Cybernetic Analysis of Ecology Research System

Introduction and Background

Microsoft AI for Earth has created (using North America animal images) a camera trap (automatically triggered camera that senses changes in the local environment) image detection and annotations ML model that identifies if (and where) there is a human or an animal in the picture since most (>80%) of camera trap images are empty false signals (Microsoft, 2020). This effort is to reduce human time investment in shifting through massive number of images and accelerate the timeline of research projects involving such datasets (Yang, 2020).

I made a webapp as part of the project to import the MegaDetector model to Australia to support ecology research and conservation efforts. This project aims to leverage conservation efforts by increasing efficiency in conservation research; massive amount of time is spent in conservation research shifting through the camera-trap data, throwing out falsely signals, and identifying the animal (Yang, 2020). There is ongoing joint work between Microsoft and DPIE NSW to update the pre-trained model to Australian context and once the model is updated this webapp will serve as a no-code/minimal-code interface to use the model. It can also be used with existing MegaDetector model (as will be demonstrated in the documentation) to classify images into animals and non-animals.

After the brief introduction, let me get to the cybernetic documentation of the project. Norbert Wiener defined cybernetics as “the study of control and communication in the animal and the machine”. At 3A Institute, we have generalized this a little bit and we consider cybernetics as “the study of control and communication in systems”. System is a broad term and rather than thinking about it ontologically it is helpful to think of it as an epistemic tool. In short, we talk about system when it is useful to talk about something as a system.

Research ecosystem, in particular ecology research ecosystem, can be thought of as a system. Indeed, it is afterall a complex social activity that affords a systems inquiry. It involves measurement of the world and collection of the data, scientists and engineers working to understand the data or at a meta level creating tools that can help us understand the data, extracting insights from the data and using those insights to create changes in the world or ask another research question. Recently there has been academic work such as Järvi et al. to understand knowledge production system as a complex adaptive system, and it is increasingly the case that we deploy systems vocabulary and metaphors to talk about social activities.

Next, we get to the critical question around thinking of the research activity as a system: Why is it useful?

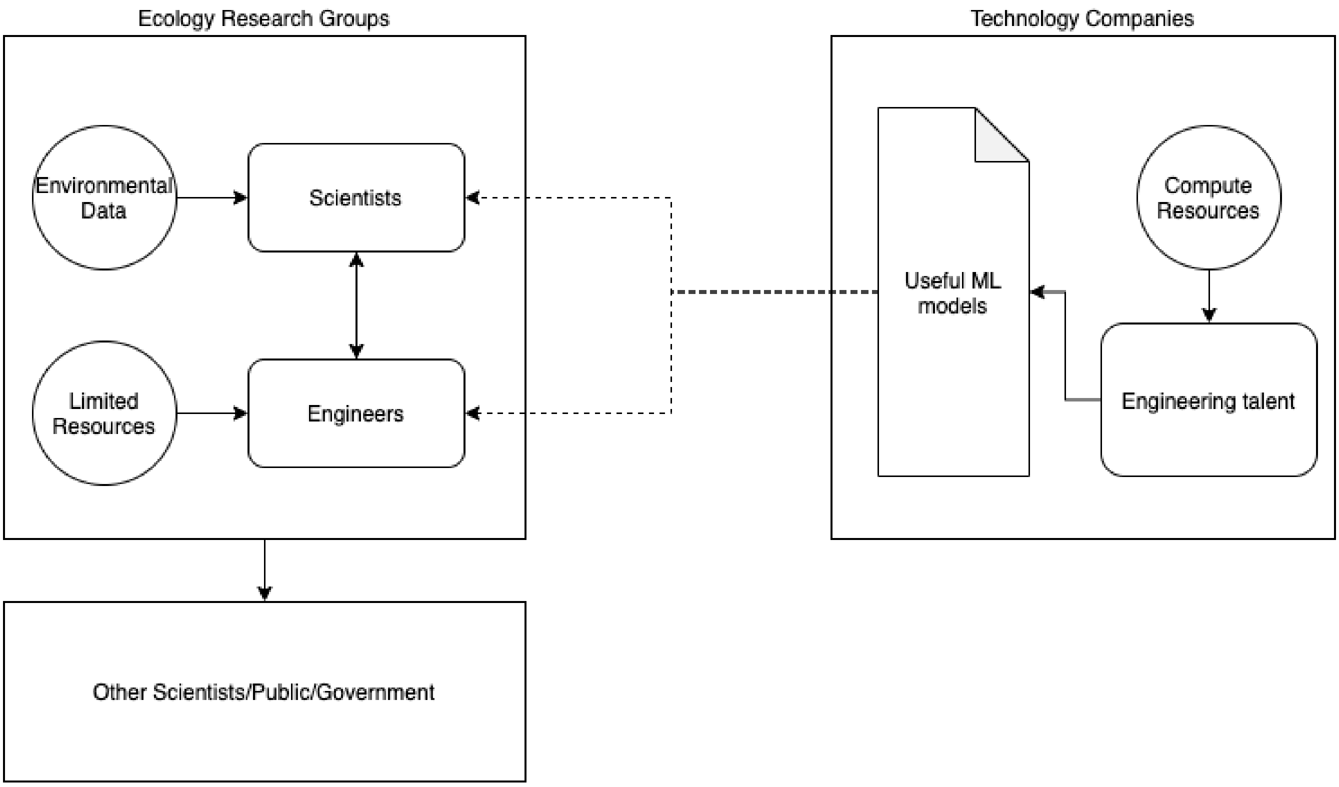
- Firstly, it is useful because it changes the default reductive element-wise framing to a relational framing. We go from talking about what might have been a Node.is in the large system to talking about the interactions in the system. Consider the following image. The stance changes from narrow and local to wide and global. One might shift their conception of research as a local hyper-specialized activity to a connected and complicated activity that requires multiple party to function and interact correctly to work well

