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Rerouting Planar Curves and Disjoint Paths

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Abstract: In this paper, we consider a transformation of k disjoint paths in a graph. For a graph and a pair of k disjoint paths $\mathcal{P}$ and $\mathcal{Q}$ connecting the same set of terminal pairs, we aim to determine whether $\mathcal{P}$ can be transformed to $\mathcal{Q}$ by repeatedly replacing one path with another path so that the intermediates are also k disjoint paths. The problem is called \textsc{Disjoint Paths Reconfiguration}. We first show that \textsc{Disjoint Paths Reconfiguration} is $PSPACE$-complete even when $k = 2$. On the other hand, we prove that, when the graph is embedded on a plane and all paths in $\mathcal{P}$ and $\mathcal{Q}$ connect the boundaries of two faces, \textsc{Disjoint Paths Reconfiguration} can be solved in polynomial time. The algorithm is based on a topological characterization for rerouting curves on a plane using the algebraic intersection number. We also consider a transformation of disjoint s-t paths as a variant. We show that the disjoint s-t paths reconfiguration problem in planar graphs can be determined in polynomial time, while the problem is $PSPACE$-complete in general.

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