Artificial Intelligence for EHS Compliance and Sustainability Management

April 16, 2020

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Today’s Speakers

Neno Duplan
Founder & CEO
Locus Technologies

Robert Pierce
Machine Learning Engineer
Locus Technologies

Dr. Todd Pierce
Director of EIM & GIS Development
Locus Technologies

Artificial Intelligence for EHS Compliance and Sustainability Management

Locus Technologies

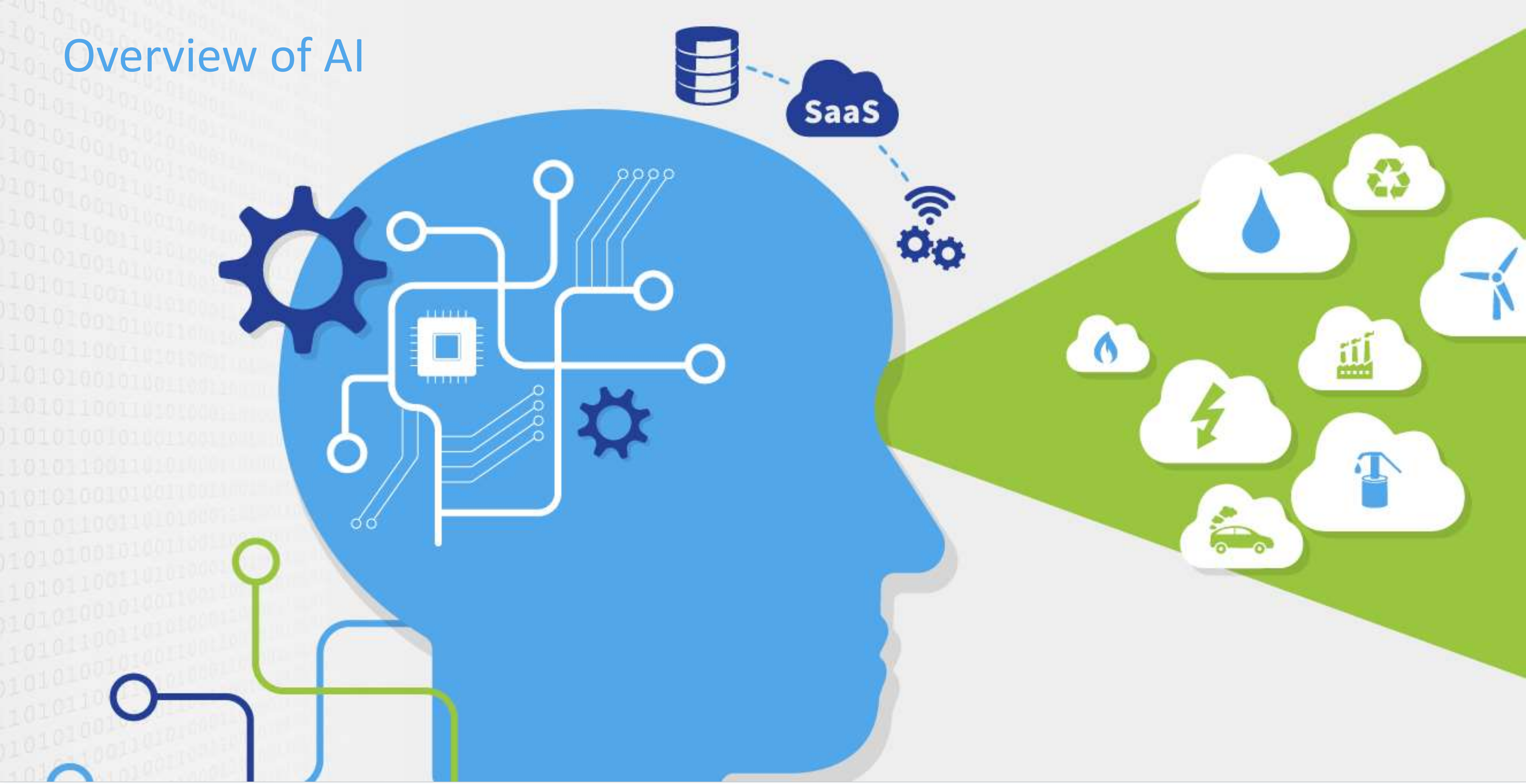
Agenda

- Overview of AI and Machine Learning
- Data requirements
- Case Study: Forest Disturbance Monitoring
- EHS&S examples
- Takeaways

Poll Question #1

- How familiar are you with AI?
  - Very familiar
  - Somewhat familiar
  - Not familiar

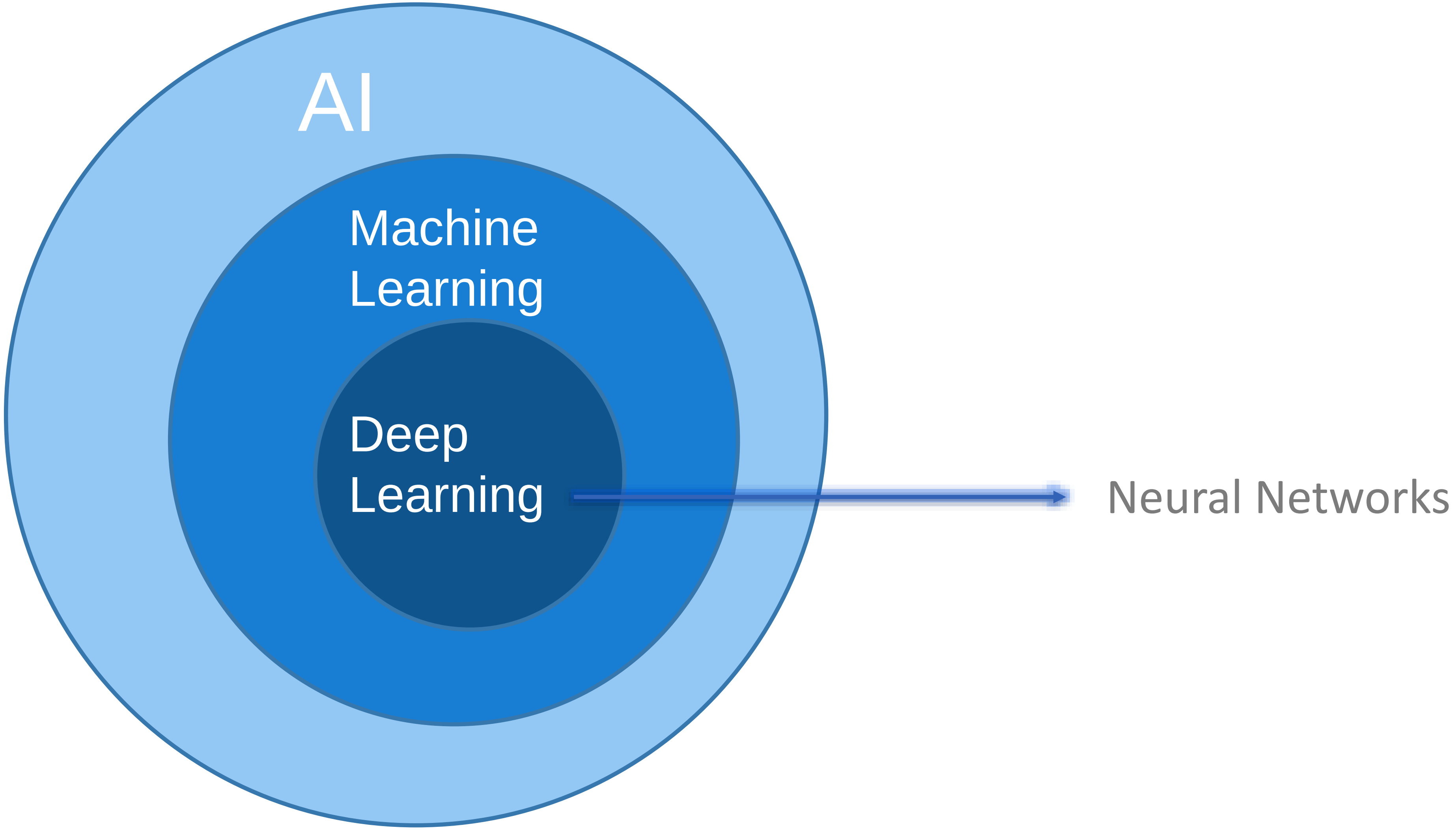
Overview of AI



Overview of AI

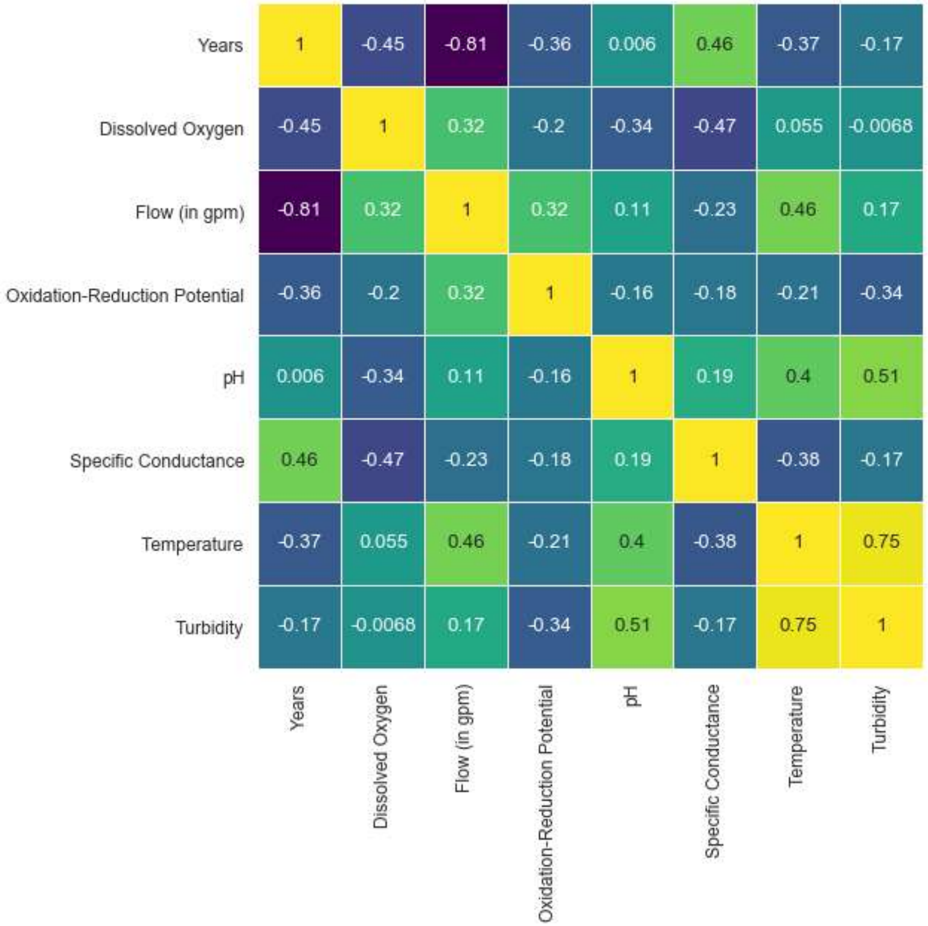
- AI is the ability of a computer to perform tasks that require human-level intelligence
- Used alongside big data to draw inferences and conclusions about many aspects of life
- Must be adaptable for many different data types and situations

