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Facial incidence 6-choosability of embedded graphs

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A facial incidence coloring of an embedded graph assigns colors to incidences (vertex-edge pairs) so that facially adjacent incidences receive distinct colors. The facial adjacency of incidences is determined by consecutive edges in the rotation system of the graph. In 2019, Horňák, Jendroľ, and Soták conjectured that such a coloring exists for every plane multigraph with at most six colors.

We prove that every embedded simple graph is facial incidence 6-choosable. Thus, compared with the conjecture, we restrict to simple graphs, but allow arbitrary embeddings and prove the stronger list-coloring statement. We provide a concise proof that combines a greedy extension procedure with the Combinatorial Nullstellensatz. We establish the required nonzero coefficients for the Combinatorial Nullstellensatz by induction and explicit computations, which can be carried out by a computer algebra system. We also give an independent purely combinatorial proof of the corresponding list-coloring statement using Alon-Tarsi orientations, sign-reversing involutions, and parity arguments.