Renormalization of complex networks

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The renormalization group is a useful tool for studying physical systems at various length scales. However, applying this approach to complex networks can be challenging due to the small-world property, which introduces correlations between different scales. To overcome this challenge, the network geometry paradigm provides a powerful framework. Specifically, we have developed a renormalization group technique that coarse-grains and rescales geometric network representations to unfold them into a multiscale shell of layers. Our analysis revealed that real networks are self-similar under the renormalization transformation, implying that short and long-range connections follow the same connectivity rule across length scales. Moreover, this result explains the self-similarity observed in empirical multiscale reconstructions of human brain connectomes. Additionally, the growth over time of some real networks also exhibits self-similarity, suggesting that their evolution can be modeled using a reverse renormalization process. The practical applications of self-similar multiscale unfolding of real networks include producing scaled (up and down) replicas that can be used in a variety of downstream tasks, such as the study of processes where network size is relevant.