Overview of AI



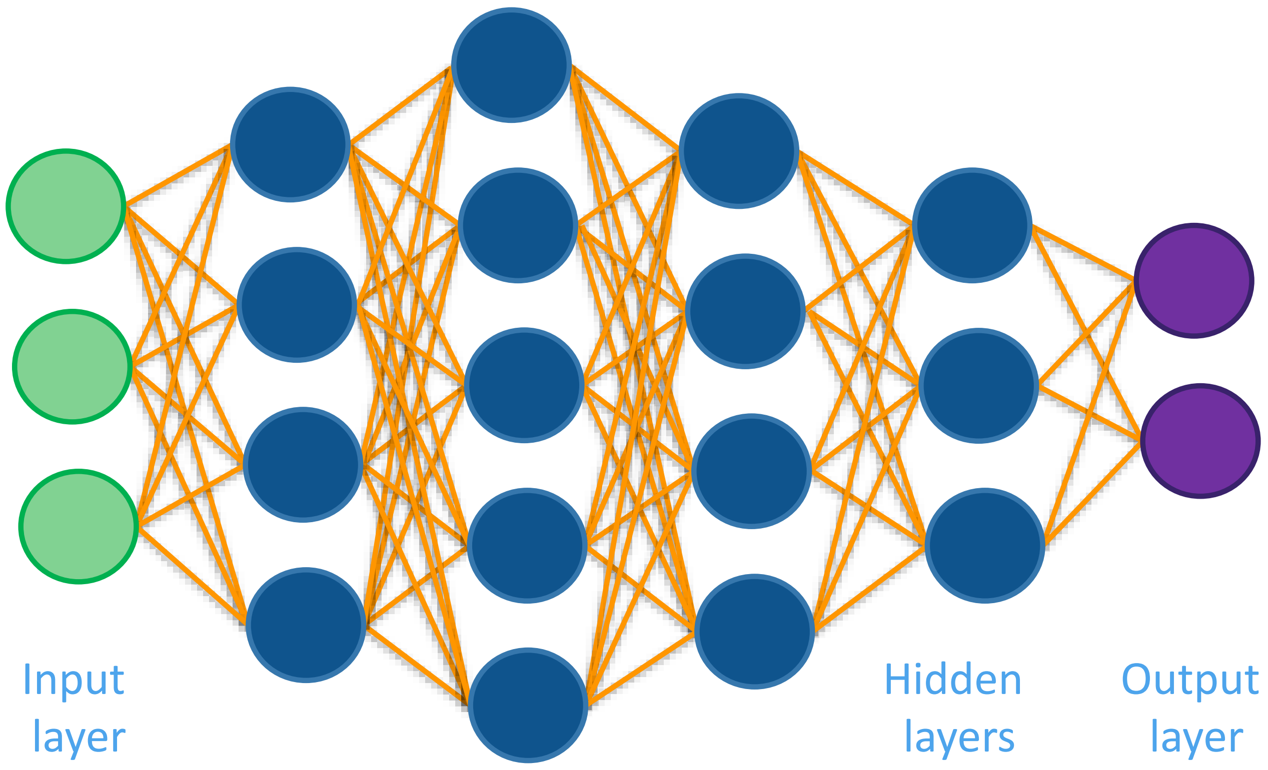
Machine Learning

- Algorithms used by computer systems to perform a task when explicit instructions are not available
- Can improve performance with training
  - Training is based on a model of a real-world process
  - "All models are wrong, but some are useful." (attributed to George Box, statistician)
- Many everyday applications such as streaming recommendations



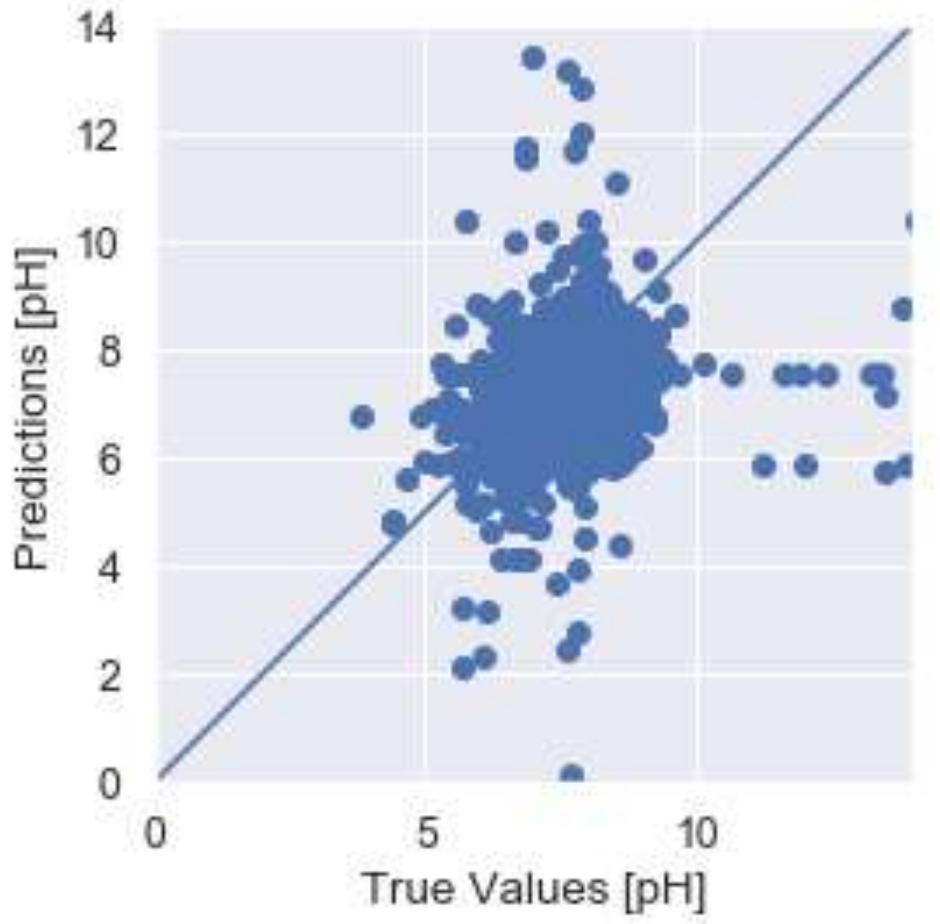
Deep Learning

- Neural Networks – designed after human nervous system
- Independent logic inside each node



Predictive Analytics

- Use of statistical techniques to make predictions based on existing data
- In terms of safety, can help alleviate risk of human error
- Most likely will not provide the exact value of a parameter, but a well-designed system can be very accurate
- Amazon "anticipatory shipping"



"It's tough to make predictions, especially about the future."
— Yogi Berra

Poll Question #2

- Has your organization implemented AI?
  - Yes
  - No, but we are planning to soon
  - No, and we have no plans to do so

Data Requirements

- Accurate AI systems require aggregate data from many sources, especially for prediction
- The data obtained must come from accurate sources
- Collected data must be an appropriate input
- Need one system of record
- Turning data into information

Data Collecting

- Cloud systems
- Shared Platform
- Internet of Things
- Big Data

Current Centralized Model is Unsustainable

THE WALL STREET JOURNAL

A2 | Saturday/Sunday, March 9 - 10, 2019

U.S. NEWS

THE NUMBERS | By Jo Craven McGinty

Forget Gigabyte, Even a Yottabyte Won't Do

Richard J.C. Brown, a British chemist who studies weights and measures, has a big idea: He wants to name the next set of prefixes used to identify gargantuan numbers.

To facilitate international trade, manufacturing and scientific communication, most countries use a standard system of units sanctioned by the International Bureau of Weights and Measures. The seven base units include the

without expanding the list of prefixes, there will be no way to talk about the next great chunk of numbers.

Even worse, dilettantes could fill the void by popularizing glib prefixes such as bronto or hella—terms that have already won fans.

Without professional intervention, Dr. Brown fears, the next numerical prefix could become the Boaty McBoatface of weights and measures.

"The most dangerous thing for people who set rules is that these prefixes get so widely adopted, they become de facto the names,"

Counting Up

The largest named prefix for a number is yotta, or 1 followed by 24 zeros, also known as septillion. A British metrologist proposes adding prefixes for even larger numbers.

VALUE: Thousand, Million, Billion, Trillion, Quadrillion, Quintillion, Sextillion, Septillion

1,000,000,000,000,000,000,000,000

PREFIX: kilo, mega, giga, tera, peta, exa, zetta, yotta

Source: National Institute of Standards and Technology

naming conventions: ronna and quecca for octillion (27 zeros) and nonillion (30 zeros)

more than a century has been tied to the mass of a metal cylinder sanctioned in 1889 and stored in France. The new

executive secretary, Estefania de Mirandes, declined to speculate, and even if the committee likes the idea, final approval would take years.

2022, then in 2026."

Even then, the proposal could be rejected.

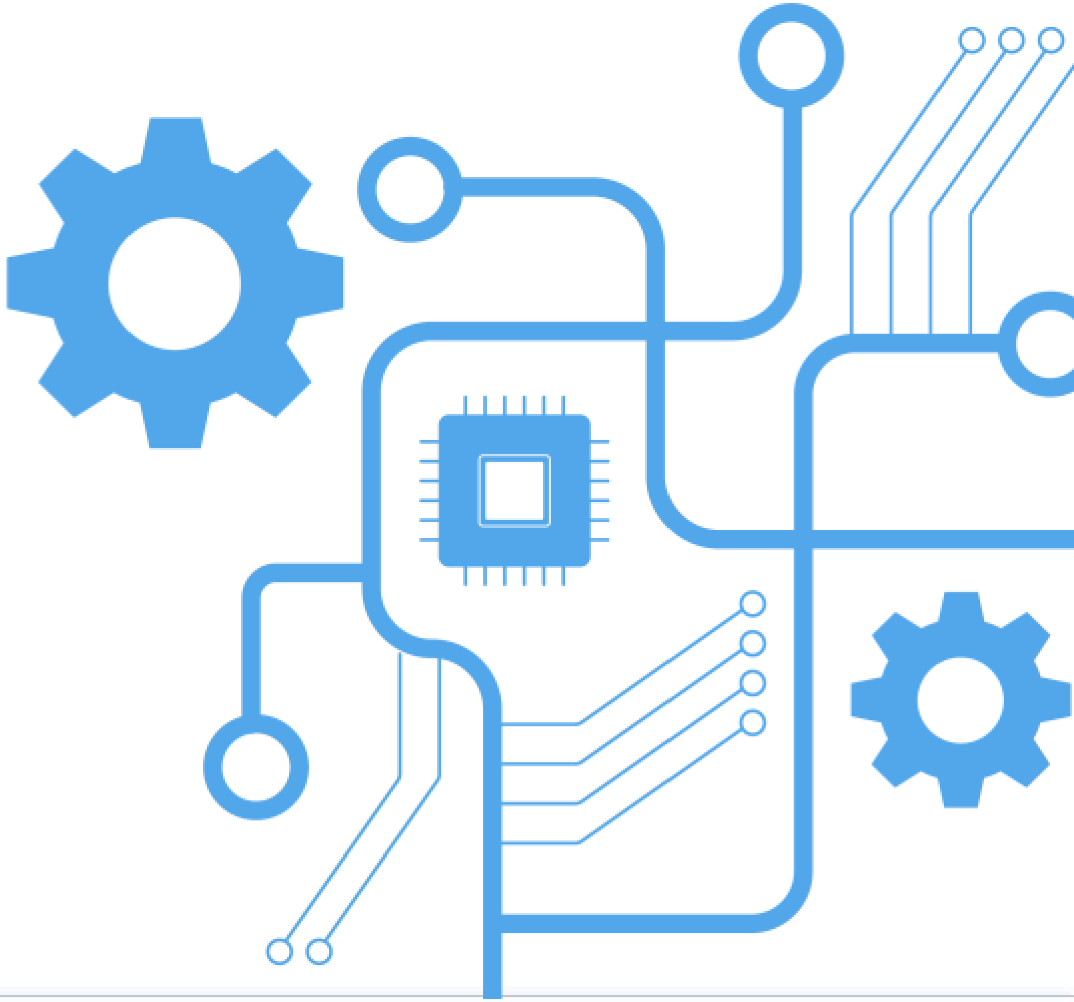
A potential sticking point is that Dr. Brown's primary reason for coining the terms is to ensure that big data can grow even bigger with a vocabulary to match.

