount of actionable data (information).**
- ☐ **Human-Agents performing direct-action aviation (DAA) tasking, to ensure the safe entry, operation, and egress of unmanned aerial vehicles within the NAS, will require a “collaborator.”**
- ☐ **NASA projects have identified an operational challenge for Ground Control Station Operators (GCSOs) that is inherent to the design of their operational environment.**
- ☐ **Develop an autonomous system that can be implemented to combat “change blindness”.**

Net Centric Architecture:

❑ A continuously-evolving system architecture

❑ A complex Symbiotic community of:

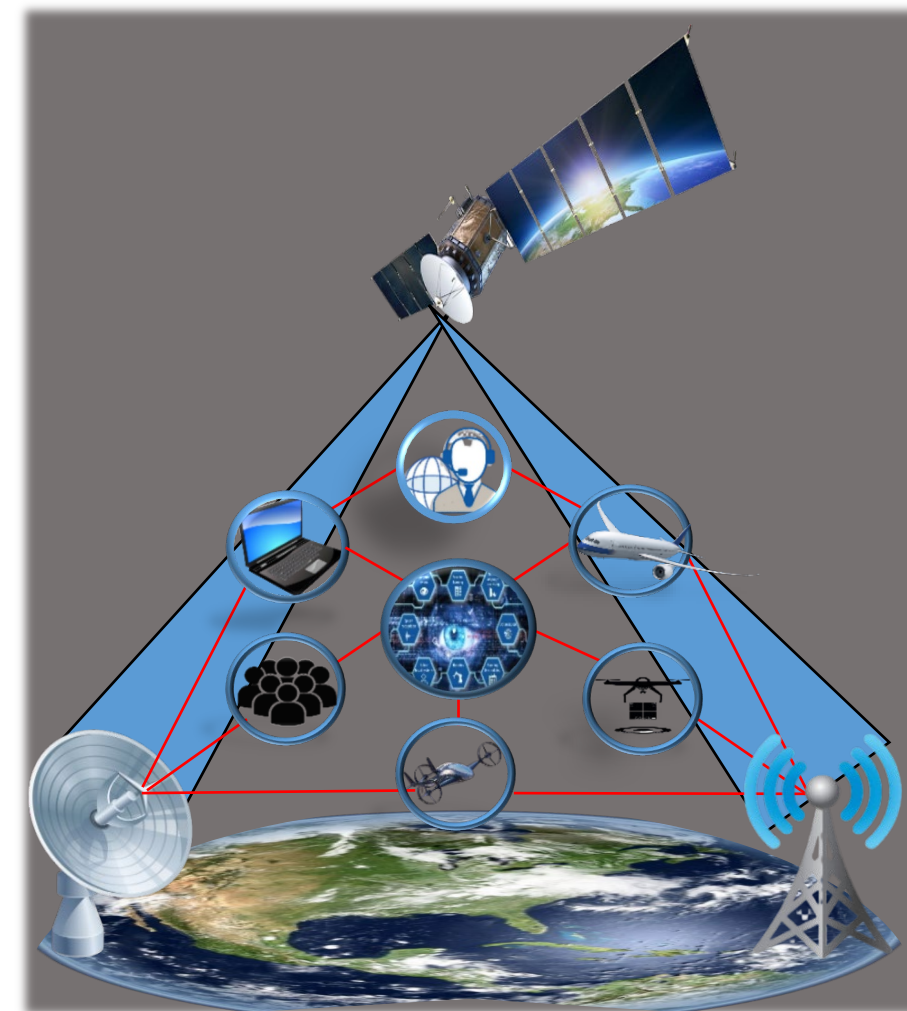
- People
- Devices (Legacy, Current, and Burgeoning technologies)
- Information and Services

❑ Operating within a Net-Centric Environment Requires:

- Possessing the Coin-Of-The-REALM => Massive Amounts of “Actionable Data”
- Using that coin (aka “Information”) to connect to the environment’s Comms
- Improvements in the ability for humans to data wrangle
- The use of intelligent systems

❑ The GOAL:

- Prevent data overload of human-agents/Direct Action Aviation Personnel (DAAP)
- Empower Direct Action Aviation Personnel (DAAP)
- Provide DAAP with preferably-pertinent information



