Notification No.: 603/2026
Date of Award: 16-07-2026

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Topic of Research: **Detection and analysis of overlapping community structure in real-world networks**

Findings

This thesis addresses the challenge of detecting overlapping community structures in large, complex networks, where existing methods often struggle with community quality, scalability, and stability, especially in weighted, directed, or attributed networks. To address these limitations, the thesis introduces a series of stable and efficient expansion-based algorithms tailored to different network types.

The work begins with PE-LCD, a local community detection algorithm for unweighted networks that uses centrality-driven seed selection along with node and edge interaction coefficients, requiring no prior knowledge of the number or size of communities. Building on this, NPCD-WC extends the approach to weighted networks by employing weighted centrality to identify cohesive nodes and introducing a novel neighbourhood proximity measure for community expansion, achieving low computational complexity and high stability. The thesis then turns to directed weighted networks with CD-DAWN, which combines a new seed selection strategy with a directed proximity measure that explicitly accounts for edge weights and directionality; alongside this algorithm, a new quality measure, Directed Weighted Overlapping Modularity, is proposed to more accurately evaluate community covers in such networks.

Extending into attributed networks, DOC-WAN detects overlapping communities in weighted attributed networks by selecting seed nodes through weighted centrality and expanding them using both Hamming similarity and neighbourhood proximity, with highly similar communities subsequently merged to form the final structure. Finally, the thesis introduces the General Modular Graph (GMG) benchmark, a versatile artificial network generation model that requires only five intuitive parameters yet can produce realistic networks featuring overlapping communities, weighted edges, scale-free degree distributions, and both community and anti-community structures, addressing key limitations of widely used benchmarks such as LFR.

Collectively, these contributions advance overlapping community detection across unweighted, weighted, directed, and attributed networks, while also providing a robust evaluation metric and a realistic benchmarking tool.

(Abhinav Kumar)