- Secondly, it allows us to readily import and use system concepts such as leverages, interfaces, adptavity and so on. In what follow, I will guide through thinking about and designing interfaces using cybernetic approach, which mean using system along with a variety of associated methods

The capstone project was at the connection point between two different and major nodes in the research ecosystem - environment agency (DPIE) and a technology company (Microsoft). Thinking about interactions over parts is the hallmark of system approach and the circumstances of the project fit a systems modeling of the situation.

The primacy of Interfaces

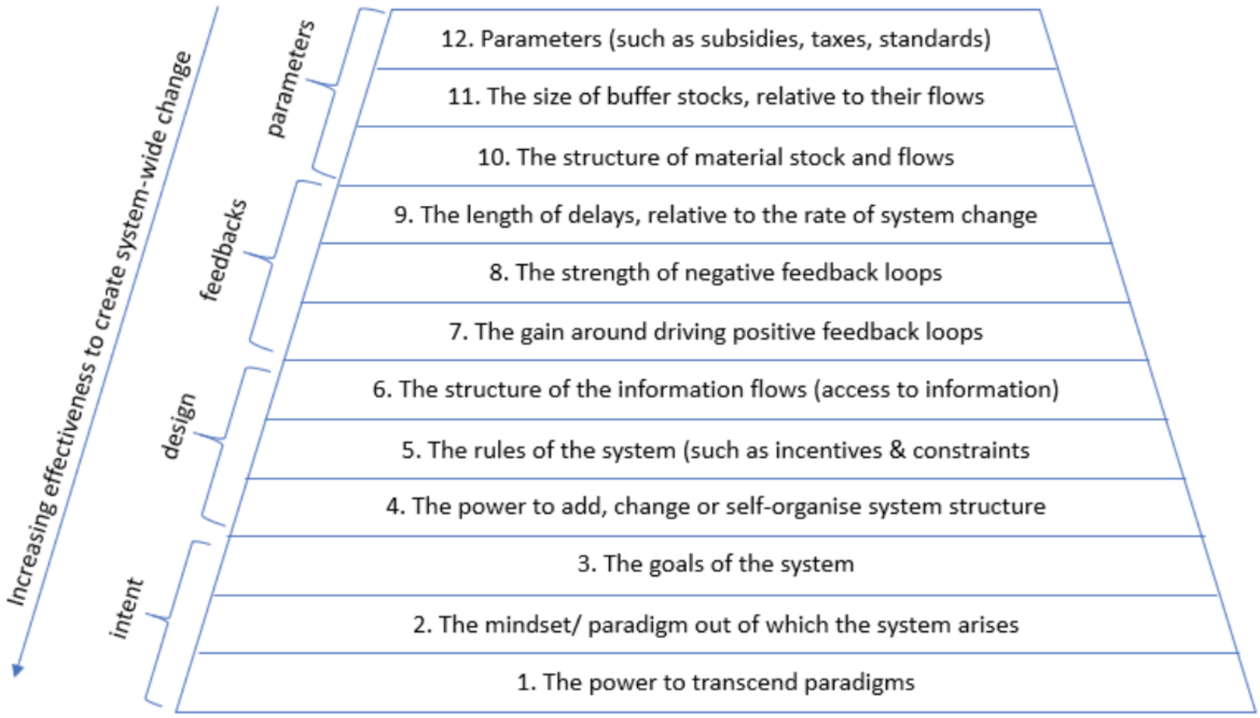
Here is a system map of the situation. The dotted line represents a weak interaction in the system.



Bratton (2016) in his book "The Stack" defines the interface as follows:

> An interface is any point of contact between two complex systems that governs the conditions of exchange between those systems.