Computer scientists and engineers, borrowing official prefixes, already use megabyte, gigabyte and terabyte to describe the capacity of a computer hard drive. But "byte" isn't a unit under the control of the Bureau of Weights and Measures, and serving the data community isn't traditionally a concern of the bureau.

In addition, since the last

Big Data

- Extremely large data sets and the field involved with analyzing them
- Too large for human analysis
- Can provide insights into many aspects of life and society

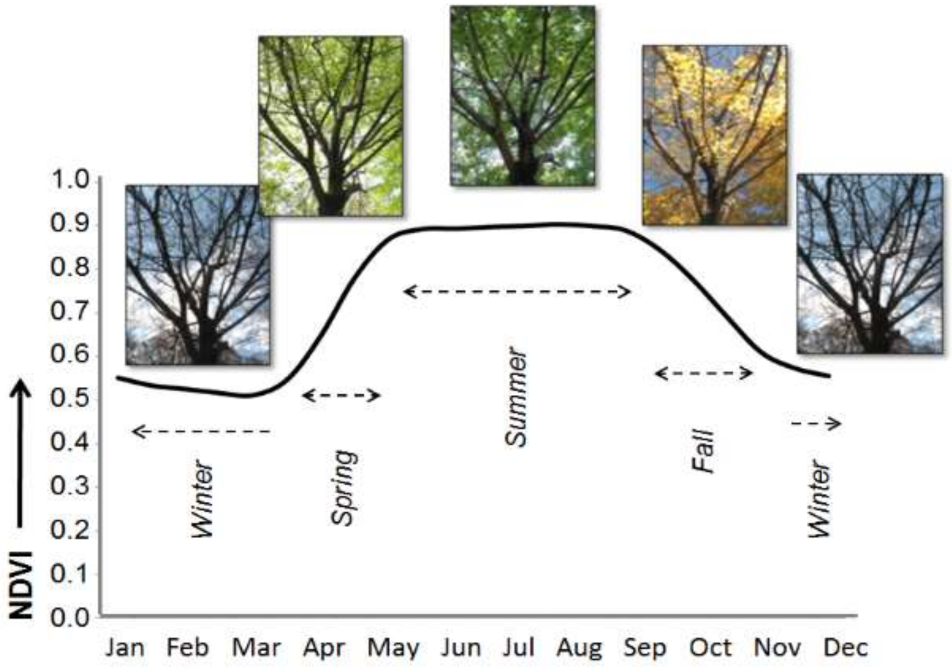


Case Study: Forest Disturbance Monitoring

- Forests change naturally through the year as trees green up in the summer and then brown down in the winter

- This cyclical pattern can be disturbed by many things:
  - Diseases
  - Pests
  - Weather
  - Climate change

Image from USFS's ForWarn



Vegetation change through the year

Case Study: Forest Disturbance Monitoring

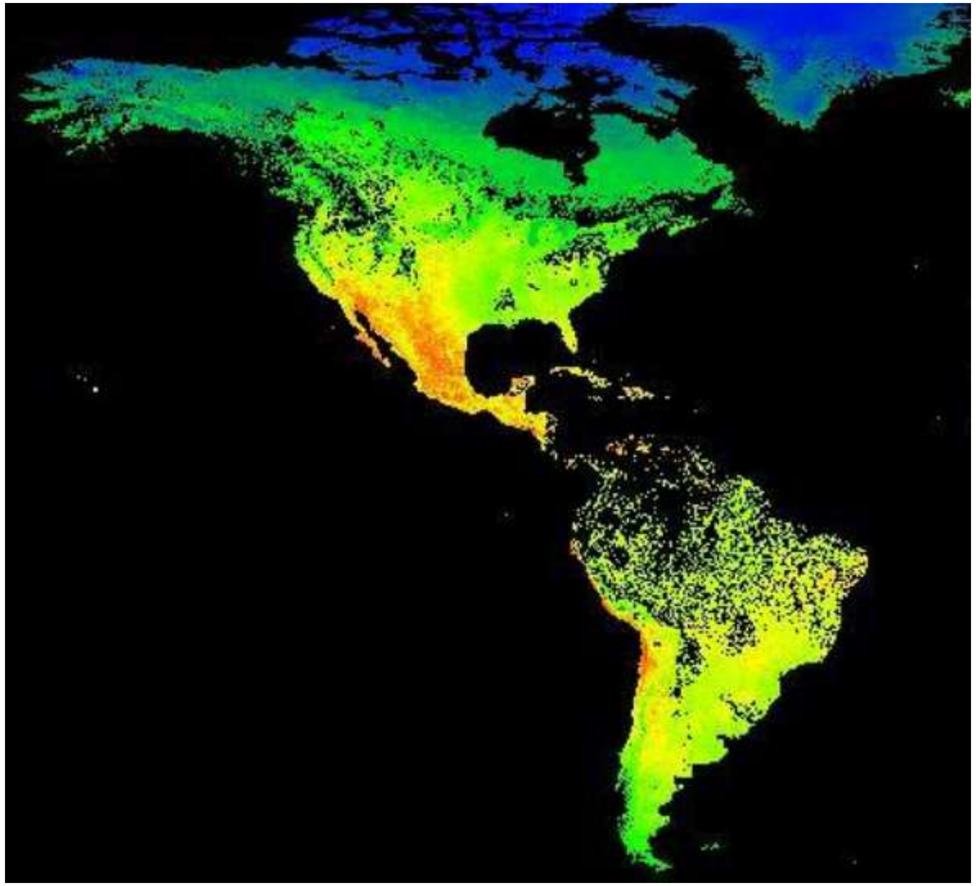
- Early identification of these disturbances is critical for natural resource managers to understand and respond to these threats
- Aerial and ground surveys can find disturbances
- In the United States, there are just too many acres of managed forests and crops for regular visual inspection

Images from USFS

Case Study: Forest Disturbance Monitoring

- Daily satellite images can be used to identify regions affected by disturbances
- The imagery is processed to show change in vegetation from the normal level
- https://forwarn.forestthreats.org/

Image from USGS EROS

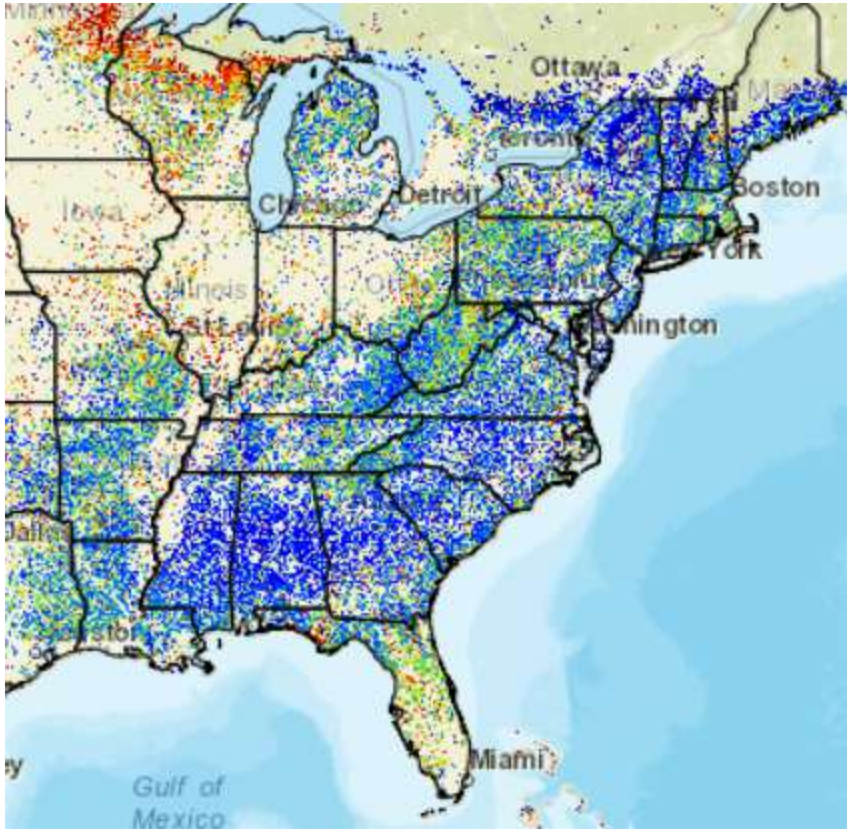


Example of daily satellite image from NASA

Case Study: Forest Disturbance Monitoring

- Again, though, there are too many images to manually inspect them
- Neural networks (deep learning) can be used to automatically identify disturbances and alert managers