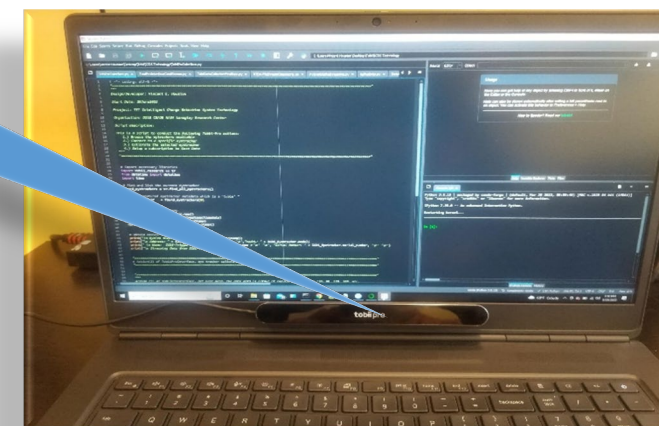
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Intelligent Change Detection System Model Development:

□ ICDS System Functionalities:

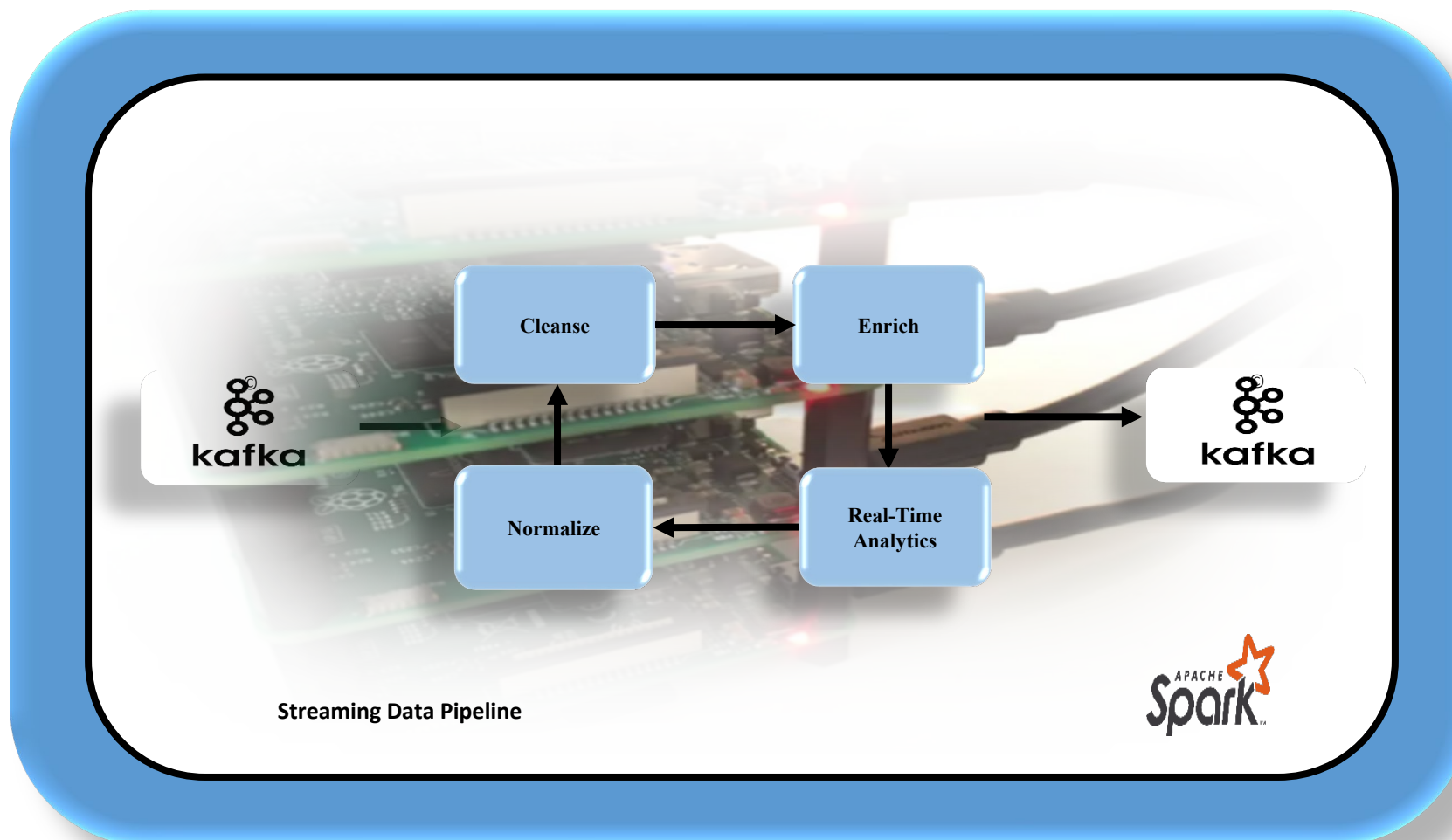
- Ingest all sUAS MPATH data Transmitted to the Remote Operations for Autonomous Missions (ROAM) Lab
- Predict the onset of Change Blindness (CB) in ROAM Ground Control Station Operators (GCSOs)
- Determine whether relevant changes to sUAS state data has been missed due to CB
- Depict missed relevant sUAS state data changes to GCSO display
- Store ingested data for continued ICDS training