As we have noted before, the hallmark of thinking about system is thinking about interaction. And thinking about interaction means thinking about the mechanisms of interaction that is interfaces. In our context, the challenge and possibilities both lie in the interface between the tech node that has the capacity to produce large scale model and research node that can use the model to produce useful knowledge. In short, it is a leverage point.Leverage points are places in the system where one can intervene and change the systems dynamics. Abson et al. (2017) proposes a way to thinking about leverage points by grouping Meadows (2008) ’12 points of leverage’ framework into four categories of parameters, feedback, design, intent:



Looking at the framework we can note that the kind of leverage point in our case if 'flow of information', which falls under the design category - an interface can be thought of as information flow between two nodes.

The point though is not merely to identify a leverage point but also intervene at the point. The first step is to ask questions.

Here are the critical questions that I asked during the project to understand the challneges more and help with designing a solution.

1. Whose voice is central in the question concerning the design of interface?
2. How to inform and constrain the deign process?
3. How to manage diverse goals?
4. What are maintenance and decommissioning considerations?

Next, I'll expand on the steps of the project by explaining how I tried to approach these questions!

Whose voice is central can only be identified through careful listening. Modern research ecosystem, especially one involving ML models tend to be large projects with multiple different voices and goals. There are data scientists who have particular interest in making the data wrangling process easier. There are rangers and ecologists who want to minimize time spent fighting the code, there are agency level goals and goal imposed by business partners. The project started with me tuning into conversations that involved many of these voices. It was a semi-strcutured interview of sorts where I attempted to understand the bottleneck interaction and possible machanisms of imporving the interface and therby the interaction. I decided that the voice that should be central is the one that aligns closely with the goals of the whole research system that is producing useful knowledge. Later, I will talk about the NGO system method that I used at a critical juncture point.

How, then, should I start the design process? Enter Affordances.

The first definition of affordances given by Gibson (1979) is as follows:

> The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. . . . These affordances have to be measured relative to the animal.

Davis & Chouinard (2016) sidesteps definitional questions of affordances and propose mechanisms for affordances. More precisely, they operationalize affordances via artifacts that requests, demands, allows, encourages, discourages, and refuses a subject. We are interested in using affordances as a *method* for design rather than studying it as a *property* of a thing.

Questions of affordances arise naturally when one considers interfaces. Interfaces are not a neutral property of an object but a utility associated property that governs interactions.

Affordance can be thought of as a method at the "design phase" of a system in the sense that one can set goals for mechanisms of affordances and use them as a design constraint.

Mechanisms	**Constraints**
Requests	Minimal Learning
Demands	N/A
Allows	Smooth, intuitive use without messing with the code
Encourages	Use of ML models over manual classification of data
Discourages	Misuse of the platform by keeping things simple
Refuses	N/A

It was with these design constraints in mind that I developed a simple looking webApp that work with zip files. It operates using upload and compression functionality that is generally much more familiar to people as compared to code level understanding that would otherwise be needed.

The feature addition process was iterated after further conversations, and I added a customizable confidence cut-off as per the request of the team.
A feature that was requested and failed to add due to technical limitation of using flask as the web development platform is the progressbar as the inference occurs. Currently one can only see the progress bar in the terminal and not on the web page.

Finally, we return back to the questions of goals and intention: objects acquire intention from the designers of the object and the question around what intentions get imbued should be part of a deliberate design decision. After the skeletons of the webapp was created, it could go various direction. It could serve as a tool in the development process of the particular task at hand, or it could serve as a frontend for once the training is complete and allow other people and groups an easier access to the model. The first route is immediately useful and helpul but the second option aligns close with the global goal and the ultimate intentions of the Rangers and scientists.

The NGO analysis indicated that taking the project in the direction of interface aligned better with the system goal and therefore that is the direction the project moved.

Here is brief NGO (Need Goals Objectives) analysis:

System Goal: Efficient Research output

NGO	In-house Use (tool for data scientists)	Outward facing use (interface for ecologists)
Need	Tool for local data wrangling and pre-processing	Easy to use, resource-preserving method for sorting images
Goals	Successfully complete the project at hand	Use and process the data to get insights and create knowledge
Objectives	Get the existing camera trap ready for training	Easy use of complicated ML model and easy model update

Reflections on Interfaces for ML

Research system, like many systems in the world carves itself up via clustered and shared activity that is a node, and not via interactions present in the systems. This leader to a cohrent and productive outcome on each Node.js but misses many possibilities to do the same by focusing on the interaction. Working on the interface and trying to translate work from one Node.js to another, it is easier but still striking to see that so much of work that seems to going on in ML lately is barely translated and shared. The work exists within confines of narrow nodes and difusion is resisted by the way the system is structured. Often while seeking local goals, the global goal takes a backstage role but thinking of the research ecosystem forces one to engage with the global goal. My observation, limited, as it may be is that thinking of knowledge production as a system and working at the interface of various nodes is under-appreciated, and the promises of ML will only be delivered once it reaches the people who actually need it.

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