Dynamic social networks in dairy cows

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Summary

From the positional data of cows in a free-stall barn in the Netherlands we obtain the adjacency matrices, social networks and communities of dairy cows. Then monadic, dyadic and polyadic features of social networks are analysed and combined to investigate the dynamics of the dairy cows' social networks.

Methods

The positional data was converted into adjacency matrices, which were then converted to social networks. Python is suitable for analyzing social network, since there are a lot of pre-existing functions to compute metrics in it.

	cow1	cow2	...	...	cowN
cow1	0				
cow2		0			
...			0		
...				0	
cowN					0

Figure 1: The structure of adjacency matrix, the adjacency matrix is symmetric, elements represent the relationship between two cows

We looked at community detection, where we used the following algorithms: Girvan-Newman , Louvain, and Clique Percolation Method (CPM).

We also looked at some monadic metrics: centrality, edge distribution, and eigenvector centrality. One dyadic metrics: average shortest path, and for the polyadic metrics we looked at transitivity, eigenvalues, laplacian eigenvalues and features of communities.

We also compared our results with simulated data to see how statistically significant our results were.

Results

The monadic metrics show that there are some clear, significant distribution of how many interactions cows had. There are some cows that have a large number of interactions, and some have almost no interactions.

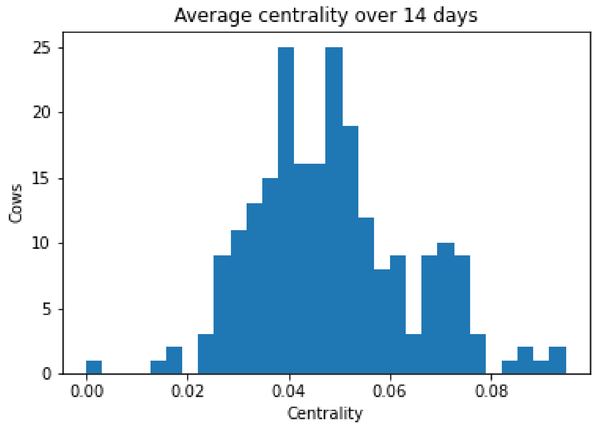

Figure 2: The Centrality for all cows in the barn, higher centrality means more social contact

The dyadic metric shows that the social network is well connected as two cows are on average less than two connections away from each other.

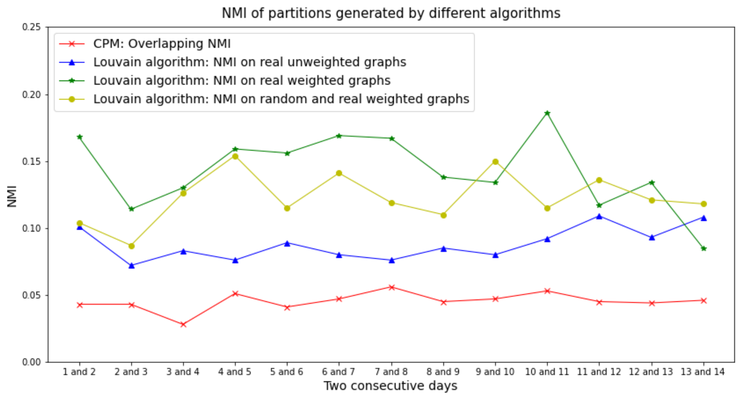

Figure 3: The Normalized Mutual Information (NMI) for partitions of different methods over 14 days, low NMI means that the partitions of dairy cows' communities change tremendously

The polyadic metrics show that cows do not follow the saying “a friend of a friend is my friend”. The chance that two of a cow's connecting cows are also connected is lower than in randomly simulated networks.

Detectable communities of cows on different days are relatively independent. They are more stable than communities from randomly simulated networks, but much less than we expected them to be.

Photo Credit: iStock

Conclusion

- There is a consistency in how cows interact, but only when looking at monadic or dyadic interactions.
- The dairy cows' communities are more stable than the random communities. But in general, the communities of different days can be seen as independent. There is no preference for group forming, and cows do not have stable social communities in the human sense.
- The social structure is more dependent on the individual standings in the group than on any type of social group or community.