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Analysis of Plumes through Neural Networks

Morgan Webb

PL: Michael Clemenson, mdcleme@sandia.gov; *Joshua Zollweg*, jdzollw@sandia.gov; *Leon Ross*, lcross@sandia.gov
Mentor: Mandy Nevins, mnevins@sandia.gov
Manager: Dale Jackson, dcjacks@sandia.gov

Virtual Intern Symposium

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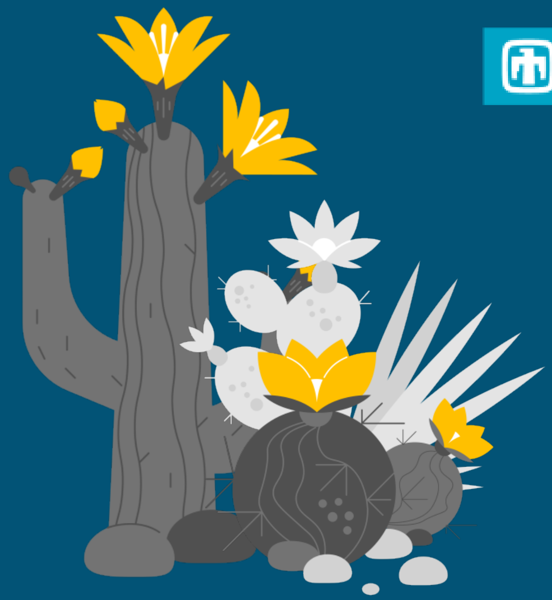
Outline



- ➢ Role
- ➢ Core Concepts
- ➢ Projects
  - ➢ Inverse Solution
  - ➢ Vapor II
  - ➢ Watershed
- ➢ DIRSIG
- ➢ Summary/Goals

My Role

Main Role

- Insert models of plumes into DIRSIG as a way to simulate their interaction with the world
    - What information does DIRSIG need in order to put plumes in the scene (vector coordinates, concentration of plume, optical properties)?
    - Create data to train neural networks (Inverse Solution, Vapor II, Watershed).
- Work on trying to do so has been ongoing for the past 15 years between Sandia and DIRS
    - No automated way or existing tool

Secondary

- Develop a data loading scheme to extract a region surrounding a queried pixel for efficient loading to feed our deep learning models.
    - Models tend to detect pixels of interest better when spatial context is provided.

Core Concepts

Plumes

- One fluid vertically moving through another- a plume of smoke rises as a column through air
- The release location shown is the rocket. Other examples include wildfires, smoke stacks, and vents.
- Relevant to national security in terms of identifying chemical makeup, detection, and tracking of plumes.

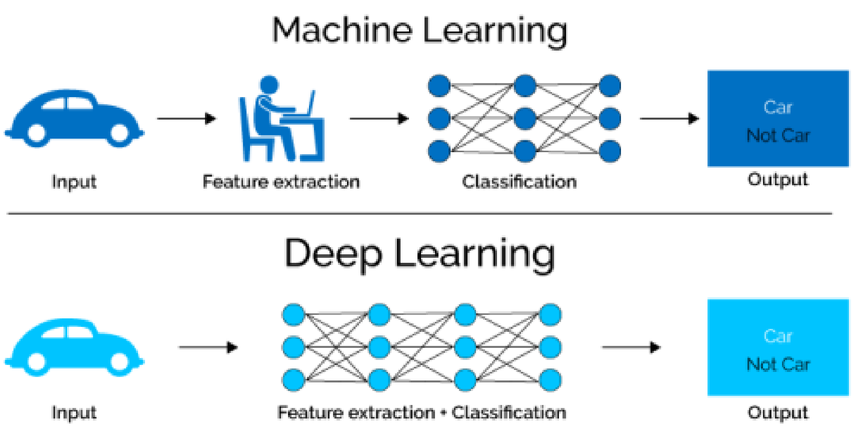
GPS III-5 satellite being launched 6/17/2021

[https://www.defense.gov/observe/photo-gallery/igphoto/2002744999/]

