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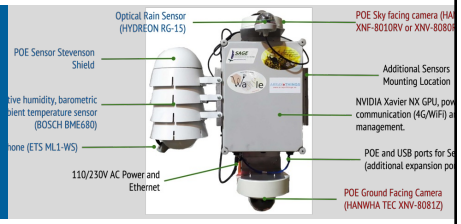
AI @ EDGE



Nicola Ferrier
Senior Computer Scientist
Mathematics and Computer Science Division

and Pete Beckman, Charlie Catlett, Scott Collis, Neal Conrad, *Dario DeMatties Reyes*, Yongho Kim, *Seongha Park*, *Bhupendra Raut*, Rajesh Sankaran, Sean Shahkarami

ALCF AI for Science Student Training Series, February 13, 2024

1

What is Waggle?

An Architecture and Software Stack for Scientific AI@Edge Computing

Waggle AI@Edge Software Stack 5G

- AI toolchain for the edge
- Goal-based scheduler & resource manager
- Fully containerized AI@Edge applications
- Support for multi-tenancy
- Extreme cybersecurity
- Resilient data movement
- Cloud-based data store and management

Standardized Open Source AI tools for the Edge

TensorFlow, TensorRT, PYTORCH, TensorFlowLite, OpenCV, docker, NVIDIA CUDA, K3S, ROS

Deployed at Instrument/Sensor outside or inside

Purpose-built Waggle node for remote instrumentation

Commodity server deployed with Waggle Software

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AI-Based Measurement & Anomaly Detection, & Control

"SOFTWARE DEFINED SENSOR"

Your software container running here

Analysis produces live results

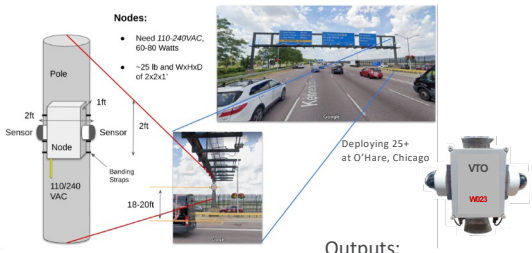
Many measurements cannot be "sensed" directly but can be computed from images, microphones or other datastreams/devices

portal.sagecontinuum.org/apps/explore

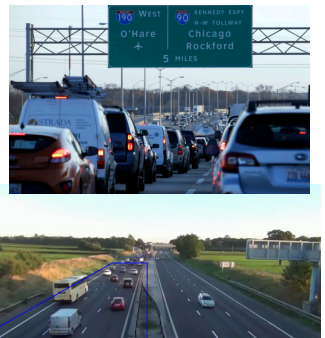
3

MEASURING TRAFFIC STATE USING VEHICLE TRACKING

Chicago O'Hare Improvement Project: Understanding Traffic Type, Flow, and Density DOE VTO (EERE)



Dual cameras to capture approaching and leaving traffic for in-situ analysis.



Outputs:

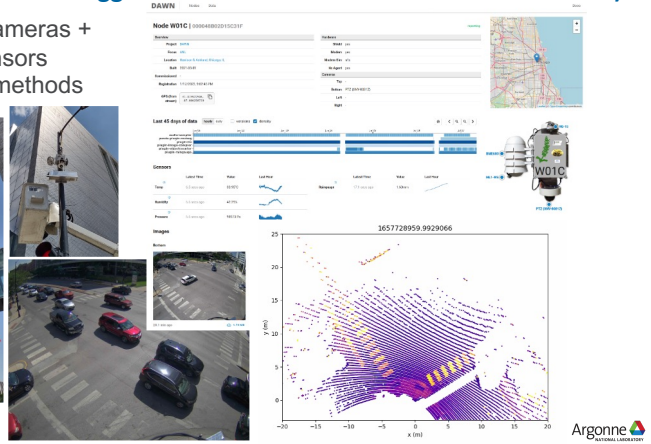
- Flow: # of vehicles / sec
- Speed: averaged speed in km/h
- Density: (# of vehicles x average length based on vehicle type) / (length of road in ROI)

4

Advanced Radiation Sensors for Safer Cities

NNSA: Domain Awareness Waggle Network (DAWN - ANL) and PANDA (LBNL)

New data streams: Cameras + LIDAR + radiation sensors
WIP: Developing ML methods



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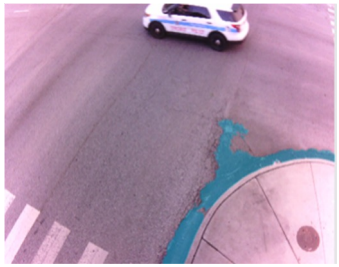
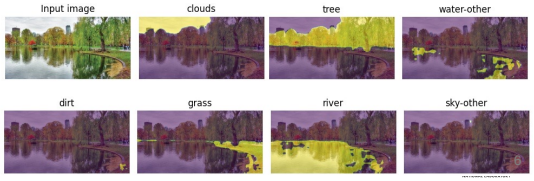
Surface Water Detection



Linked with HPC, can be used to build hydrology models and predictive capabilities



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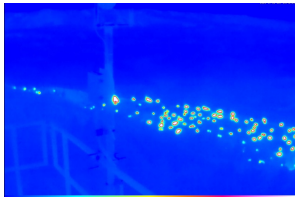
Wildfire Detection and Prediction

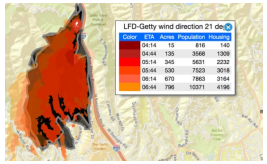
AI@Edge for wildfire detection linked to HPC simulations

WIFIRE

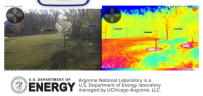
Ilkay Altintas, UCSD, Co-PI for SAGE

Konza Prairie controlled burn: April 2022.





