T is for Topology

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Abstract

Pending…

Plain Language Summary

We want to know a bit more about the different network topology generators (predict tools) and how they differ - *i.e.,* their strengths and weaknesses

1 Introduction

The standard run of the mill that we cannot always feasibly construct networks because 1. hard, 2. time (yay dinosaurs, but also the future and impending doom I guess), and 3. probably something else meaningful that's just slipping my mind at the moment.

Maybe a brief history of the development of predictive tools? Sort of where the theory/body of work was based and how that has changed?

Maybe start here with discussing the core mechanistic differences that models will work at — some are really concerned about (and thus constrained by) structure, others are more mechanistic in nature *i.e.,* species *a* has the capacity to eat species *b* because traits (read gob size), and then you get Rohr et al. (2010) and Strydom et al. (2022) that sit in the weird liminal latent space…

At some point we are going to need to discuss the key differences and implications between predicting a metaweb and a network realisation. And here I can't help but think about Poisot et al. (2015) (and probably other papers) that discuss how the local factors are going to play a role and even the same pair of species may interact differently in different points in the landscape.

> Do we need to delve into individual-based networks? (*sensu* Tinker 2012, Araújo 2008) I think its probably a step too far and one starts creeping into apples and pears type of comparisons. Especially since these work off of already existing networks (I seem to recall) and its more about about 'tweaking' those - so not so much *de novo* predictions. Although this might be useful to keep in mind when it comes to re-wiring… Also on that note do we opn the re-wiring door here in this ms or wait it out a bit.

2 Data & Methods

2.1 Overview of topology generators

I know table are awful but in this case they may make more sense. Not sure about putting in some papers that have used the model - totes happy to drop those I think…

Table 1: Lets make a table that gives an overview of the different topology generators that we will look at

Approach	Reference	Core Mechanism	*e.g.,* uses
Niche model	Cohen et al. (1997)	structural	
Cascade model	Williams & Martinez (2000)	structural	
PFIM	Shaw et al. (2024)	mechanistic	Dunhill (in review)
Log-ratio	Rohr et al. (2010)	latent trait space	Yeakel et al. (2014), Pires et al. (2020) (?)

Approach	Reference	Core Mechanism	*e.g.,* uses
Nested hierarchy	Cattin et al. (2004)		
ADBM	Petchey et al. (2008)	mechanistic	probably multiple
Stochastic	Rossberg et al. (2006)		
Graph Embedding	Strydom et al. (2022)	latent trait space	
Trait-based	Caron et al. (2022)	mechanistic	Caron et al. (2023)

> Might be nice to have a little appendix/supp mat that breaks down the models in detail so that they are all in one place so that someone (grad student being told they need to build networks) some day can go and educate themselves with slightly lower effort. This will also be useful for me should I end up having to do some actual coding - think of this as step one in the pseudo code process.

2.2 Datasets used

Here I think we need to span a variety of domains, at minimum aquatic and terrestrial but maybe there should be a 'scale' element as well *i.e.,* a regional and local network. I think there is going to be a 'turning point' where structural will take over from mechanistic in terms of performance. More specifically at local scales bioenergetic constraints (and co-occurrence) may play a bigger role in structuring a network whereas at the metaweb level then mechanistic may make more (since by default its about who can potentially interact and obviously not constrained by real-world scenarios) *sensu* Caron et al. (2023). Although having said that I feel that contradicts the idea of backbones (*sensu* Bramon Mora (sp?) et al & Stouffer et al) But that might be where we get the idea of core *structure* vs something like linkage density. So core things like trophic level/chain length will be conserved but connectence might not (I think I understand what I'm trying to say here)

I think we should also use the Dunne (I think) Cambrian (also think) network. Because 1) it gives the paleo-centric methods their moment in the sun and 2) I think it also brings up the interesting question of can we use modern structure to predict past ones? Here one might expect a more mechanistic approach to shine.

2.3 Comparing different models

1. Shortlist/finalise the different topo generators
2. collate/translate into `Julia`
   - *e.g.,* some models wil be in EcoNets.jl, Transfer learning (strydom) should be ready to play
   - others will need to be coded out (the more simpler models should be easier)
   - can also consider `R` but then it becomes a case of porting things left and right depending on how we decide to do the post analyses
3. Create networks for the different datasets/scenarios we select - I feel like there might be some scenarios that we can't do all models for all datasets but maybe I'm being a pessimist.
4. compare model performance based on the ideas currently listed in the results section.
5. Make a pretty picture that summarises things - maybe overlapping Venn circles that showcase which models do well in the different spheres/aspects of life

3 Results

How we want to compare and contrast. I think there won't be a 'winner' and thus we need to think of 'tests' that are going to measure performance in different situations/settings. With that in mind I think some valuable points to consider would be:

- Structural vs pairwise link predictions (graph vs node level)
  - % of links correctly retrieved
  - connectence
  - trophic level
  - generalism vs specialism
  - something related to false positives/negatives
  - intervality
- Data 'cost' (some methods might need a lot lot of supporting data vs something very light weight)
- I think it would be remiss to not also take into consideration computational cost
- something about the network output - I'm acknowledging my biases and saying that probabilistic (or *maybe* weighted) links are the way

> maybe we can put these into broader categories - if we do start doing the venn overlap thing. *E.g.,* local scale predictions, regional scale predictions, pairwise interactions, structural (energetics), computationally cheap, low cost data

4 Discussion

I think a big take home will (hopefully) be how different approaches do better in different situations and so you as an end user need to take this into consideration and pick accordingly.

I probably think about this point too much but a point of discussion that I think will be interesting to bring up the idea that if a model is missing a specific pairwise link but doing well at the structural level when does it matter? I think this is covered with the whole node vs graph level performance but I kind of just want to bring it up here again because also one of those things that I think about a bit too much probably…

> Thinking very longterm here and maybe a bit beyond the scope but also thinking about a multi- model approach? SO using one model to build an initial network but maybe a second one to constrain it a bit better. I blame this thought on the over-connected PFIM food webs…

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Source: Article Notebook

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