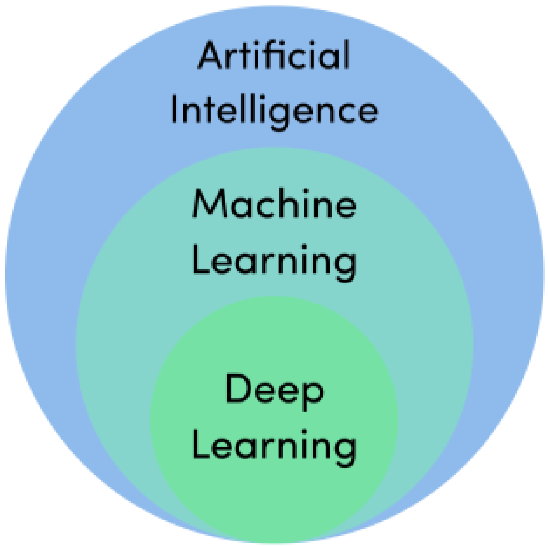
Core Concepts

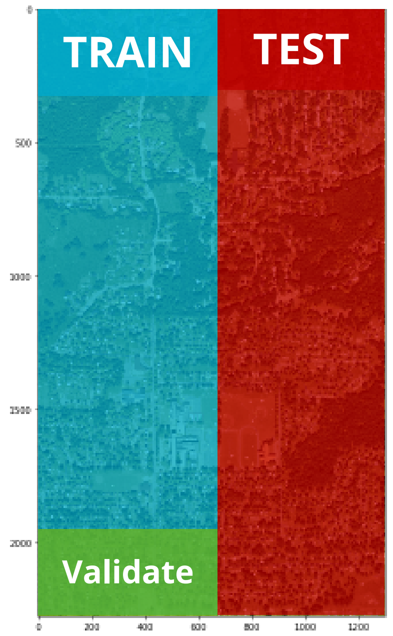
Neural Networks

- Algorithms that try to recognize underlying relationships in data through a process meant to mimic the human brain
- Each pixel in the data are run through the model
- Beneficial as a way of sorting through an exuberant amount of data (for identification purposes) relatively quickly compared to humans



