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Damage Response in Fluid Flow Networks

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— The networks found in biological fluid flow systems such as leaf venation and animal vasculature are characterized by hierarchically nested loops. This structure allows the system to be resilient against fluctuations in the flow of fluid and to be robust against damage. We analytically and computationally investigate how this loopy hierarchy determines the extent of disruption in fluid flow in the vicinity of a damage site. Perturbing the network with the removal of a single edge results in the differential flow as a function of distance from the perturbation decaying as a power law. The power law exponent is generally around -2 in 2D, but we find that it varies due to edge effects, initial edge conductivity, and local topology. We expect that these network flow findings, directly applicable to plant and animal veins, will have analogues in electrical grids, traffic flow and other transport networks.

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