Image from USFS ForWarn

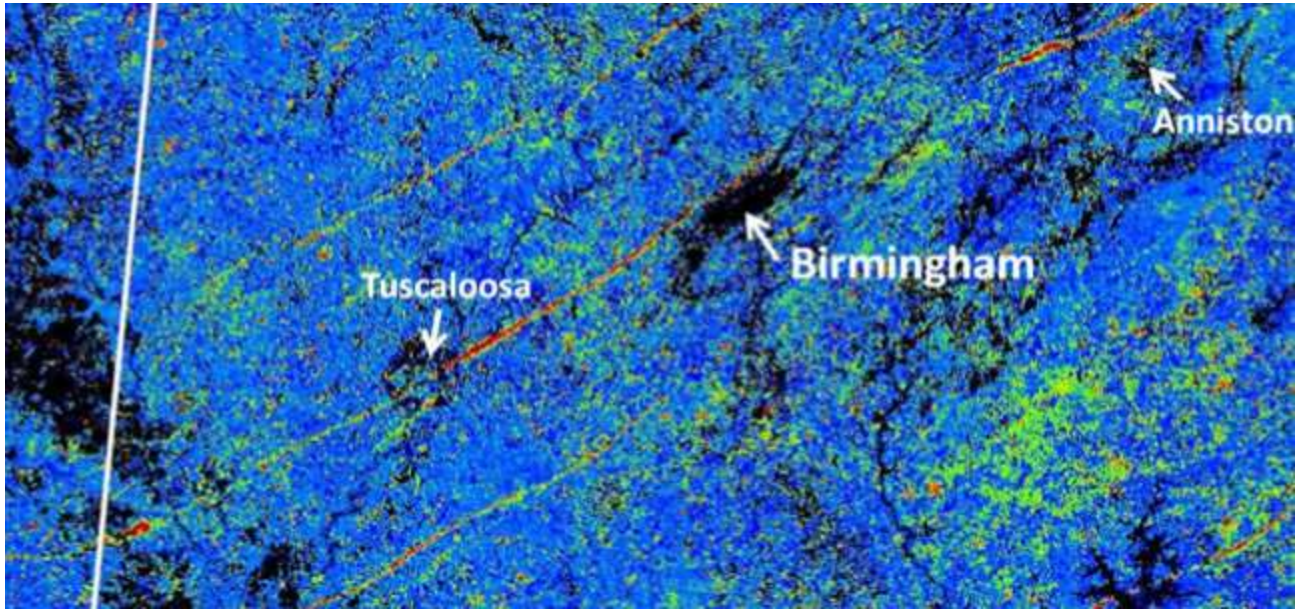


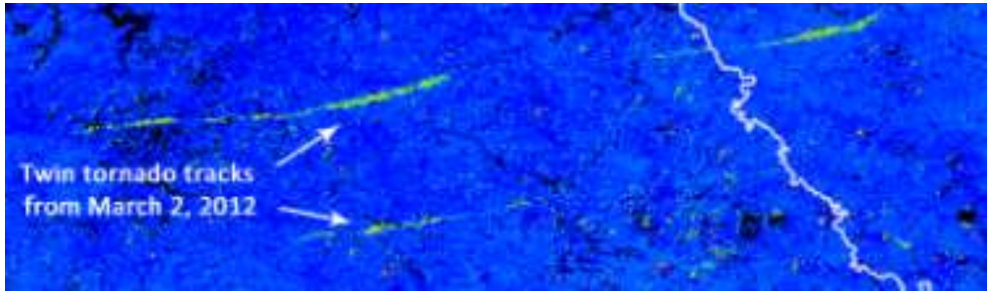
Example of vegetation change
(red below normal, blue above normal)

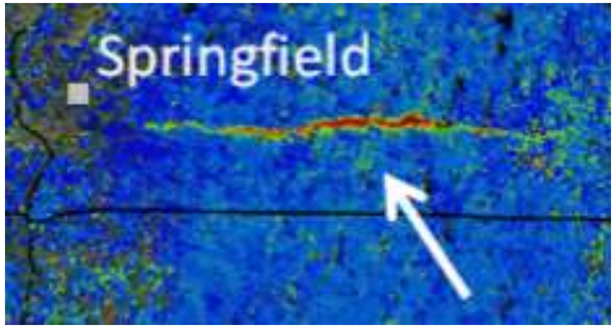
Case Study: Forest Disturbance Monitoring

- To train the network, known disturbance patterns must be fed into the system

- Here are examples of vegetation differences due to tornadoes



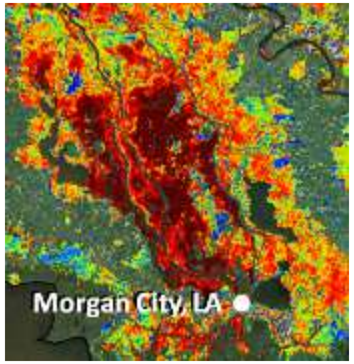


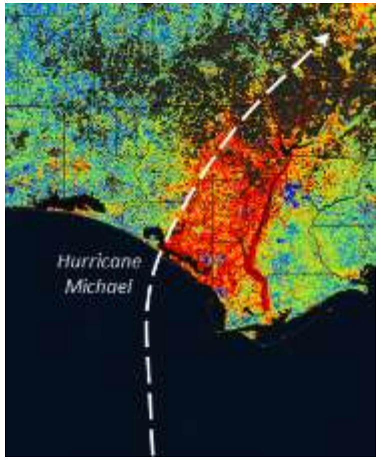


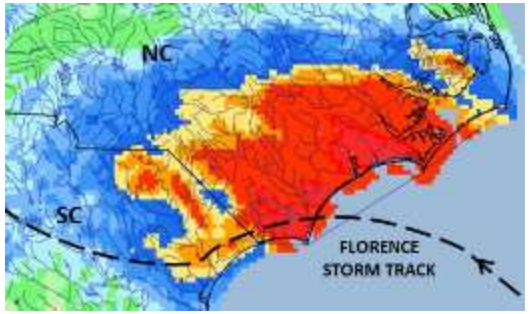
Images from USFS's ForWarn

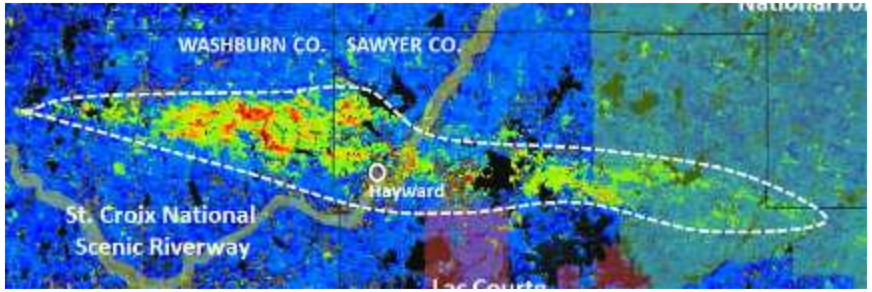
Case Study: Forest Disturbance Monitoring

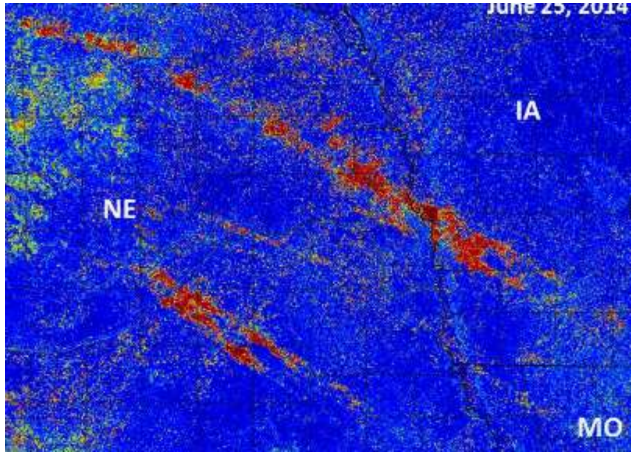
- Different disturbances show different patterns
- The first row here shows <u>flooding</u> and <u>hurricanes</u>; the bottom row shows <u>hailstorms</u>

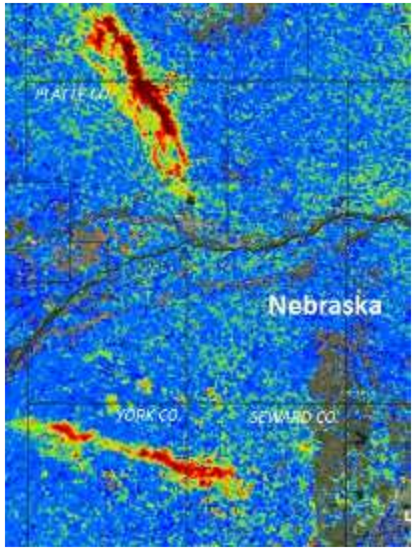








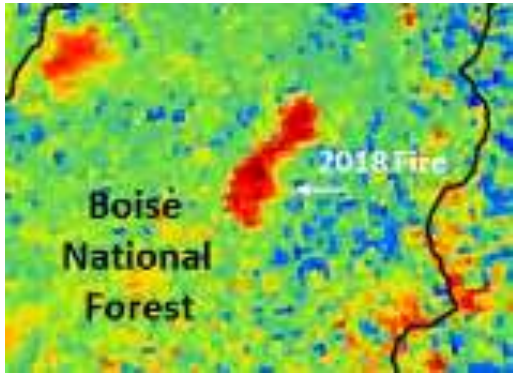


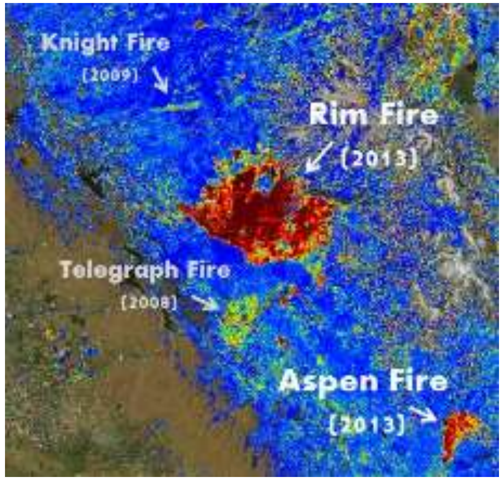


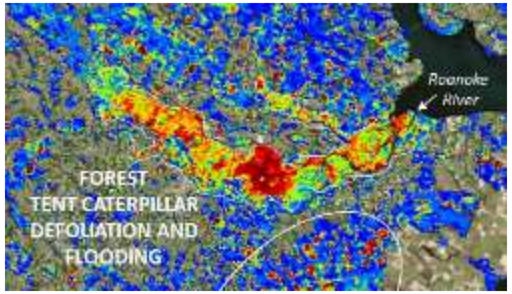
Images from USFS's ForWarn

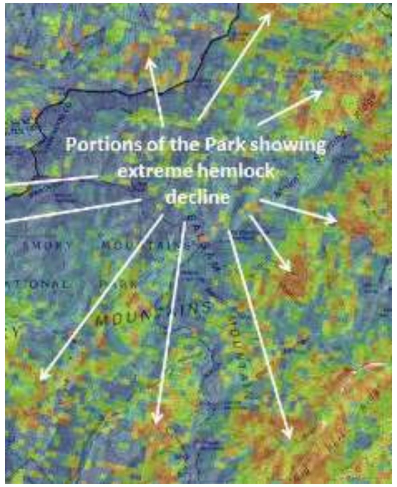
Case Study: Forest Disturbance Monitoring

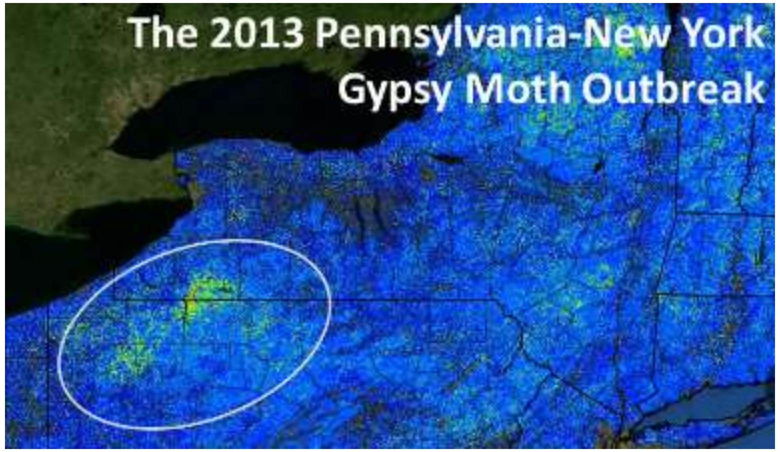
- Here are vegetation patterns from other disturbances including wildfires and various insects