[1] Anderson

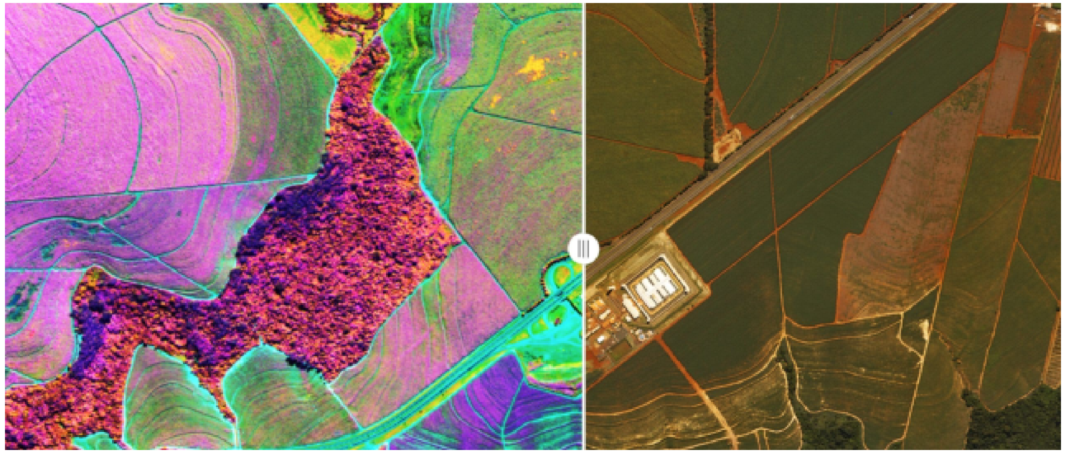




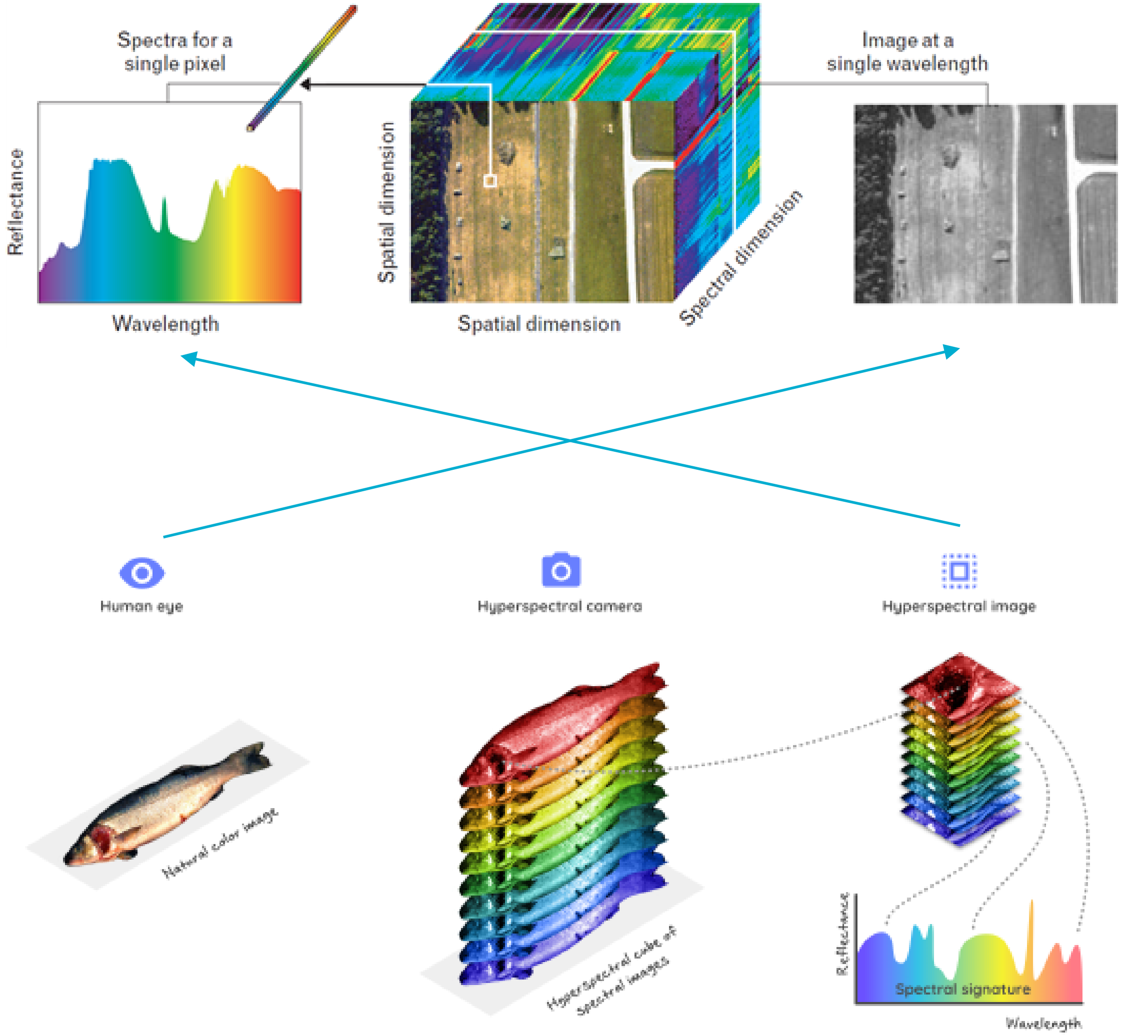
Core Concepts

Hyperspectral Imagery

- Obtains spectra for each pixel that encompasses a scene
  - A spectra can consist of hundreds of thousands of bands 10-20 nm wide.
- Relevant to national security in terms of identifying specifics chemicals within large areas (scenes)



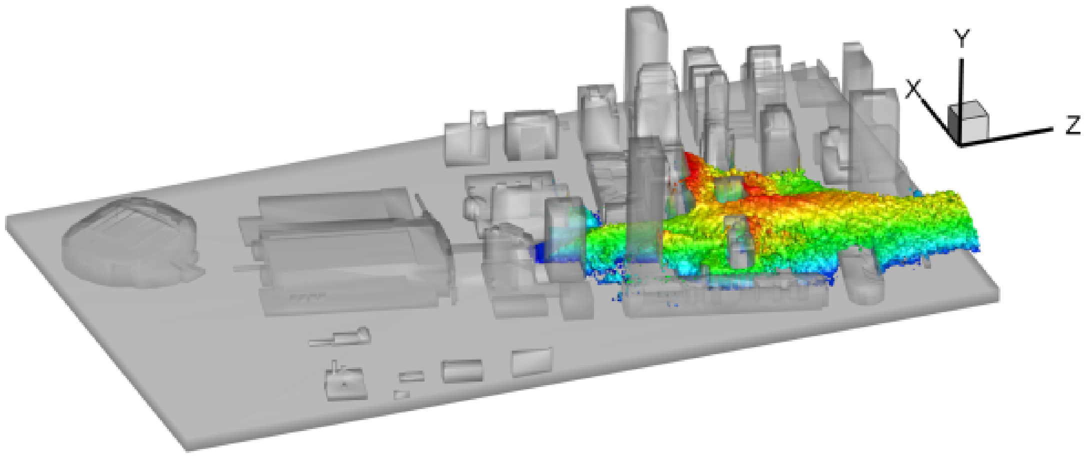
[https://agfundernews.com/growing-impact-hyperspectral-imagery-agrifood-tech.html]