Intelligent Change Detection System Architecture: (AT)

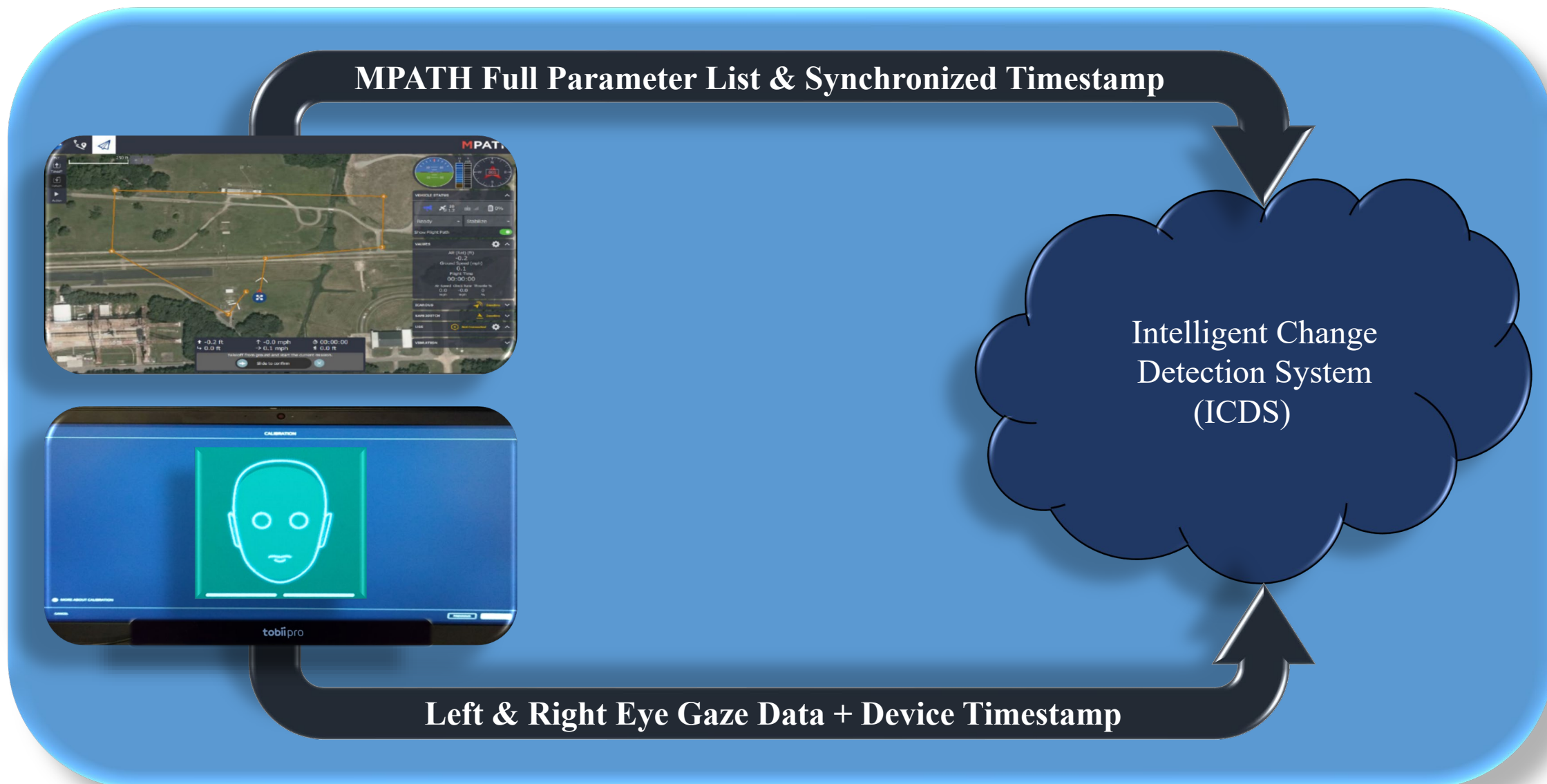


- ❑ Time synchronized with MPATH data stream
- ❑ Autonomously identifies loss of GCSO eye focus
