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Gain Graphs and Polyhedral Geometry

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A *gain graph* is a triple (G, h, H) where G is a graph, H is a group, and h is a homomorphism from the free group on the edges of G to H . Gain graphs appear in physics, rigidity theory, geometry of polytopes, graph theory, operations research, etc. An ordered cycle in G is called *balanced* if it lies in the kernel of h . A gain graph is called balanced if all its cycles are balanced. For some choices of H , I will give necessary and sufficient conditions for a gain graph (G, h, H) to be balanced. For example, if H is free abelian, then (G, h, H) is balanced if and only if all elements of an arbitrary basis of its binary cycle space are balanced. This is also true for any H such that its abelianization is infinite and torsion-free. However, if the abelianization of H is finite, our criterion does not work.

The case of torsion-free abelian H is important to polyhedral geometry and physics. I will describe applications of our criterion to recognizing if a given polyhedral partition of a domain in n -space can be lifted to a convex surface. If time permits, I'll describe applications to computing the dimension of the space of C_r^{r-1} -splines over a cell-decomposition of a domain D in n -space with $H_1(D)=0$.

This is a joint ongoing work with Tom Zaslavsky.

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