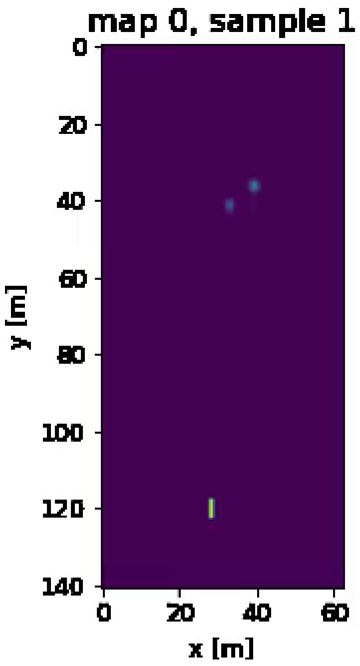


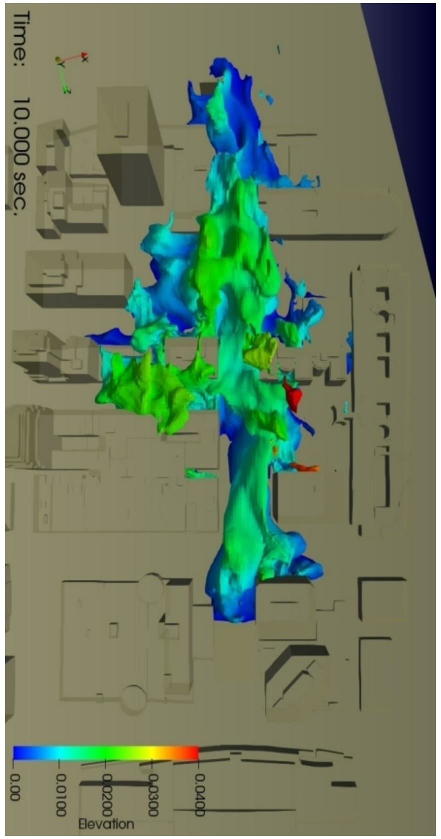
[https://condifood.com/hyperspectral-imaging/]

Inverse Solution

- “The aim of this project is to determine the release location and concentration of effluent releases with some level of confidence. Synthetic image data for algorithm development is based on **c**omputational **f**luid **d**ynamics simulations of various scenarios and environments.”