- ❑ Triggers the ingestion of all sUAS MPATH state data
- ❑ Triggers the implementation of the ICDS relevant data determination

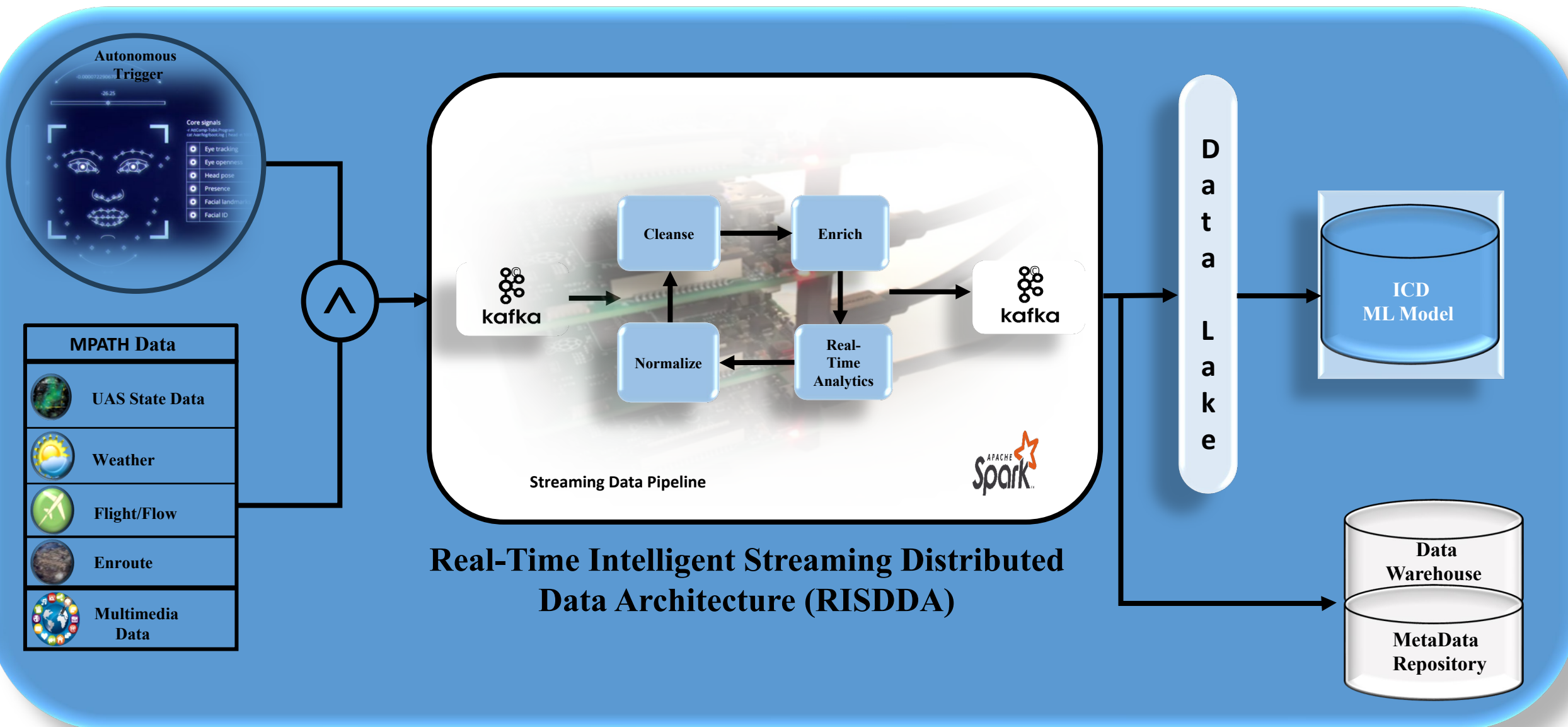
Intelligent Change Detection System Architecture: (RISDDA)