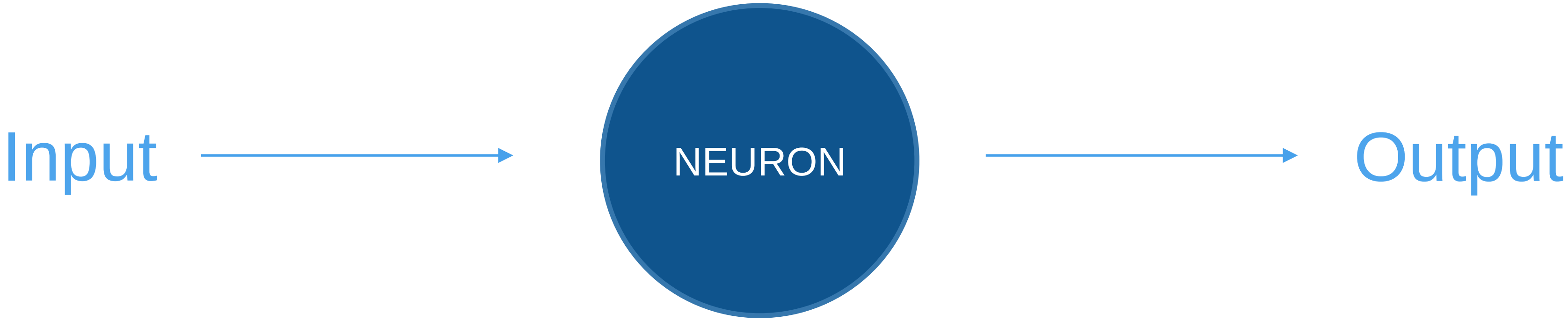




Images from USFS's ForWarn

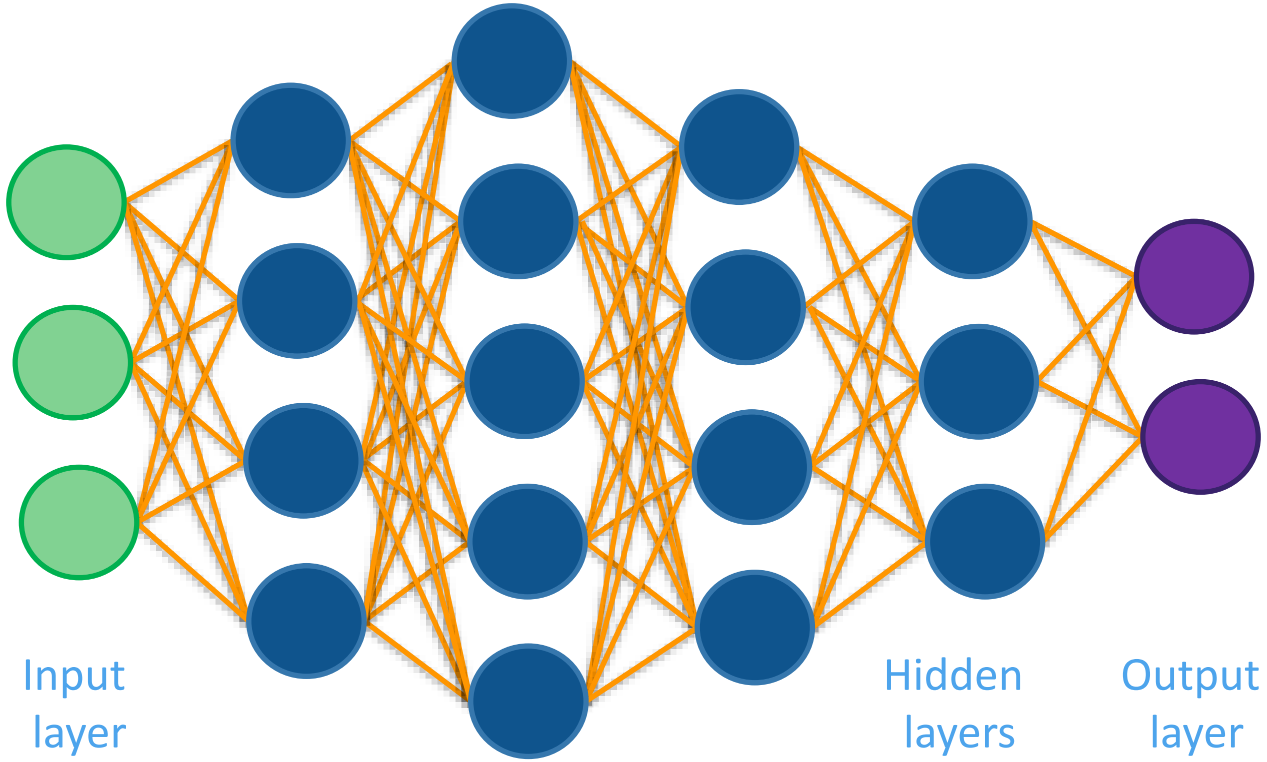
Case Study: Forest Disturbance Monitoring

- A neural network consists of multiple units called neurons
- Each neuron is a distinct model that takes some input, processes it, and returns some output
- A neuron by itself is not powerful; multiple neurons working together can do much more



Case Study: Forest Disturbance Monitoring

- Neurons are organized into layers of increasing complexity
- Each layer feeds into the next layer
- The layers between the Input and Output layers are "hidden" and are what makes deep learning "deep"

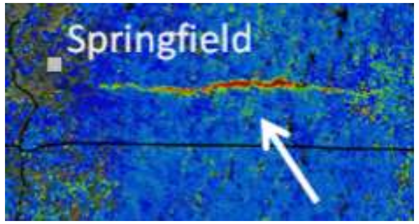


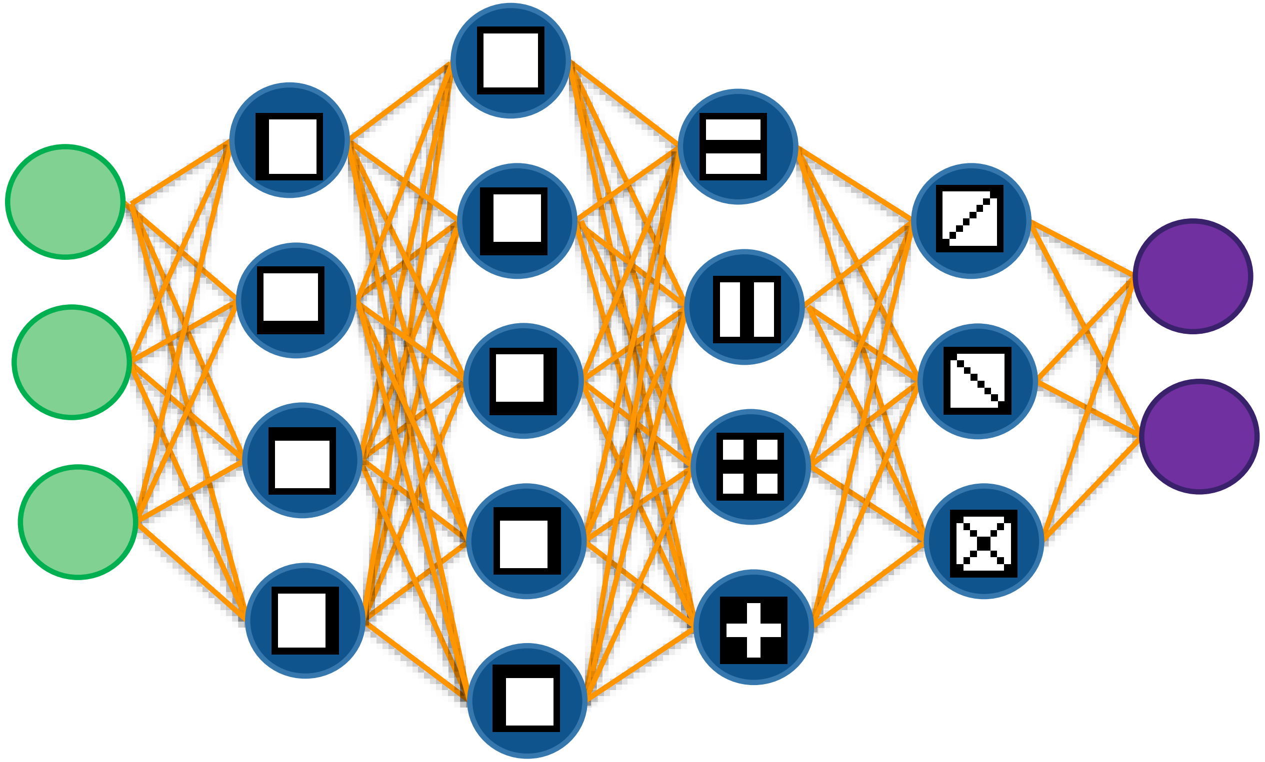
Case Study: Forest Disturbance Monitoring

- For our forest disturbance model, each neuron recognizes a specific pattern of pixels in an image

- These patterns are very low level

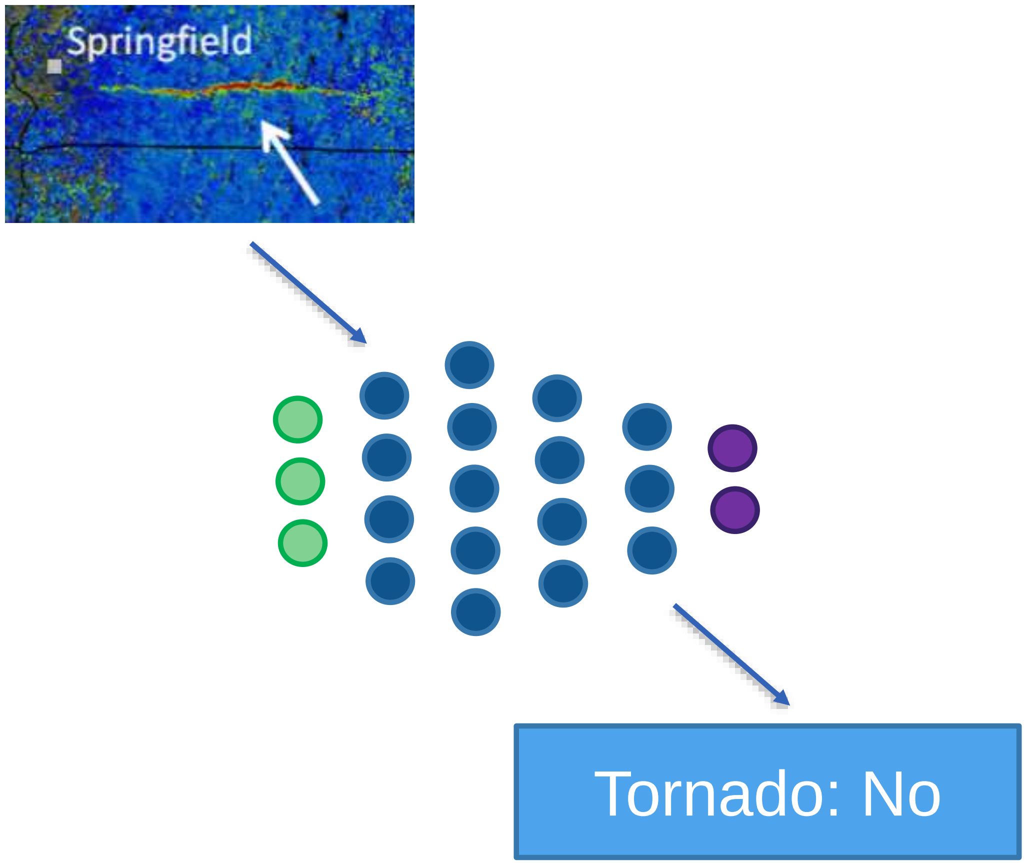
- Combined, the neurons can recognize high level patterns that point to a specific forest disturbance