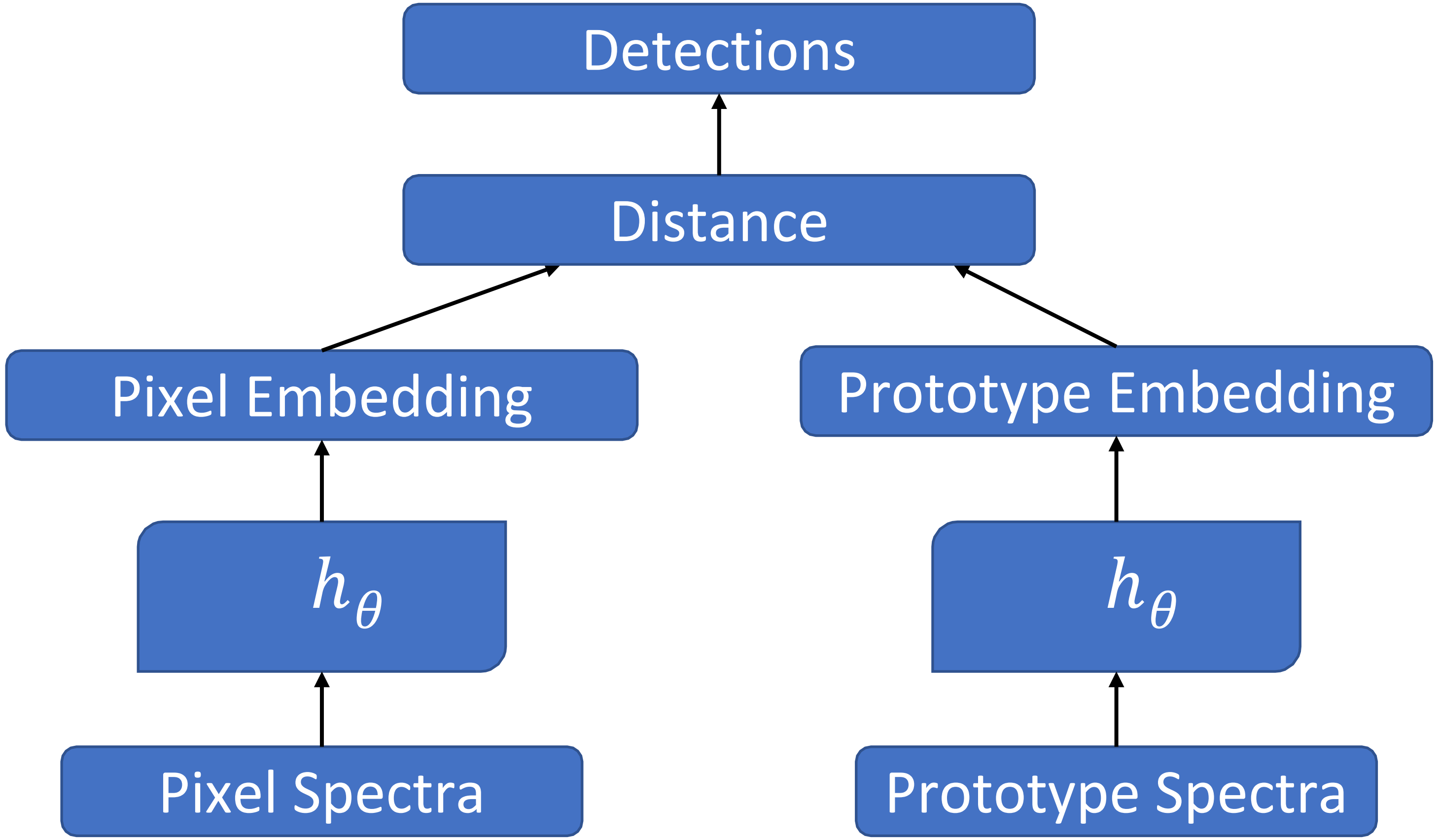




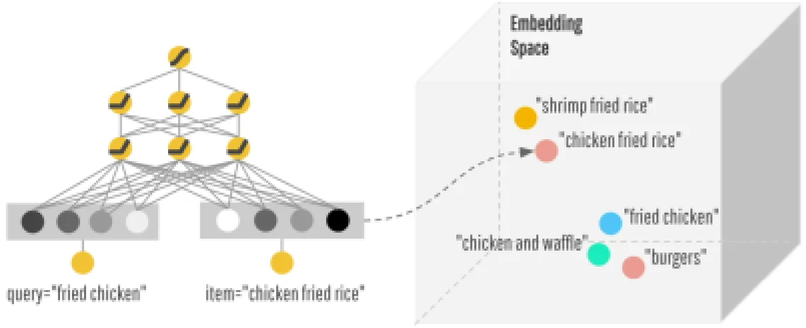
[1] Inverse Solutions Team

Vapor II

- "Deep-learning approaches such as **p**aired **n**eural **n**etworks are being studied and developed for detecting plumes in hyperspectral imagery."
- Work originated with Vapor I for using PNN's on hyperspectral imagery to try and solve the Expanding Library Problem.
    - Collect a library of target spectra under as many different conditions as possible.
    - This construction must be performed for each new target material. [1] Anderson

