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Competition super-hypergraphs: Revealing hierarchical competition in real-world networks

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Abstract. Graph theory provides a powerful language for modeling pairwise connections through vertices and edges [9, 20]. Hypergraphs generalize this idea by permitting hyperedges that join any number of vertices simultaneously [7], while super-hypergraphs iterate the Power-set operation to capture multi-level, hierarchical relationships among hyperedges [40, 22].

A competition hypergraph associates each prey species with a hyperedge containing all its predators, thereby encoding multi-way competition in ecological networks. In this work, we introduce the *competition super-hypergraph*, which lifts the competition concept to higher tiers of aggregation. We present its formal definition, explore theoretical properties, and illustrate its practical use in real-world scenarios, such as modeling layered competition in food webs and multi-agent systems.

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