Case Study: Forest Disturbance Monitoring

- For training, known disturbances are fed into the network and compared to the output
  - If the output is not correct, the neurons' models are tweaked and the network run again
  - Only adjustments that improve the output accuracy are kept
- The training stops when the output matches the expected results
- In this way the model trains itself by evaluating its own performance



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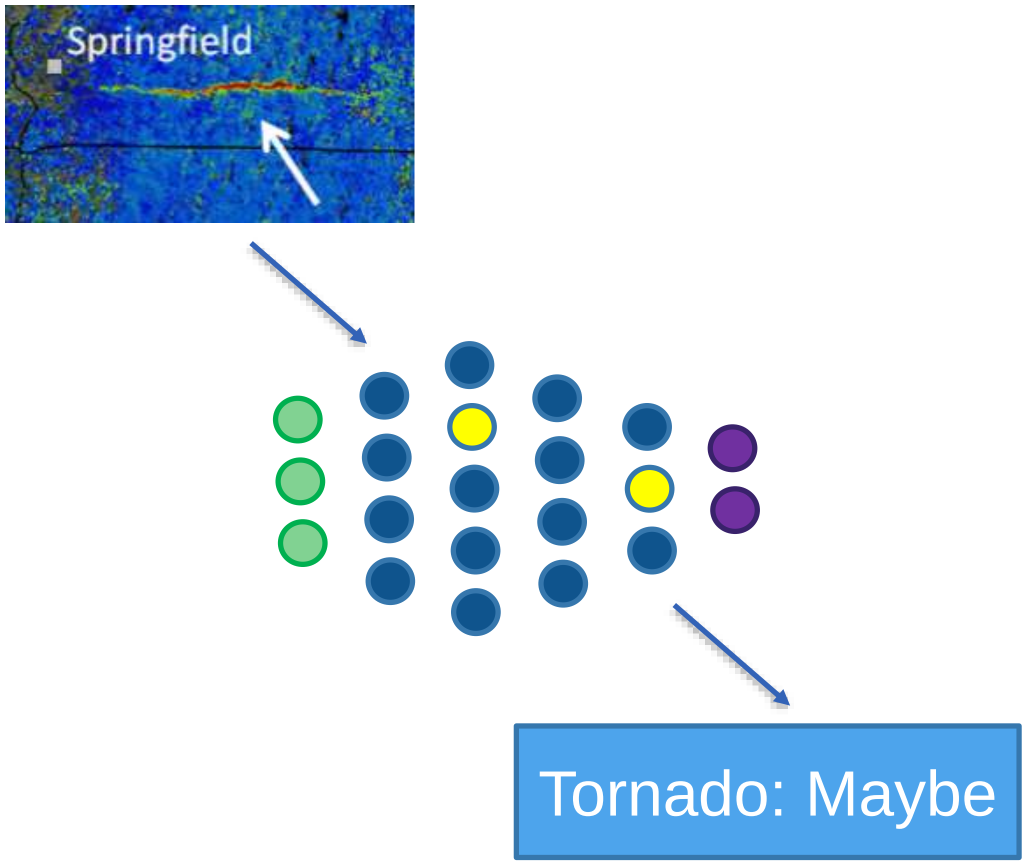

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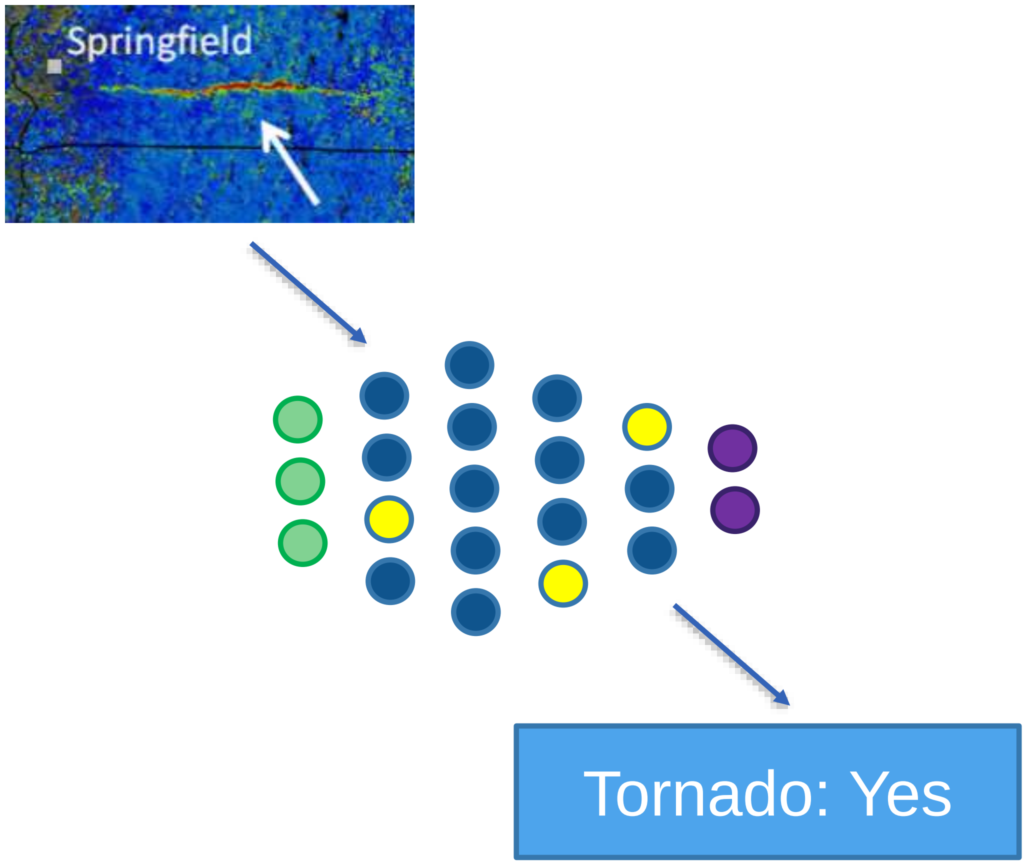
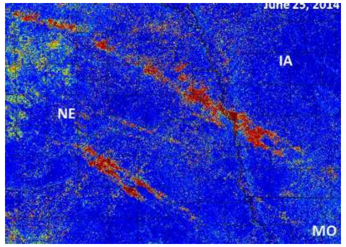
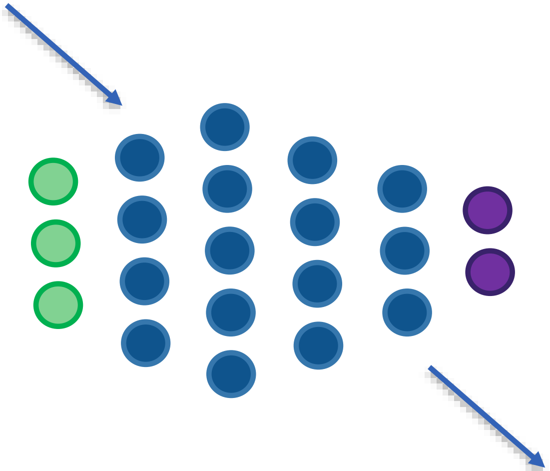


Case Study: Forest Disturbance Monitoring

- The network must be trained for different disturbances
- Multiple examples of each disturbance are needed
- Disturbances not considered will not be recognized





Tornado: No
Hail: Yes

Case Study: Forest Disturbance Monitoring

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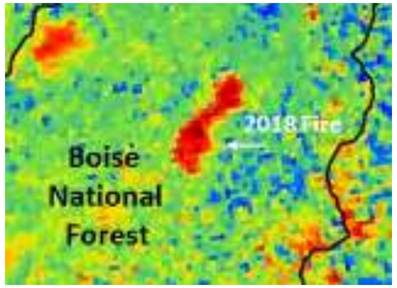

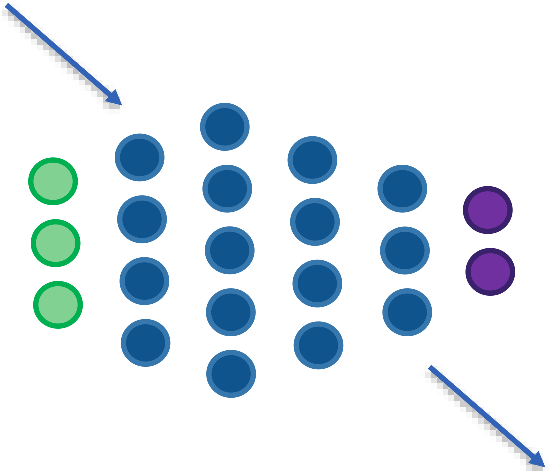

Tornado: No
Hail: No
Fire: Yes

Case Study: Forest Disturbance Monitoring

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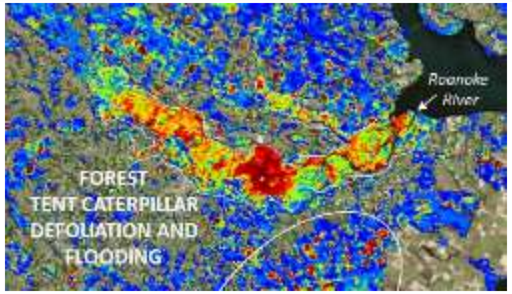
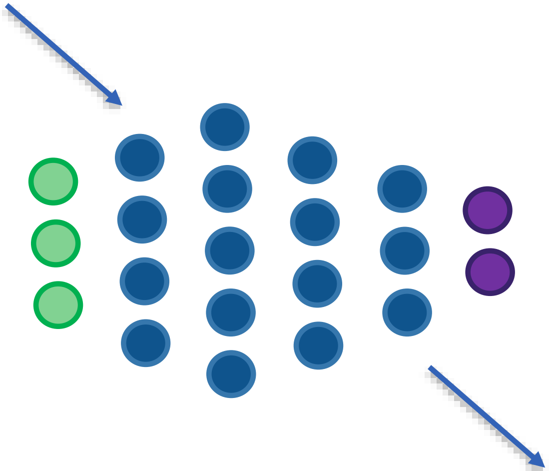
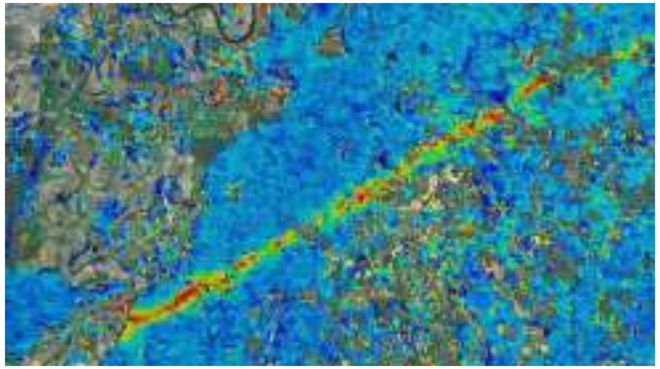


