

Notes for network study group

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List of Attendees:

Faculty: Daniel Bolnick, Tina Eliassi

Student/Scientist: Kajia Gahm (presenter), Amanda Hund, Andis Arietta, Rogini Runghen, Wan He, Bailey Arcilla, Audrey McCombs, Allison Roth, Lei Ma, Helen Pointkivska

Main presentation: Kajia presents [Pilosofo et al. \(2017\)](#) about half an hour. The paper [Pilosofo et al. \(2017\)](#) focuses on summarizing the types of ecological multilayer networks and data examples with multilayer network tools. Specific calculation of the analysis tools are omitted in the paper.

Kajia's presentation follows the three questions below with answers:

1. What is a multilayer network?

A multilayer network includes a stack of networks, in which the meaning of the layer, number of nodes in each layer (state nodes), and the meaning of edges in each layer may be different. Compared with the monolayer network, the multilayer network involves both intralayers (edges in a particular layer) and interlayers (edges connecting the nodes across the layers).

2. How can we represent ecological systems as multilayer networks?

Figure 1 in [Pilosofo et al. \(2017\)](#) summarizes different types of multilayer networks in ecology. Kajia mainly talks about the temporal, spatial, shared species, different interaction, and multilevel multilayer networks.

3. What kinds of analyses are facilitated by multilayer networks?

The main analysis tool for multilayer networks mentioned in the paper is called maximum modularity. However, the detailed method and math for the method is not emphasized in the main body. Kajia shows two data analyses: one is about the host-parasite association changing along with time, and the other one is about the queen wasp selection in which the multilayer tool highlights the queen candidates and the monolayer tool fails to distinguish the queen candidates.

Last, Kajia summarizes the limitations of multilayer networks and their applications:

1. we do not know when to use multilayer tools and when to use monolayer tools;
2. multilayer networks lead to more intensive data collections;

- edges in different layers may have totally different meanings and scales, and the paper does not mention how to deal with such cases.

Open discussions:

Today's discussion is leaping. I think the main topic of the discussion is how to apply the multilayer network analysis to Dan's real datasets. I try to organize the main discussions between Dan and Tina in a reorganized order.

Dan recalls the main goals for real data applications. We want to study whether there are any changes that exist in the fish (with parasite) gene co-expression networks or fish-parasite networks in different lakes or at different time points. The study of gene co-expression networks should be the primary goal. The study of host-parasite networks may be very similar to the application in Figure 2 or the shared species network (Figure 1, c) in [Pilosof et al. \(2017\)](#).

Tina mainly discusses the data objects we can used for multilayer network analysis. In one way, we can use tensors to represent the multilayer networks and analyze the network with tensor tools (like HOSVD or other eigen-value based methods). However, we need to assume the nodes in each layer are the same. (In my opinion, tensors also can not well record the interlayer which indicates the connections between layers.) Another way is to unfold the tensors or multilayer networks into sparse matrices. See Figure 1. Dan then mentions that the fish parasite network can also be represented as the matrix unfolded by the multilayer network. See Figure 2.

Tina also mentions that their group is working on extracting latent features from the network and reconstructing the networks based on the learned features. They plan to present their works in a few weeks.