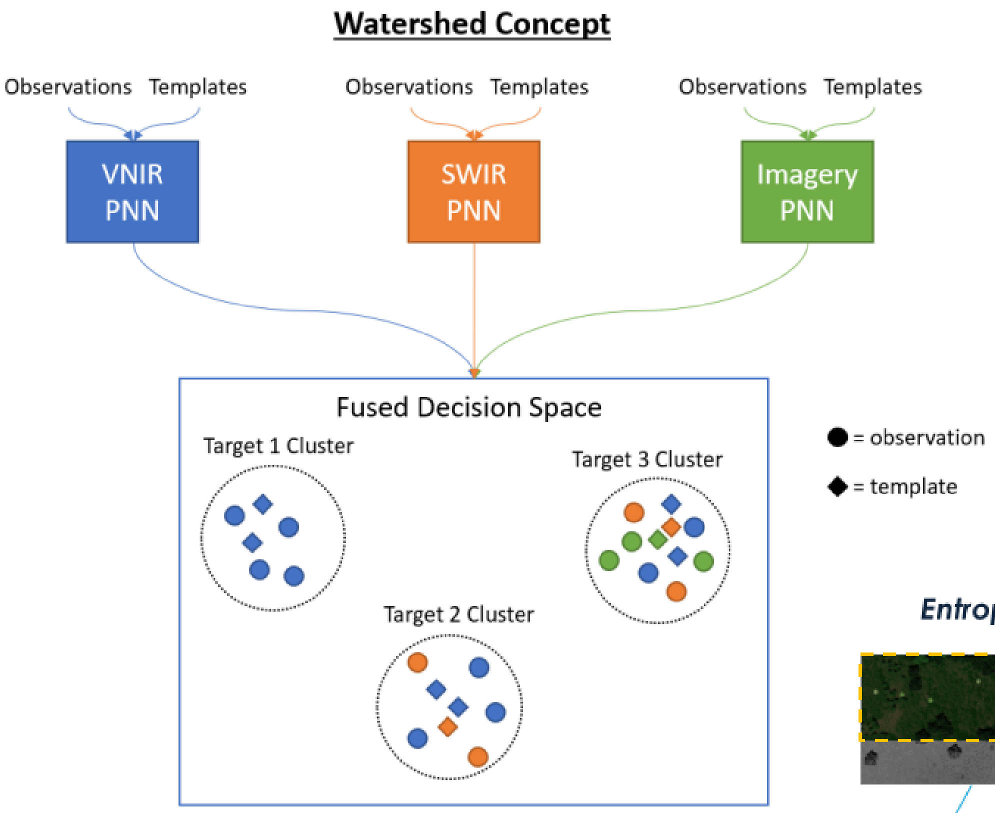


[2] Anderson

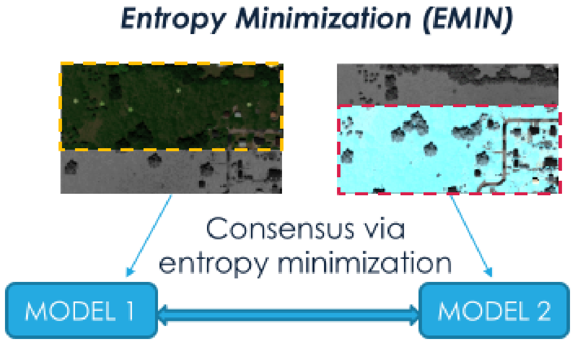


Watershed

- "This project investigates multi-modal techniques to solve hyperspectral imagery problems, including studying the effects of a missing data stream. The data fusion process uses pixel-to-pixel **p**aired **n**eural **n**etworks."
- Using similar concepts to Vapor I (embedding spaces) while trying to fuse data from different sensors
- Entropy (randomness) minimization with PNNs encourages modality specific models to learn a shared embedding space.



[3] Watershed Team



*Predictions **benefit** from full data coverage and **benefit** from context using disparate data sources.*

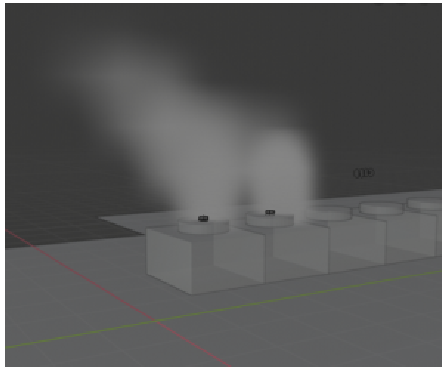
***Example:** PNN learning a shared embedding space for VNIR and SWIR*

Digital Imaging and Remote Sensing Image Generation

[4] DIRS

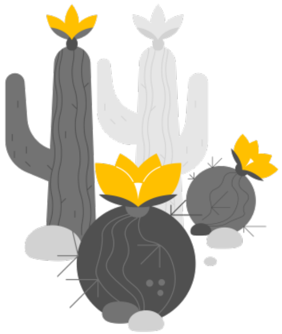
- Produced and expanded on by professors and scientists out of **R**ochester **I**nstitute of **T**echnology for over 20 years
  - Used by Laboratories and Universities across the country
- A model designed to produce imagery, test image systems, and produce data for training.

