Exercise: The Chow-Liu Algorithm

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1/1 point (graded)

Consider four variables with the following empirical mutual information:

$\widehat{I}(X_i; X_j)$	1	2	3	4
1	0.3415	0.2845	0.0003	0.0822
2	0.2845	0.3457	0.0005	0.0726
3	0.0003	0.0005	0.5852	0.0002
4	0.0822	0.0726	0.0002	0.5948

Find the Chow-Liu tree of the four variables by specifying which edges are present in the tree.

- [x] $(1, 2)$
- [ ] $(1, 3)$

- [x] $(1, 4)$
- [x] $(2, 3)$
- [ ] $(2, 4)$
- [ ] $(3, 4)$

✔

Solution:

If we sort the mutual information values from the largest to the smallest, we get:

$$\hat{I}(X_1; X_2), \hat{I}(X_1; X_4), \hat{I}(X_2; X_4), \hat{I}(X_2; X_3), \hat{I}(X_1; X_3), \hat{I}(X_3; X_4).$$

Note that we only consider when $\hat{I}(X_i; X_j)$ for $i < j$ here because mutual information is symmetric and $\hat{I}(X_i; X_i)$ is irrelevant. Then the Chow-Liu algorithm says that we begin with a fully disconnected graph and start adding edges with the largest empirical mutual information. Thus, we add edges $(1, 2)$ and $(1, 4)$. If the next edge $(2, 4)$ is added, the resulting graph has a cycle $1 - 2 - 4$, so instead, we add $(2, 3)$. Since there are 4 variables, a tree over 4 nodes has 3 edges, so the algorithm terminates. Thus, the edges in the tree are $\boxed{(1, 2), (1, 4), (2, 3)}$.

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