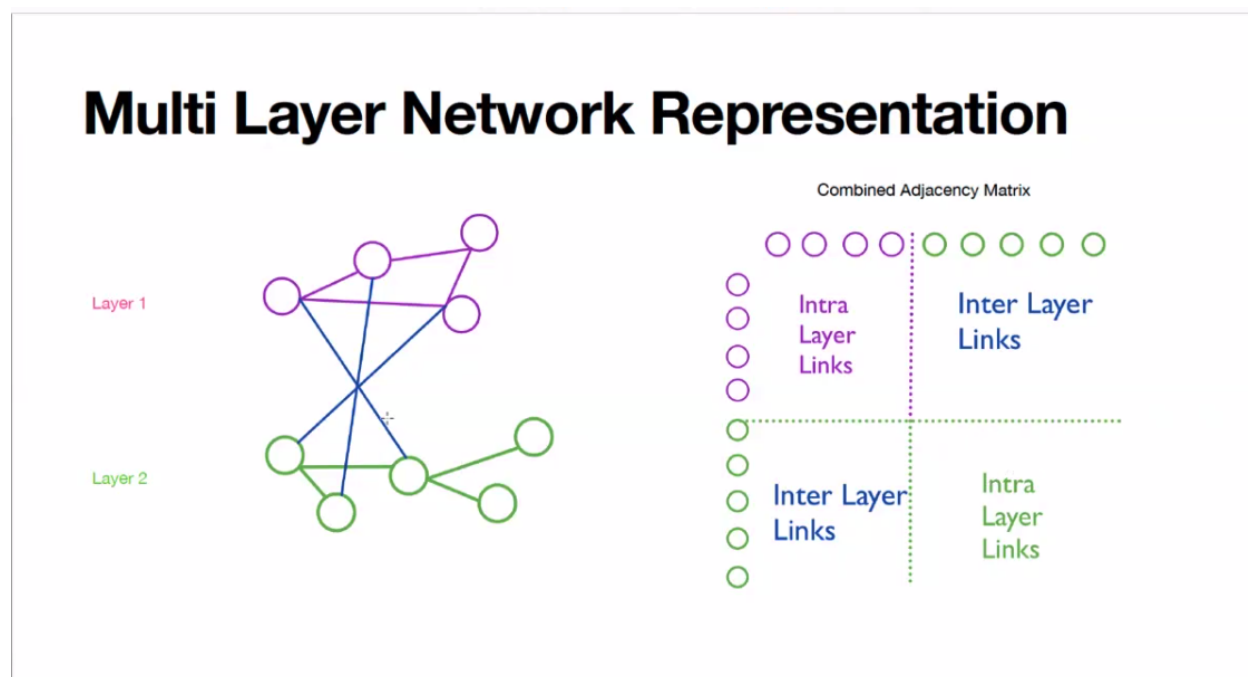


Figure 1: Represent the multilayer network in matrix.

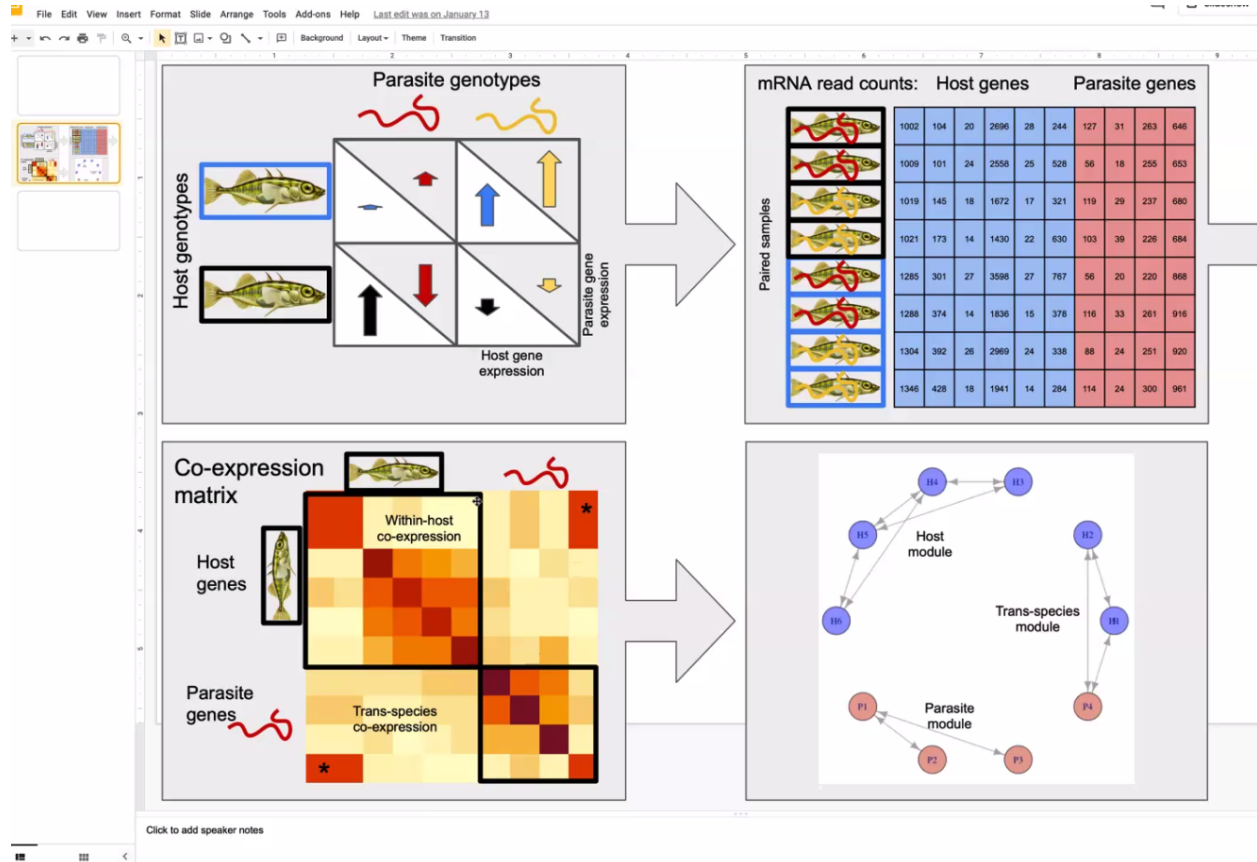


Figure 2: Fish-parasite networks.

References

Pilosof, S., Porter, M. A., Pascual, M., and Kéfi, S. (2017). The multilayer nature of ecological networks. *Nature Ecology & Evolution*, 1(4):1–9.