Sage project will move Pan-Tilt-Zoom cameras toward suspected outbreaks, and use infrared cameras to build self-supervised AI training



Oregon Sage Node, ALERTWildfire Nov 2023

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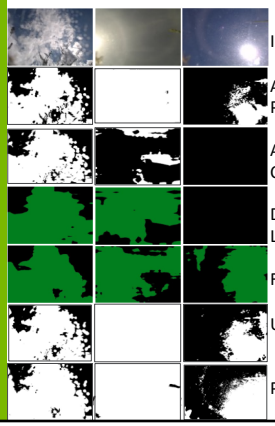
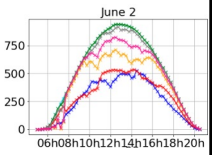
Exelon: Measuring Cloud Coverage for Estimating Solar Irradiance

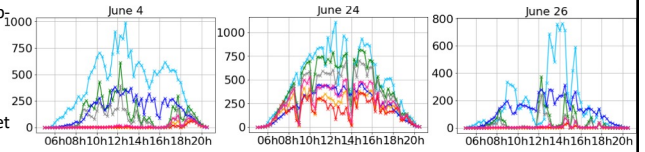
- Cloud cover using FCN, U-Net, DeepLab v3, PLS, and AdaBoost models
- Solar irradiance = (1-cloud cover(ratio)) x max solar irradiance

Park, Seongha, et al. "Prediction of solar irradiance and photovoltaic solar energy product based on cloud coverage estimation using machine learning methods." *Atmosphere* 12, no. 3 (2021): 395.



Model	mIoU	mAP	mAR
PLS	0.6467	0.8961	0.6991
FCN	0.5649	0.8974	0.6040
U-Net	**0.7626**	**0.9869**	**0.7703**
DeepLab	0.5335	0.9234	0.5582
AdaBoost (class)	0.6128	0.8494	0.6875
AdaBoost (norm)	0.5856	0.8646	0.6448





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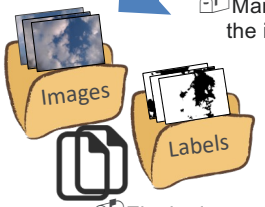
Supervised learning to generate AI@Edge

Example: Cloud segmentation for estimating solar Irradiance

- Images collected from a node
- Red box: sky facing camera
- Orange box: Solar irradiance measuring sensor

- Manually labeled the images



- Zip the images and labels with relative information

- Store the dataset in the cloud or HPC server

- Use the dataset to train a model

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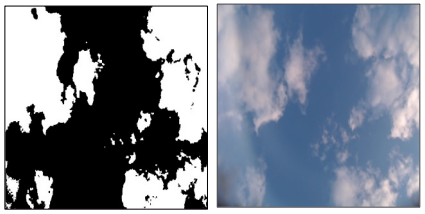
Labeling Examples



Need large labeled data sets for science including:

- Flooding detection
- Snow depth / coverage
- Smoke and Fire detection
- Cloud coverage
- Rime ice detection
- Urban heat island detection
- Predicting photovoltaics performance
- Seismic activity

