On Some Results in Unmanned Aerial Vehicle Swarms

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Abstract

We first summarize our results on managing data in unmanned aerial vehicle swarms, such as development of a co-simulation environment, a study of Extensible Markup Language (XML) data compression engines, and a k-dimensional extension to the skip graph data structure for querying data stored at the mobile nodes. The third result motivated research on canonically ordering nodes in the swarm using more robust methods than the z-order space-filling curve applied in the k-dimensional extension of the skip graph data structure.

We opted to explore how to canonically order the nodes using the PageRank algorithm applied in certain search engines to order query responses. A key reason is that the PageRank vector canonically orders vertices of nearly all random graphs, which is a result of the relationship an equitable partition has with the eigenvector yielded by the PageRank algorithm. An equitable partition can be obtained by applying 1-dimensional Weisfeiler-Lehman stabilization to the graph and can be implemented in $\mathrm{O}(m \cdot \log n)$ time, where $m = |E|$ and $n = |V|$, as established by Paige and Tarjan, and separately, by Cardon and Crochemore.

We use the equitable partition to eliminate a class of errors in PageRank values, which ensures vertices that are equivalent in a given equitable partition have equal values and also facilitates early termination of the power method. The equitable partition yields many other methods of reducing the number of computations, such as computing one PageRank value for equivalent vertices. We also explore estimating PageRank values using the quotient graph induced by an equitable partition. We conclude by describing future research avenues, including generalizing a lemma applied in this work to k-dimensional Weisfeiler-Lehman stabilization, building a library of graphs based on given values of k, and implementing a method that decides graph isomorphism by leveraging multiple processors.

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