Intelligent Change Detection System Architecture: (ICD ML Model)



Intelligent Change Detection System Architecture



Intelligent Change Detection ML Model (Dataset Design):

- ☐ Twenty-two Parameters Representing MPATH sUAS data
- ☐ Ten thousand rows every 15 seconds
- ☐ Eight hundred and eighty thousand data points per minute
- ☐ Random value starts for each parameter
- ☐ Tobii Eye Tracker gaze and eye-close data
- ☐ Timestamp for data inputs
- ☐ Nominal and off-nominal data values

Parameter	Normal Value	Units
Ground Speed	20	Knots
Vertical Speed	-2	Feet / Seconds
Position Change	+1024	Feet
Distance Traveled	+1400	Feet
Flight Time	+15	Seconds
Altitude	+3200	Feet
Battery Time Remaining	+7.5	Hours
Battery Percentage	71	Percent
Tobii Eye Tracker (Gaze-Left)	60	Hertz
...	...	...

Intelligent Change Detection ML Model (Dataset Design):

□ Data Processing and Normalization

- Raw data rounded, reducing data input and increasing model speed
- Actual model input is the change in parameters between time steps
- Eight hundred-eighty-eight thousand entries of the 23 input parameters implemented as model input

GroundSpeed	VerticalSpeed	Altitude	Heading
0	-19.34349678	95.5245654	5.017056115
3.219003496	-18.04384328	94.65649907	0
5.793699829	-19.39352358	91.30264436	125.7869949
6.725049304	-20	89.03990235	113.8153044
6.656569253	-20	88.58881414	103.5928512
36.69810433	-20	85.29990979	109.6706762
37.51456019	-3.815602836	84.84101347	99.99946446
40.45575375	-4.525839727	82.19338219	111.7147233
88.01267167	-4.788048534	84.40434856	112.4071636
85.6927283	-4.202117258	86.52331083	220.1032192
47.10876656	-4.44848889	84.28178809	215.8050642
88.3463142	-4.093183304	84.43040011	213.4823099
99.64328674	-3.766436845	81.70187134	222.5086988
98.89344282	4.186926333	81.55260228	211.5495752
97.93042598	3.428444346	79.60924573	354.0630586
64.33288412	4.508365435	80.26715935	357.9273112

