Large-Scale Networks: From Intelligent Robotics to Emergency Response

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Abstract:
Since the turn of the century, the theory of large-scale networks have been studied extensively and lead to a wide range of applications in various disciplines, including computer networks, the www, sensor networks, transportation networks, power systems, the IoT, biological networks, genetic networks, social networks, and many others. We overview the foundation of network theory going back to the pioneering work on Erdos-Renyi on random graphs and phase transitions, followed by small worlds, such as Barabasi-Albert, Strogatz-Watts, scale-free systems with Black Swan statistics, as well as Dragon Kings. Depending on the statistical properties of the structures of these networks, their dynamics may be predictable of essentially unpredictable. Various methods are being developed to control the corresponding network dynamics. The theoretical results lead to novel approaches to autonomous robot control. Another application area includes highly flexible and rapidly reconfigurable distributed sensor networks to support robust decisions. Transitions between various scenarios and corresponding strategies are made rapidly and robustly via phase transitions. The introduced methods are applicable in emergency scenarios during natural or man-made disasters.

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