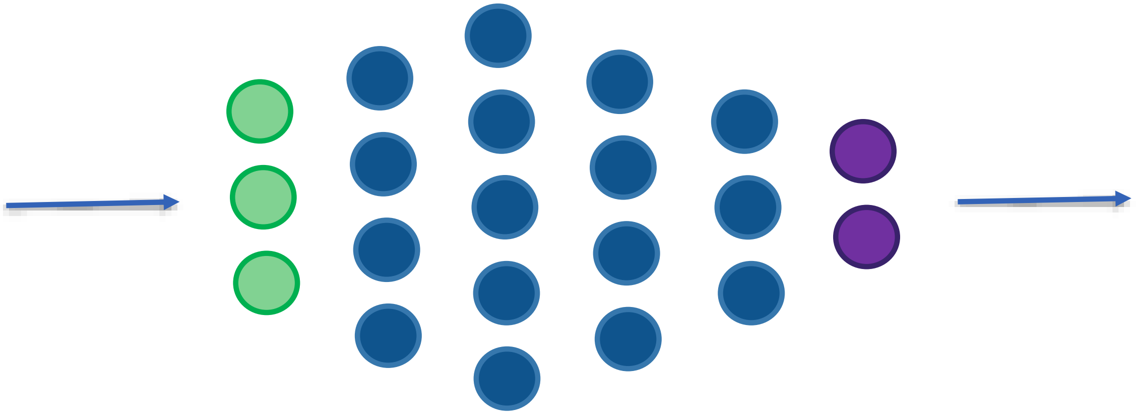


Tornado: No
Hail: No
Fire: No
Insects: Yes

Case Study: Forest Disturbance Monitoring

Once trained, the model can be used to analyze images and identify disturbances





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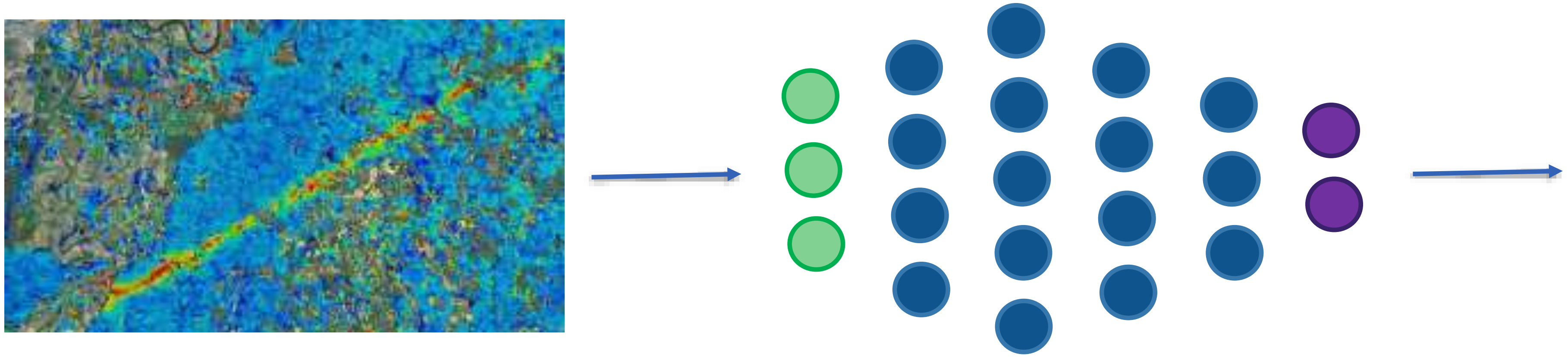

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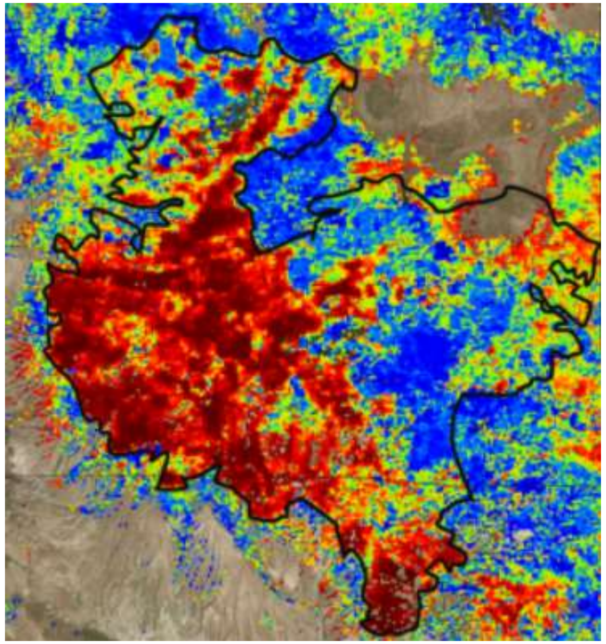

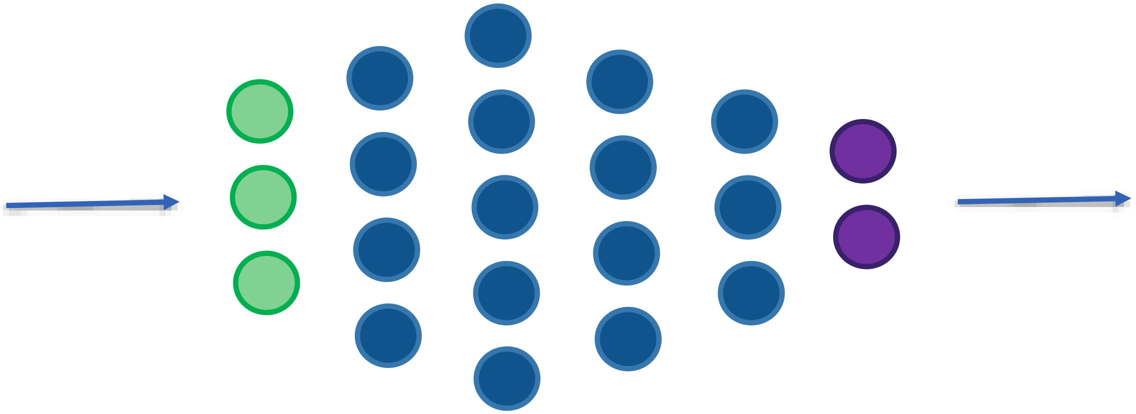

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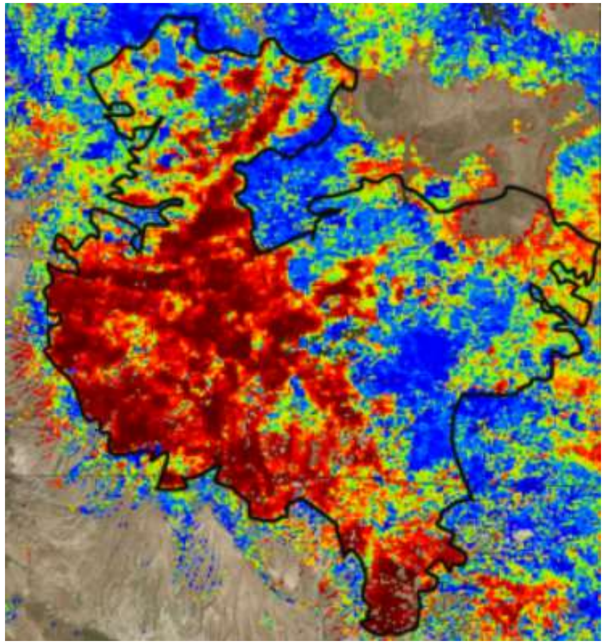

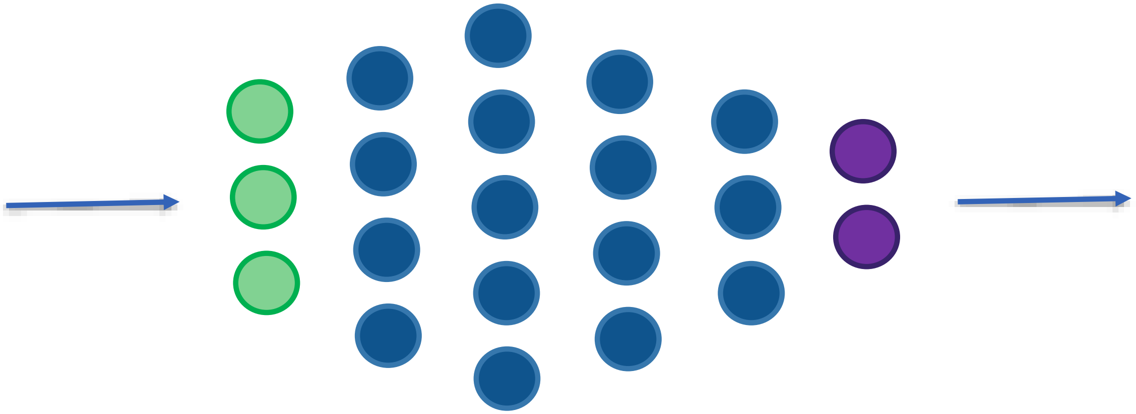

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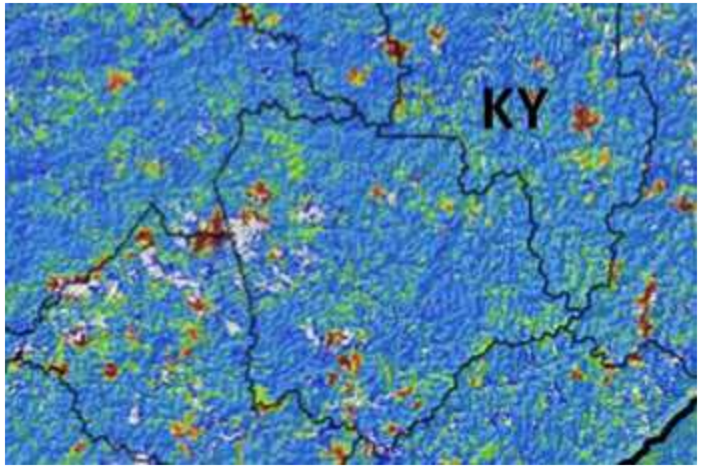
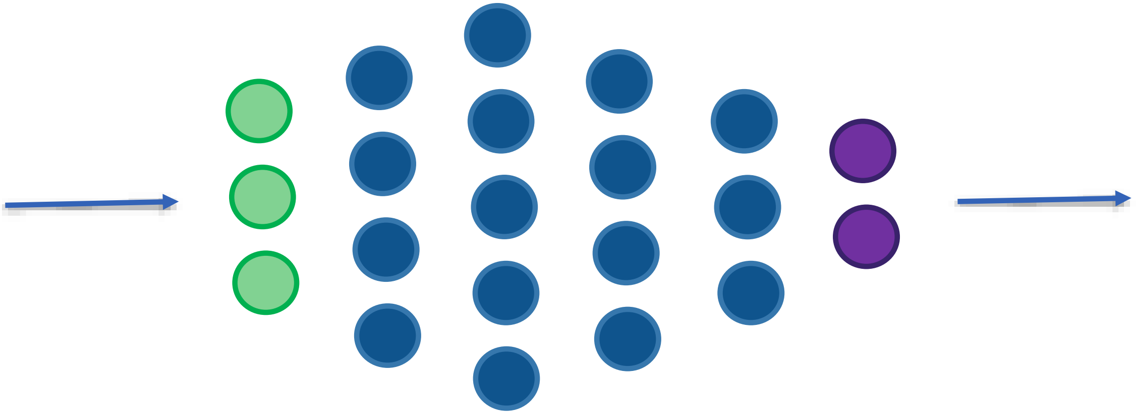
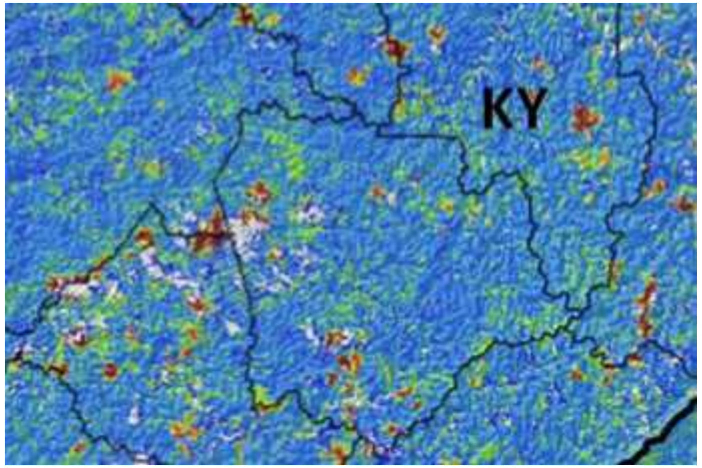
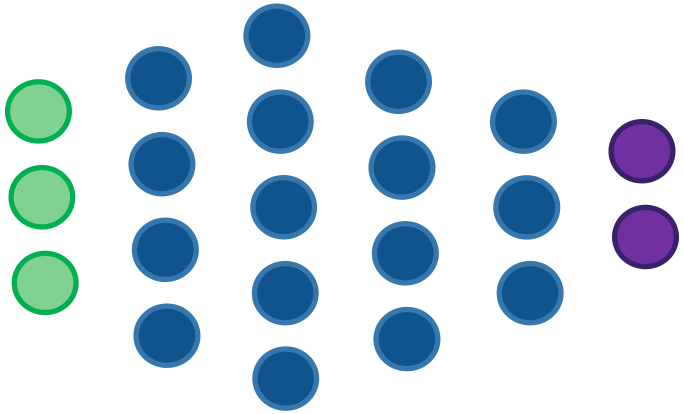




Case Study: Forest Disturbance Monitoring

Disturbances not considered will not be recognized; the model must be trained for them





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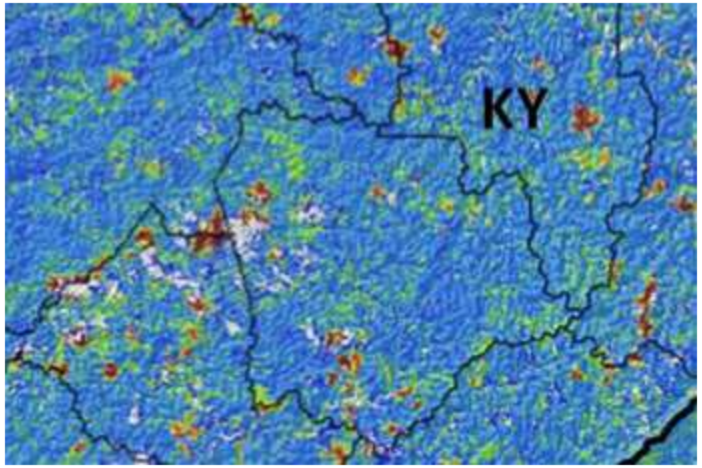

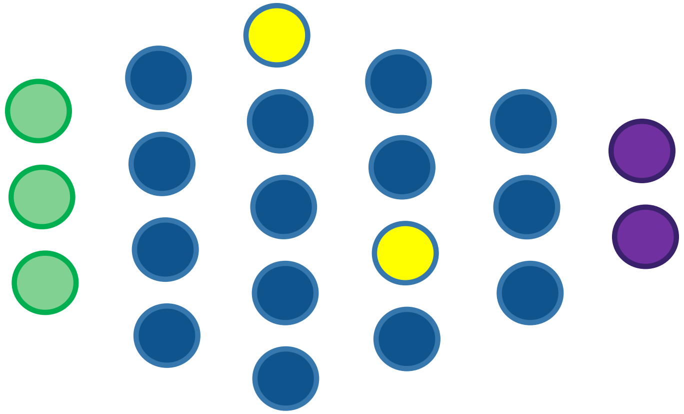

Tornado: No
Hail: No
Fire: No
Insects: No
Strip mine: Yes

Case Study: Forest Disturbance Monitoring

- Positives:
  - Disturbances can be identified automatically and in real-time without manual surveys or analysis of images
  - Disturbance identification is cheaper and faster
  - Managers and landowners can get notices much quicker
- Caveats:
  - Must spend time and effort training network on different disturbances
  - Cannot handle previously unknown disturbances
  - Should periodically 'ground truth' findings

Case Study: Forest Disturbance Monitoring

- A successful deep learning implementation requires good training, which requires good data
- For this case study, there are special considerations
  - The normal baseline can change, especially with climate change
  - Data must span different time scales
  - Data must span different spatial scales
- Bottom line: a significant investment may be needed for developing a well-trained network

EHS&S Examples

- Health
- Safety
- Compliance
- Sustainability
- Water Quality

Health

- Deep Genomics uses AI to develop new drugs
  - Helps find compounds to target specific diseases, and to predict effects on humans taking new drugs
  - Reduces time and cost to bring new drugs to market
  - A successful model would reduce the amount of clinical trials and human testing needed
  - The first of Deep Genomics compounds will be tested this year

Image from Getty Images

Health – Coronavirus

- AI speeds up genome sequencing
- AI can mine recent research, searching for patterns and common factors in outbreaks
- Potential problems:
    - Misleading and Insufficient data
    - Limitations
    - Difficulty of modeling

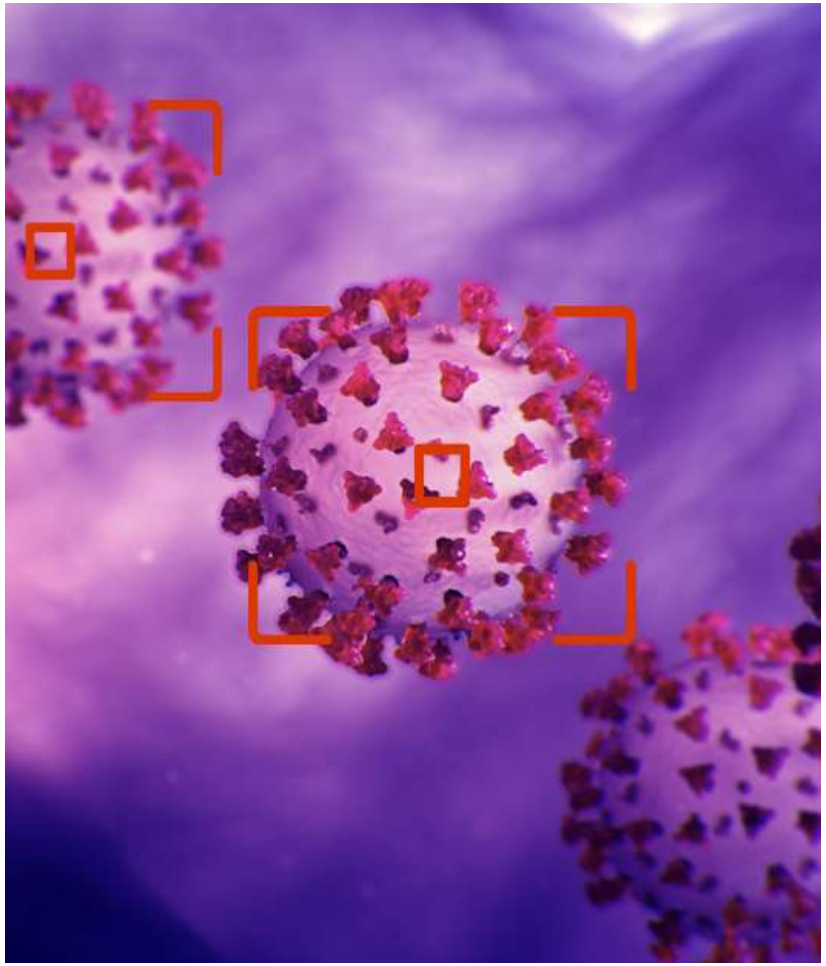

Image from Futurism.com

Safety

- Wearables
- Ability to predict proximity to equipment or in certain areas
- Given appropriate data, AI can monitor equipment and forecast failures or accidents
- AI-monitored safety gear in the workplace

Compliance

- AI systems can scan EHS permits and regulations in order to extract requirements, potentially eliminating weeks of work

- Pitfalls:
  - Effect of misinterpreting permits (they must be accurate)
  - Unlike with prediction, "good enough" is not sufficient

Sustainability

- Currently available AI technology could reduce US energy use by 12 to 22 percent
- Land: Erosion monitoring, migration tracking, poacher route prediction, effects of natural disasters
- Air: Air quality monitoring, reduction of traffic (dynamic routing, intelligent stoplights)
- Water: Tracking marine litter, improving water management systems

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Water Quality

- Predictive AI systems can analyze the parameters of water sources and estimate a water quality index (WQI)
- A well-constructed system removes the need for extensive lab analysis
- Aids identification of poor quality water before it is released for use
- Alerts for bad conditions, certain bacteria/viruses
- Pitfalls: More parameters lead to a more complex system
- Study: Predicting Water Quality with Machine Learning

Poll Question #3

- If you're not using AI, what is stopping you?
    - Budget
    - Implementation
    - No need for it

Where to Start

- Identify needs for AI – where can it make a difference
- Identify Identify appropriate data inputs for the model
- Collecting data – this is often the biggest cost and hurdle
- Standardization
- Shareability, industry groups
- Where can you improve productivity
- Uniform set of applications

Takeaways

- Blog: Artificial Intelligence for Environmental Compliance
- Why is AI coming up now
- Isolation as an environmental science dataset, reduction in traffic has led to marked improvements in air quality, how it will progress after things go back to normal

Thank you!

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Sustainability Impact Conference

- **Aug 3-5**

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Thank you for Attending!

A recording will be available in 3-4 days. You will receive an email once it's posted to our site.

Have a safe & healthy day!

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