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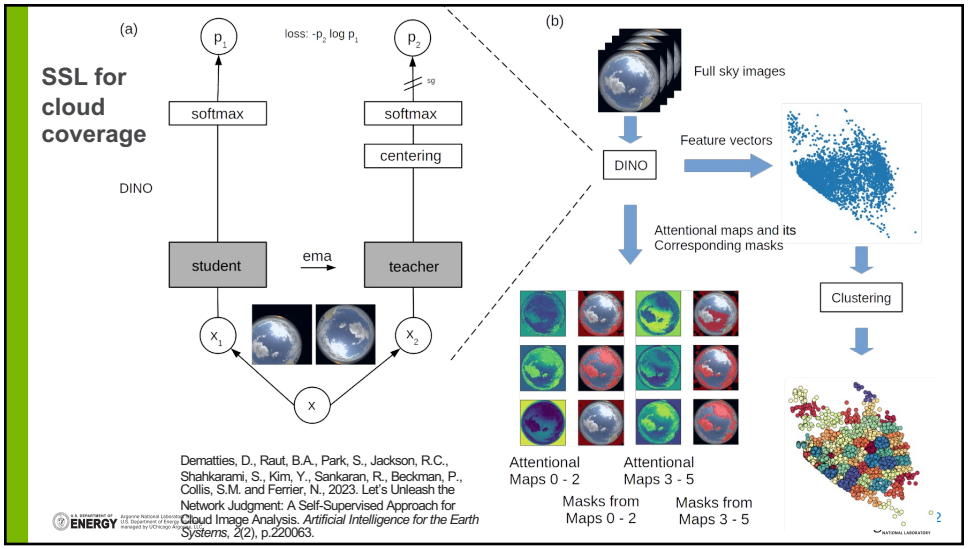
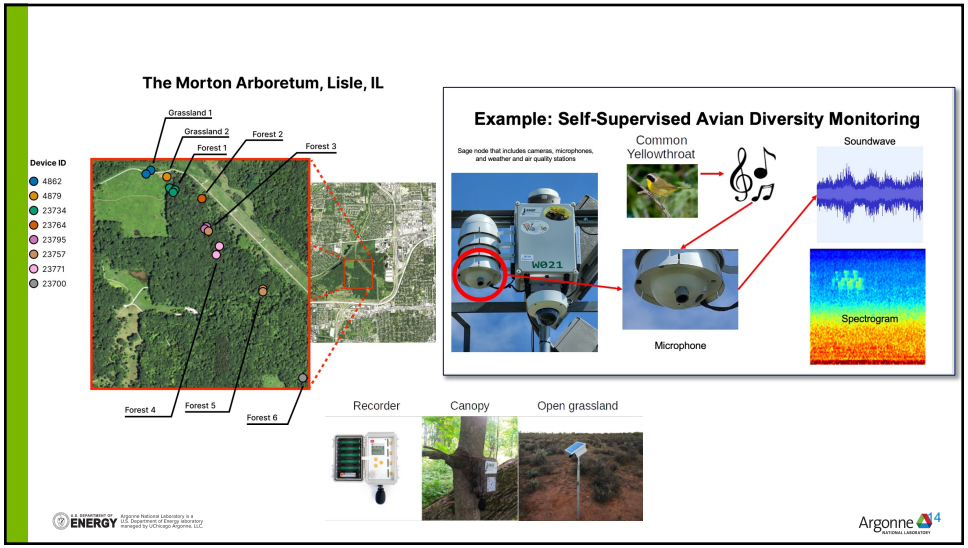
Previous examples used ***Supervised Learning,*** requiring large annotated data-sets.

Self-supervised learning methods are well suited for Edge computing.




The Morton Arboretum, Lisle, IL
Grassland 1
Grassland 2
Forest 1
Forest 2
Forest 3
Forest 4
Forest 5
Forest 6
Device ID
4862
4879
23734
23764
23795
23757
23771
23700
Example: Self-Supervised Avian Diversity Monitoring
Sage node that includes cameras, microphones, and weather and air quality stations
Common Yellowthroat
Soundwave
Spectrogram
Microphone
Recorder
Canopy
Open grassland
Argonne
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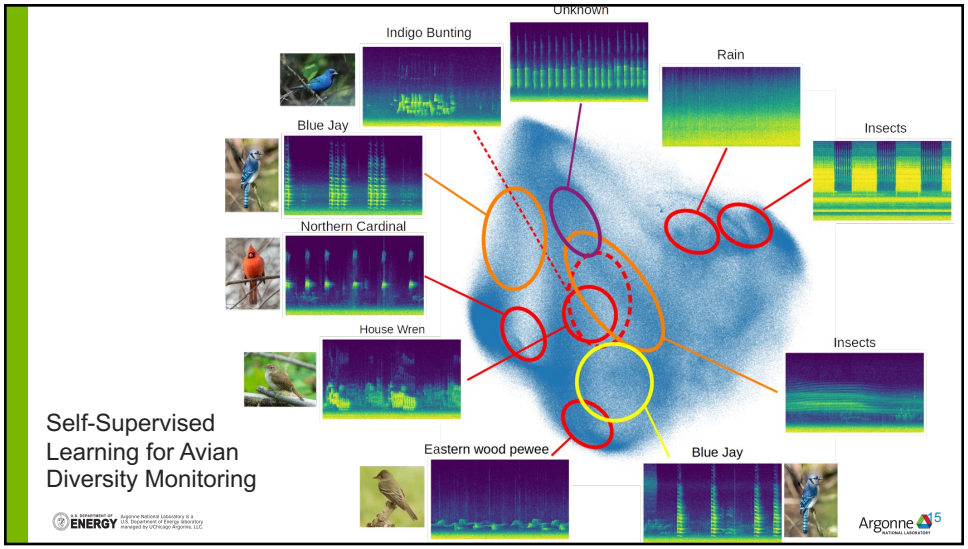
Unknown
Indigo Bunting
Rain
Blue Jay
Insects
Northern Cardinal
House Wren
Insects
Eastern wood pewee
Blue Jay
Self-Supervised Learning for Avian Diversity Monitoring
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AI provides a powerful tool to analyze data streams. Moving the compute to the edge can reduce bandwidth and provide a measurement of the “important information”.

QUESTIONS/DISCUSSION?

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