- Projects use Hyperspectral data made in DIRSIG as a way to test and build up models

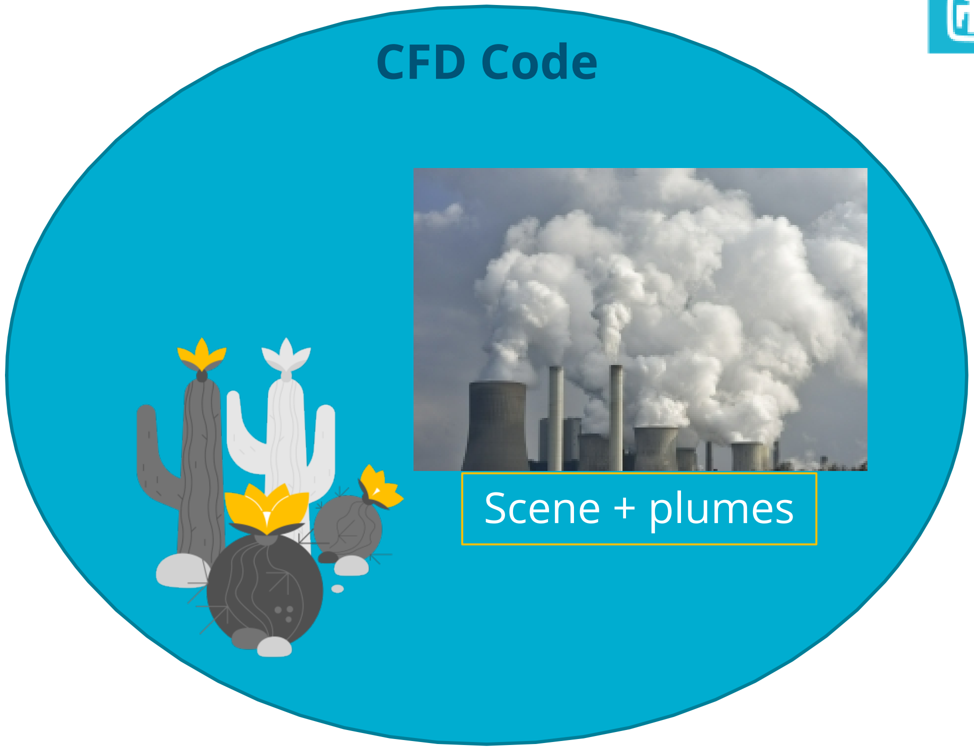


Current Goals

Work Goal



Scene in appropriate format



DIRSIG + Plumes

DIRS
Digital Imaging and
Remote Sensing Lab

[4] DIRS

Professional Goals

- Convert Summer Internship into Year-Round Internship
- Finish Undergraduate degree and earn a MS/PhD in Imaging Science at RIT

References

[1] Inverse Solution Team, “Inverse Solution Overview,” [PowerPoint slides]. Available: https://wiki.sandia.gov. [Accessed: July 1, 2021]

[2] Dylan Z. Anderson, Joshua D. Zollweg, Braden J. Smith, "Paired neural networks for hyperspectral target detection," Proc. SPIE 11139, Applications of Machine Learning, 111390J; 2019. [Online]. Available: https://doi.org/10.1117/12.2531310. [Accessed: June 29, 2021]

[3] Watershed Team, “Watershed Kickoff,” [PowerPoint slides]. Available: https://wiki.sandia.gov. [Accessed: June 30, 2021]

[4] Digital Imaging and Remote Sensing Lab, “Digital Imaging and Remote Sensing Image Generation(DIRSIG), ”Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, 2021. [Online]. Available: https://dirsig.cis.rit.edu. [Accessed: June 28, 2021]