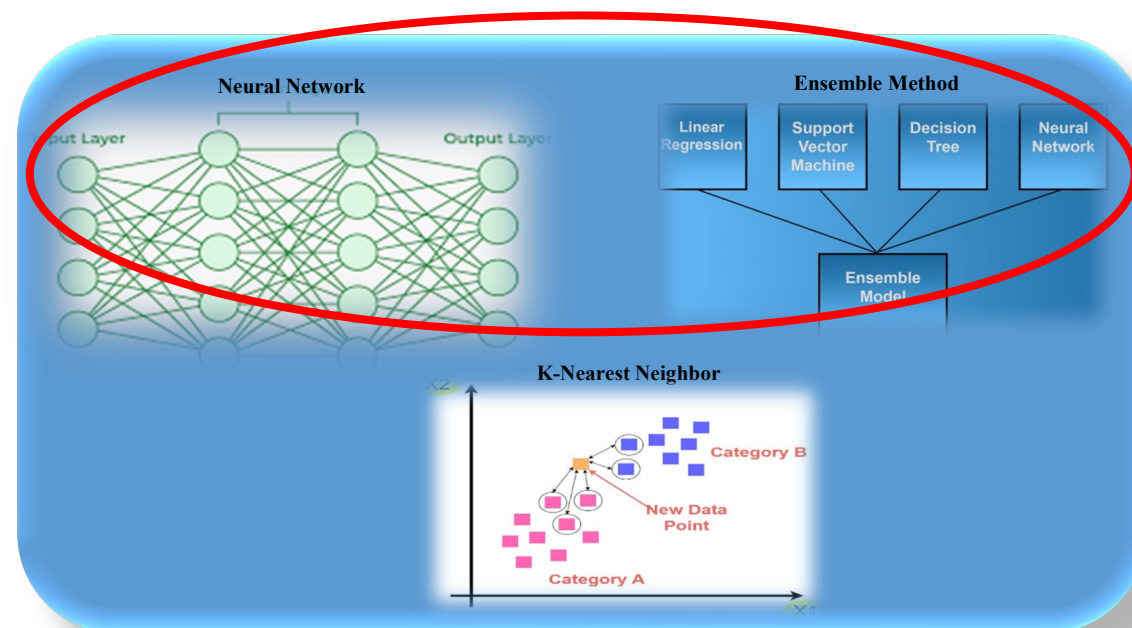
Intelligent Change Detection ML Model (Model Selection & Feature Extraction):

☐ Machine Learning Algorithms Considered

- ☐ Neural Networks
- ☐ Ensemble Methods
- ☐ K-Nearest Neighbor

☐ Feature Extraction to Improve Model Accuracy

- ☐ Altitude
- ☐ Heading
- ☐ Ground Speed
- ☐ Vertical Speed
- ☐ Pitch
- ☐ Roll
- ☐ Battery Percentage



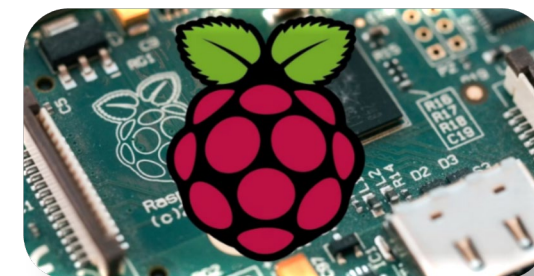
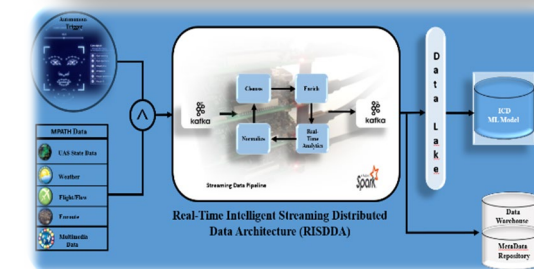
Intelligent Change Detection ML Model (Test Results):

- ❑ Supervised machine learning model test and evaluation conducted with MATLAB
- ❑ ICD Machine Learning model top performer: RUSBoosted Tree
- ❑ Model parameters and input vectors fine tuned with RUSBoosted Tree
- ❑ Accuracy of change blindness detection and missed relevant sUAS stated state data is: **87.55%**

True Class	Altitude	5752			1	1052			1
	BatteryPercentage		2163			299			
	GroundSpeed			9643	1	1989			1
	Heading				4482	739			
	None					7982			
	Pitch					467	3502		
	Roll					369		2732	
	VerticalSpeed				1	1307			7517
		Altitude	BatteryPercentage	GroundSpeed	Heading	None	Pitch	Roll	VerticalSpeed
		Predicted Class							

Intelligent Change Detection Future Research Efforts:

- ❑ **Real-Time Streaming MPATH data ingestion into ICDS**
 - Verify ICDS improved accuracy w/non-simulated data
- ❑ **Full ICDS Integration into the ROAM Lab**
- ❑ **System footprint reduction**
 - Verify non-intrusive portability of full ICDS
- ❑ **Human-In-The-Loop research study**
 - Determine ICDS design correctness
 - Verify ICDS effectiveness at human-machine teaming
 - Acquisition of human knowledge w/respect to missed data relevance



Questions/Comments:

