In the know. Can artificial intelligence interpret camera trap data from the Kaua'i forest?

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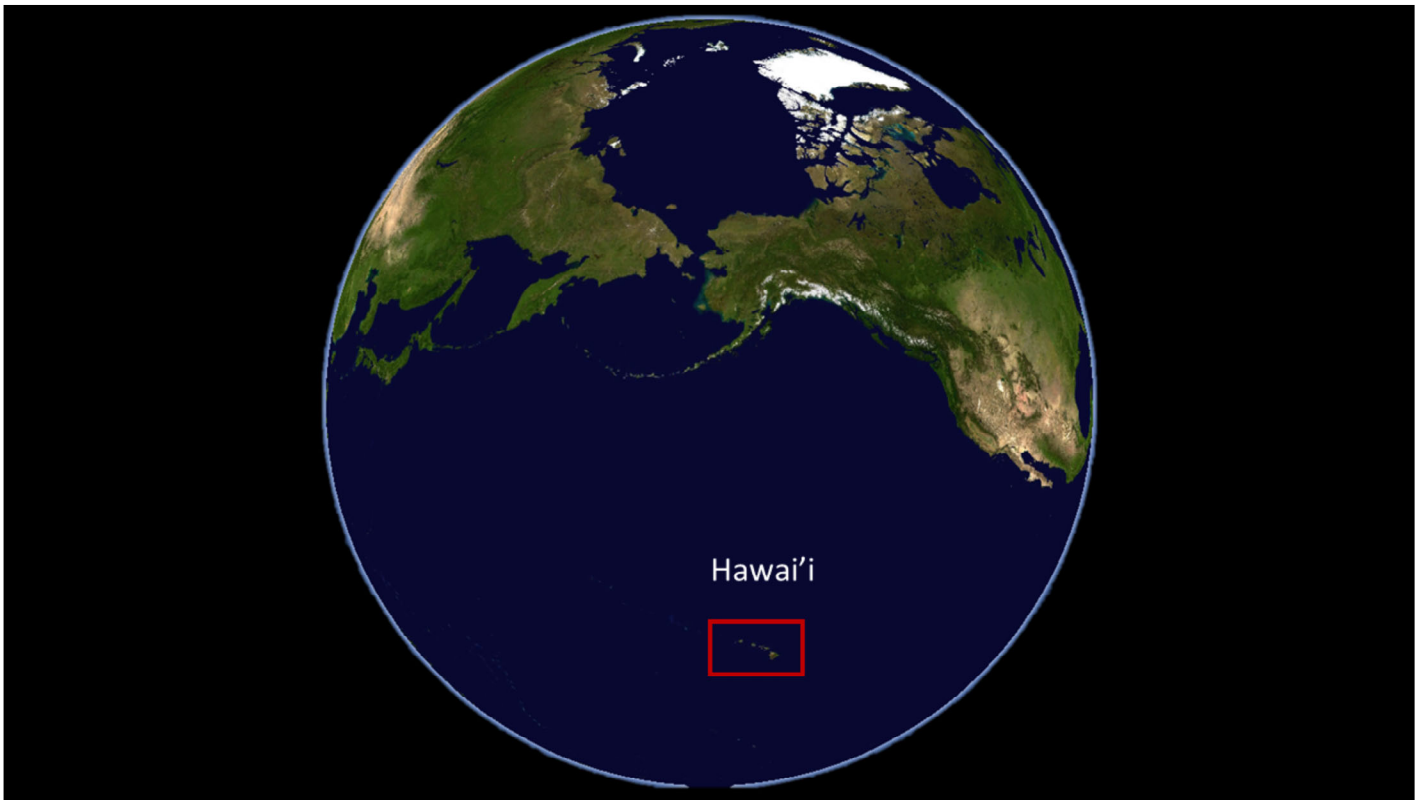
I'm Mari Reeves, PhD Ecologist with Strategic Habitat Conservation Group of the Pacific Islands Field Office

Going to talk to you about photos, rats, endangered Hawaiian birds, traps, cameras, and artificial intelligence in Hawaii.

My primary goal is to link these disparate things together, as I describe a project we've been working on since January. My secondary goal is to keep you awake. So I have some fun surprises in here…

It's still a work in progress, not perfect yet, not finished yet, looking forward to feedback



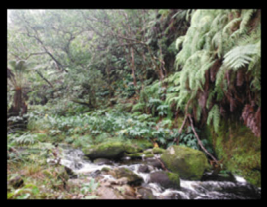
Where in the world are we?? In the Hawaiian Islands, which you will notice are in the middle of the Pacific Ocean

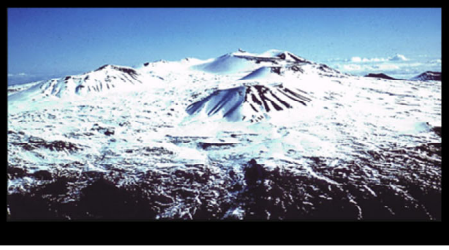
High Biodiversity

Old islands + Varied topography + Consistent weather patterns =

Multiple habitat types

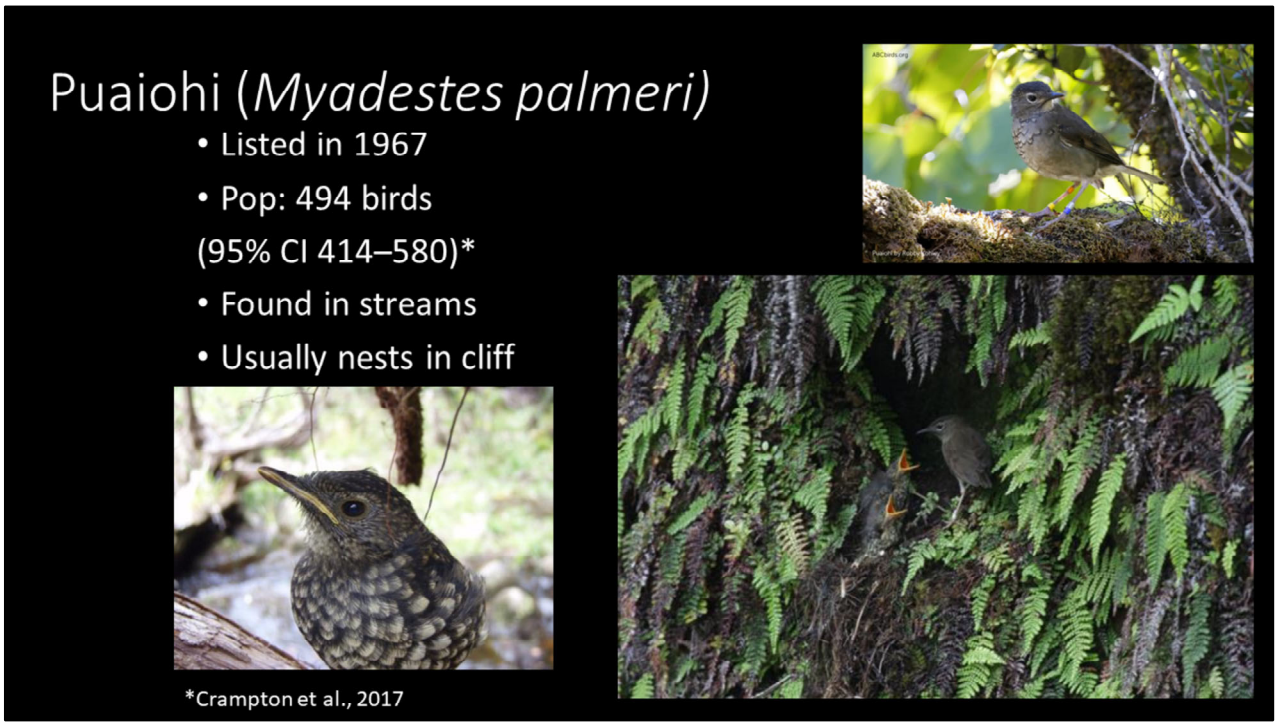
(many niches)





They are also somewhat tall (Mauna Kea is nearly 14K ft asl,) and fairly old. Most of them tend to have a dry side and a wet side, due to the prevailing climate.

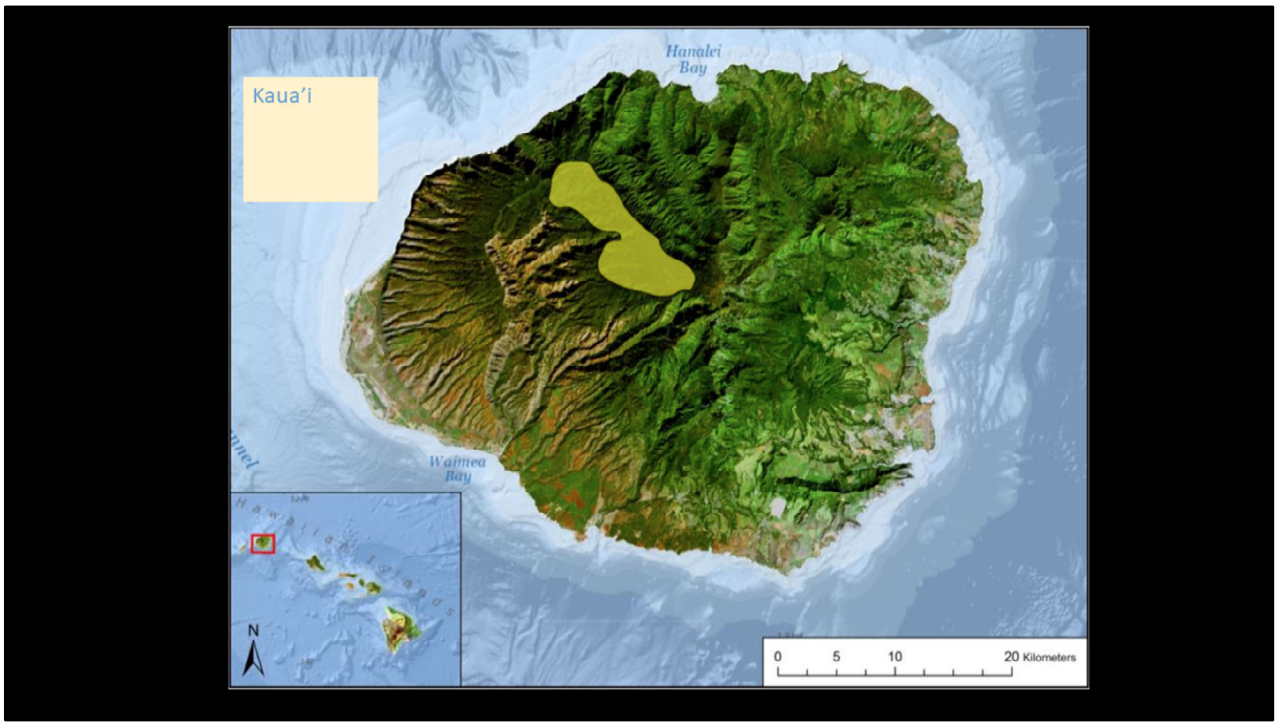
This leads to multiple niches and very high biodiversity in the Hawaiian islands. Lot of challenges in conserving this biodiversity and one of our friends that we are trying to conserve is …



Leads to the first star of our show, the Puaiohi – it says its name

Population estimate is based on studies published by my co-author on this talk, Cali Crampton and others, but these were done before some of the habitat management activities I'm about to talk about today, and they have not been re-don, so it's difficult to assess the impacts of the habitat management on the population, but that is a talk for another day.

*12 streams: 250 stations 5 times each, more than 1000 17-min surveys



So, specifically on Kauai island, the Puaiohi and several other endangered passerine species only remain on the Alakai plateau.
Historically *many* of the forest birds were found all over the island, down to the beaches and up in the swamp, but today they have mostly been extirpated from these areas.

We know this from the fossil records found throughout the island.

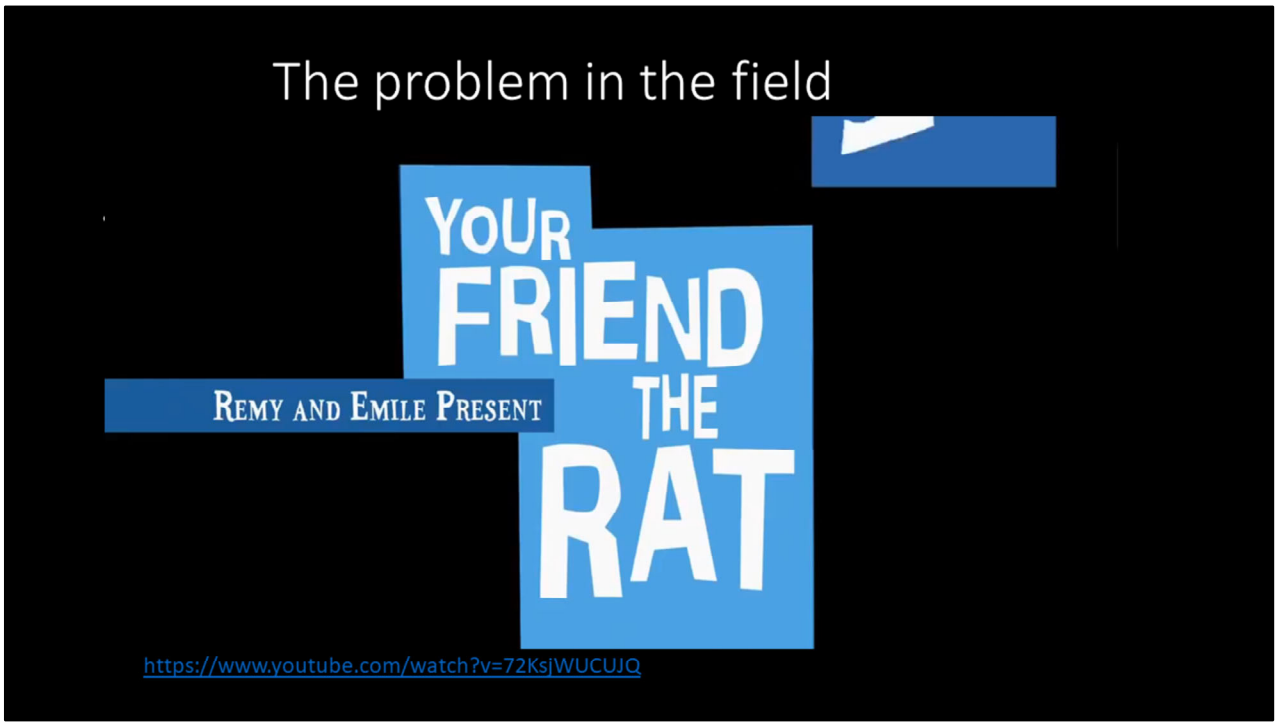
Distribution & Abundance

- Where in the Alaka'i are they?!?!
- Remote, rugged area
- Rare, cryptic species

→ Technology!

Distribution and abundance is challenging to map, and KFBRP has been doing a lot with technology. With remote cameras, remote audio sensors, radiotelemetry. It's difficult to get to these areas and the species themselves are cryptic. So I'm going to describe one of the uses of technology, which is using camera traps, and trying to use AI algorithms to sort through some of those camera trapping data.

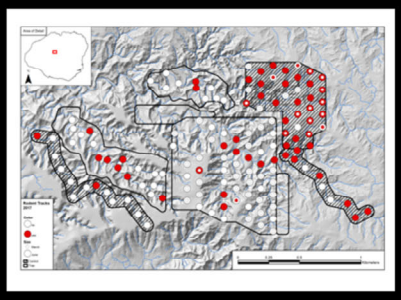
Little more background on the Puaiohi and other endangered forest birds in Kauai, they face numerous threats including human industrial development, changing patterns in climate, including more intense storms, floods, and hurricaines, invasive plants and animals, like our friend the pig, invasive mosquitoes (there are no native mosquitoes in Hawaii, as my colleague Adam was describing) that transmit avian malaria to them, and invasive diseases, like the newly introduced fungal pathogen causing rapid ohia death, and by killing off a keystone species, altering the structure of the forest. But from here I'm going to focus on the second star of our show….



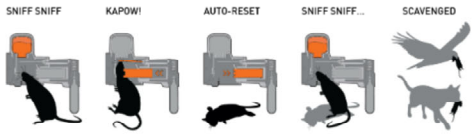
So that is a clip from one of my absolute favorite Pixar short films, this is my gift to you in the post-lunch hour in hopes you would be entertained. And if you do anything with rodent management, I highly recommend that you watch the entire short, you can find it on YouTube

Waging that war in Hawaii

- Rat trapping grids…
- Decrease nest predation
- Increase juvenile and female survival



How it Works https://www.automatictrap.com/



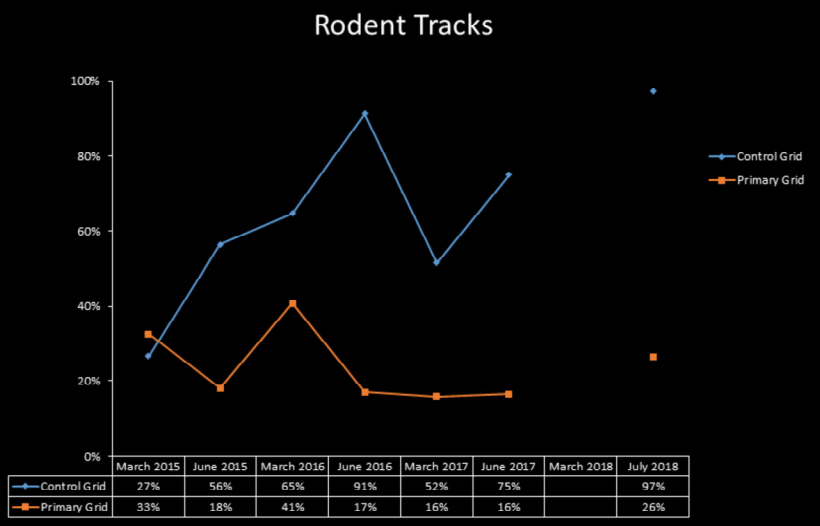
So in terms of waging the war against invasive rats in Hawaii, our partners and KFBRP have set up two fairly extensive rat trapping grids using Good Nature's A24 rat traps. The goal of this habitat management action is to decrease nest-based predation, which is what we think is the mechanism of reduced Puaiohi survival and reduced populations.

So in hopes of improving female and juvenile survival, they have been killing rats in the field. They have over 450 traps set out in two grids, the first of these was installed in 2015.

The mechanism of the trap is shown here, there is a bait in the trap, the rat sticks its head into the trap to get the bait, and then is killed by a blow to the head (in a fairly humane way without poisons) and then the trap resets itself and the carcass is scavenged.

Birds, Not Rats!

- Monitor with track tunnels
- At least 4x fewer rodents on trap vs reference grids
- Is it enough?



	March 2015	June 2015	March 2016	June 2016	March 2017	June 2017	March 2018	July 2018
Control Grid	27%	56%	65%	91%	52%	75%		97%
Primary Grid	33%	18%	41%	17%	16%	16%		26%

In terms of rodent control, it really does appear that in the Alakai plateau, where they've had these grids running for several years, that the rodent management is working, that there are fewer tracks in rodent tunnels on the grids than there are in control areas without rat trapping grids in place, where overall they have measured a 4-fold rodent suppression particularly in the centers of the grids, relative to the edges, there are distinct spatial patterns in these data.

But is it enough to increase the Puaiohi population, and other endangered bird populations? Is a question we don't quite have the answer to yet, and also..

Just this year, sd

But…The traps are taking Birds!

Since November 2018, we have found 5 birds taken by GoodNature traps.

Several hypotheses about why:

Increased bird populations

Change in bait type last year

Can trap modifications help?

And a new problem we identified just this year, despite much more frequent monitoring when the traps first went it, more like weekly biweekly monitoring, where we had never seen a take of any of the listed birds, since November of 2018, we have now found 5 of our endangered Puaiohi that appear to have been taken by these GoodNature traps. And at first, we thought it was a fluke, and then with more investigation, we are much more concerned.

WE have several hypotheses about what's happening. Maybe we increased the populations? They started using a different bait type last year, where it used to be more like a pot of bait, that would eventually get moldy and lose its attractiveness to the rats, now there is more of a pump action bait they've been using and we're concerned that it may be attracting the birds, whether directly, with the lure itself being more delicious. Or because the pump action eventually oozes out onto the trap, and may be attracting bugs to it that the birds are trying to eat.

So we're wondering are there modificaitons we can make that will make them safer for birds (and eliminating their take) while still maintaining their effectiveness for rats.

Study: How to maintain trapping efficacy and reduce bird risk?

- "Static" vs "Replenishing" Lures
  - Cheaper, last longer, but less attractive?
- Prevent non-target impacts with "blockers"
  - Effective? Impacts on rat kills?

→ 2x2 Factor design over 120 traps

- Monitor with cameras

We're going to in a 2x2 factorial design compare the static versus automatic lures, and see whether we can reduce take, while still maintaining efficacy with these excluders or blockers on the traps.

So we have ways to count, in terms of monitoring carcasses of rats, or there are these counters we put on the traps that count when it deploys, but we have also acquired ~20 wildlife camerasa so that we can examine bird behavior and rat behavior relative to the traps.

So how often are the birds and rats visiting the traps, without necessarily getting killed?

The problem in the lab

- Taking pictures of small, cold, or fast animals can lead to a lot of pictures.

We've talked about the problem in the field, but the problem in the lab is that taking pictures of small, cold, or fast animals with heat based motion sensors can lead to taking a lot of pictures. Which is fine, when they are like this, allowing us to study what we want to know about, but is less fine when…

The problem in the lab

- Watching plants grow is boring – and actually kind of complicated

They are more like this because nobody really wants to sit around all day and watch leaves fall and plants grow (well a botanist maybe)…but the other thing you can notice about this picture is that it is actually kind of complicated, in that when you review these photo series as a human, your eye cues in to movement, but you'll notice in this photo series that there is actually a lot of movement that you really don't care about, and it makes the photos more difficult to review.

And then…

The problem in the lab…How to separate signal from noise???

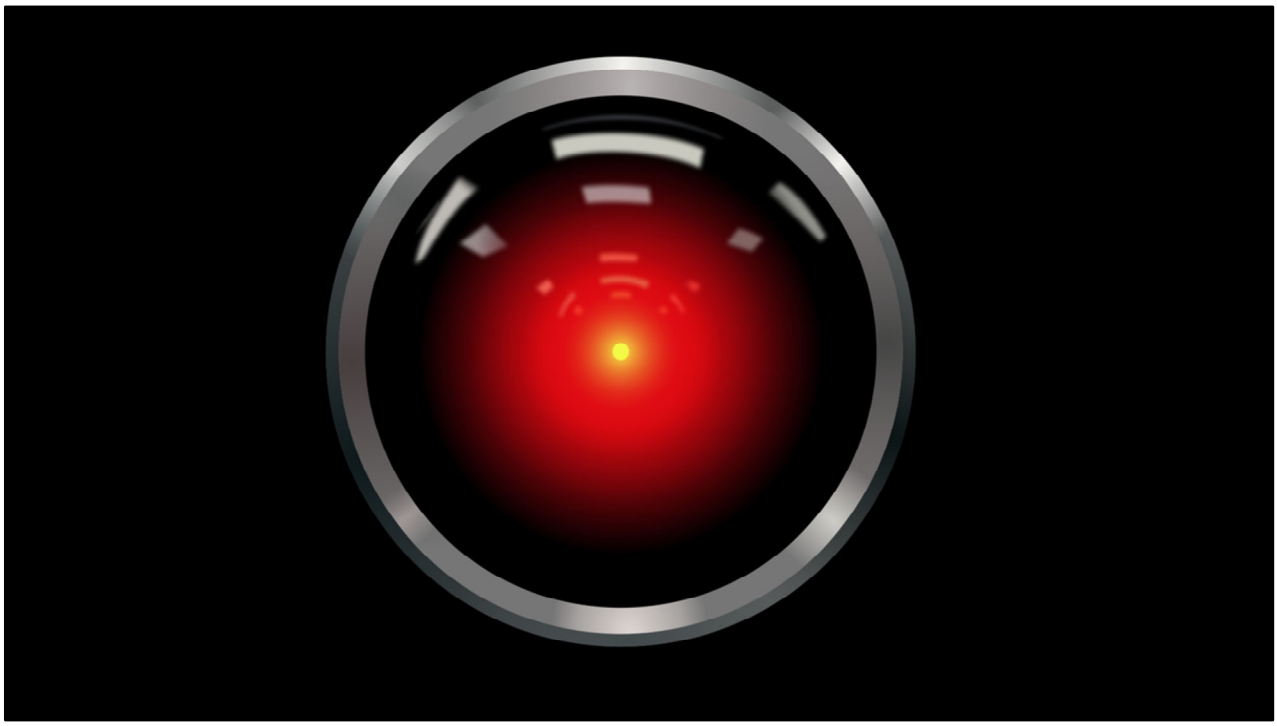
- Boldly going where others have just recently gone
  - Norouzzadeh et al. 2018
    - https://doi.org/10.1073/pnas.1719367115

You add on that you are trying to develop a model that can identify a rat not in one relatively static photo stream, but in multiple photo streams with multiple non-target objects in them, and it's really kind of a complicated problem that you are trying to teach the computer to do for you.

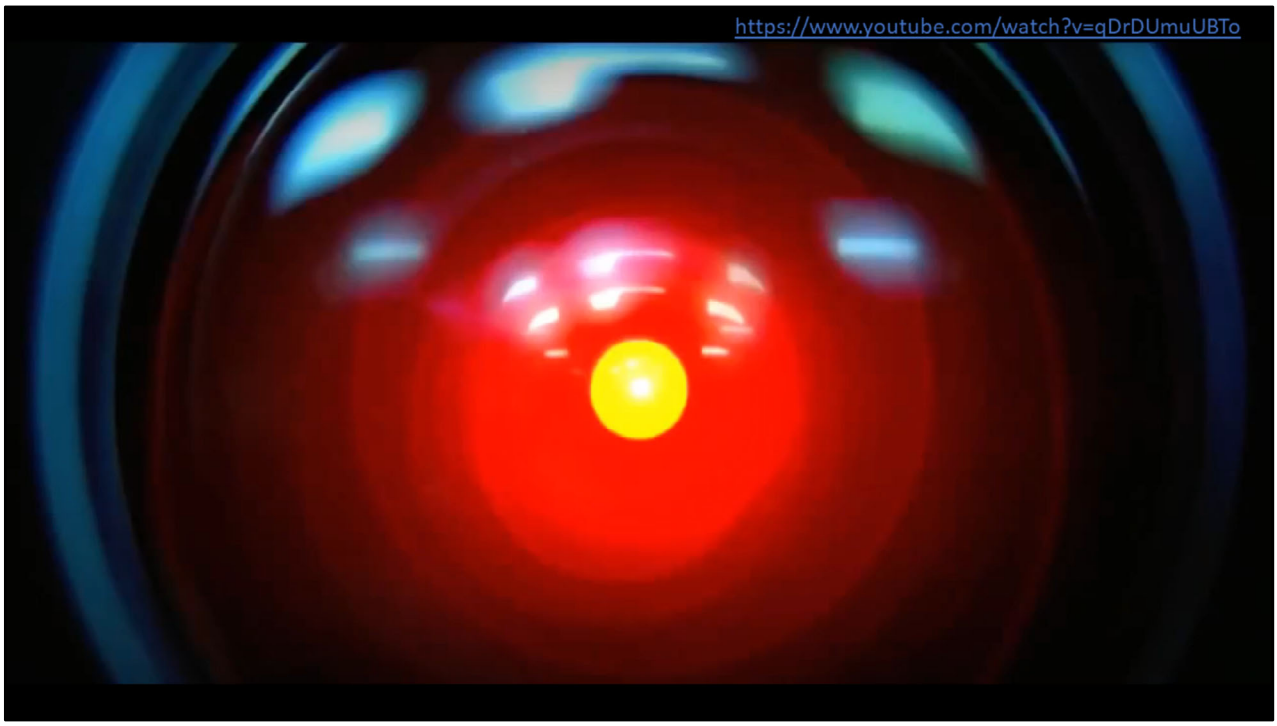
So how do we separate the signal from the noise in the lab?

Science…

This is an excerpt from my now favorite youTube personality, Mark Rober, who just makes these excellent videos to teach about Science and Technology, so I was laughing when he put this into his own TED talk, so check that out.

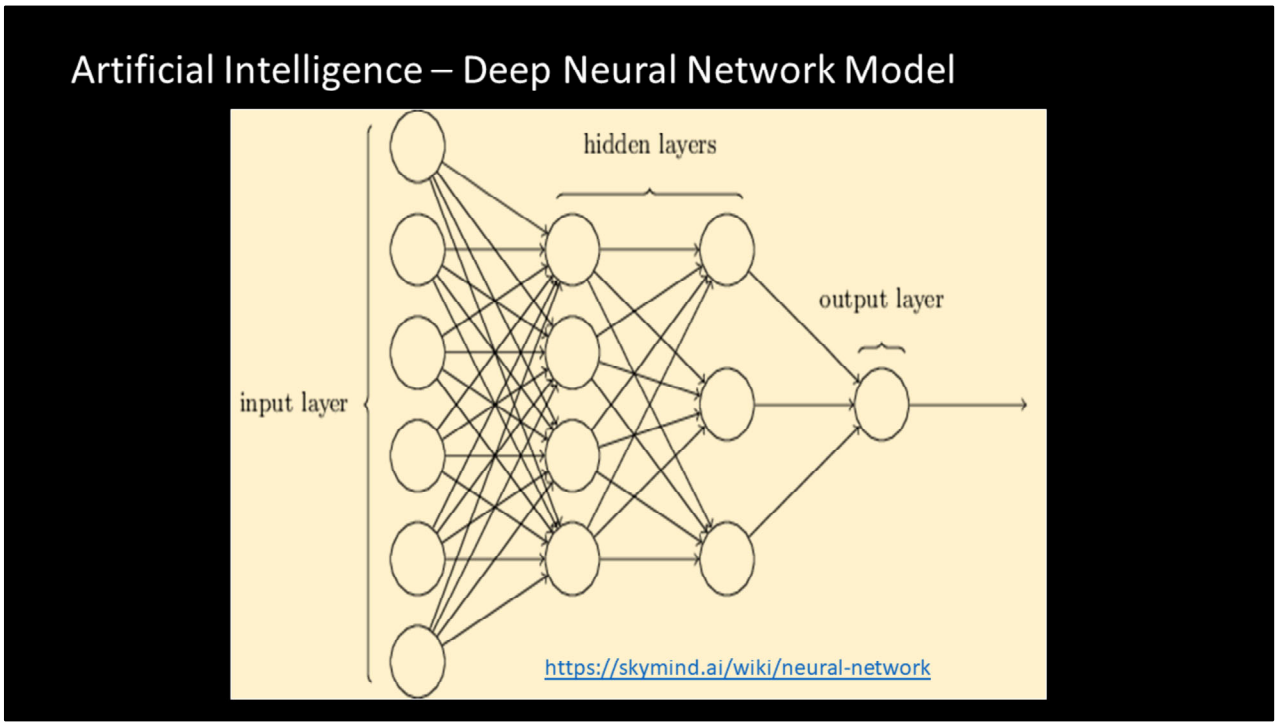


And so, we've had lots of .gifs, but in support of my secondary goal, which is to keep you awake after lunch and possibly even enteratain you, I am offering a GIFT to the first person who can tell me what this is?



That's right, it's HAL 9000, the 1968 depiction of artificial intelligence in the movie 2001 A Space Oddesy…

And while AI kind of got off to a rough start in terms of its public perception, it is actually more and more and more in use these days by people like me using it to make decisions about your life ranging from whether your picture on FaceBook is of you or your friend Emily, to whether your email is spam, to whether you're a high risk for the insurance company…And so if you can't beat them join them, right?



And you can thing of the defining aspect of the deep learning or neural network type models is that when provided with a sample or training dataset, they actually teach themselves.

artificial intelligence
You can think of deep learning, machine learning and artificial intelligence as a set of Russian dolls nested within each other, beginning with the smallest and working out. Deep learning is a subset of machine learning, and machine learning is a subset of AI, which is an umbrella term for any computer program that does something smart.---
https://skymind.ai/wiki/ai-vs-machine-learning-vs-deep-learning

Usually, the initial guesses are quite wrong, and if you are lucky enough to have ground-truth labels pertaining to the input, you can measure how wrong your guesses are by contrasting them with the truth, and then use that error to modify your algorithm. That's what neural networks do. They keep on measuring the error and modifying their parameters until they can't achieve any less error.

Classification -- https://skymind.ai/wiki/neural-network
All classification tasks depend upon labeled datasets; that is, humans must transfer

their knowledge to the dataset in order for a neural network to learn the correlation between labels and data. This is known as *supervised learning*.

Introducing RATem 333…

	Actual	
Predicted	0	1
0	341	0
1	59	400

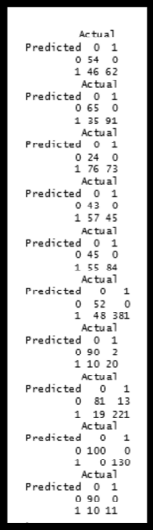
RATem 333 was able to classify an unseen subset of the training data correctly 92% of the time….

…named after the optimizer that worked best during testing, the Adam optimizer.

And

Collecting and classifying the training data

- Iterative process
  - One stream (classify photos and test)
  - Multi stream (repeat)
  - Brand new multi stream (repeat - -true test of model)
- How much data do I need?
  - We did better with 400 pictures of rats and 400 empty frames
    - Balanced design was important to model fit
- What do I care about with training data?
  - Maximize variance in the training set
    - Move the camera
    - You want it to learn important things, not everything.



```
          Actual
Predicted  0  1
        0 54  0
        1 46 62
          Actual
Predicted  0  1
        0 65  0
        1 35 91
          Actual
Predicted  0  1
        0 24  0
        1 76 73
          Actual
Predicted  0  1
        0 43  0
        1 57 45
          Actual
Predicted  0  1
        0 45  0
        1 55 84
          Actual
Predicted   0   1
        0  52   0
        1  48 381
          Actual
Predicted  0  1
        0 90  2
        1 10 20
          Actual
Predicted   0   1
        0  81  13
        1  19 221
          Actual
Predicted   0   1
        0 100   0
        1   0 130
          Actual
Predicted  0  1
        0 90  0
        1 10 11
```

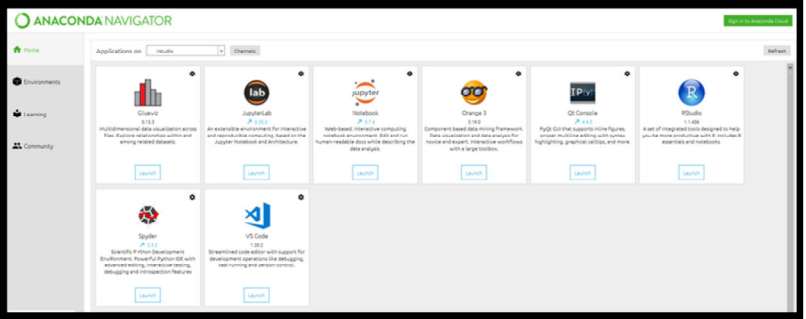
Some nuts and bolts

In the Field

- Ideal camera distance depends on the animal
- Insights on settings

In the Lab

- Anaconda Navigator installation of R Studio enabled backend use of Python and Tensorflow
- Use of the keras package in R is an wrapper to these programs, but needed to open R from Anaconda
- The adam optimizer did best, relative to RMSprop and SGD optimizers
- Adding two dropout layers as regularization parameters improved performance (accuracy and loss)



Sgd = stochastic gradient descent

Mahalo!