

Extracting Natural Phenomena Combining CML with Graph Signal Processing

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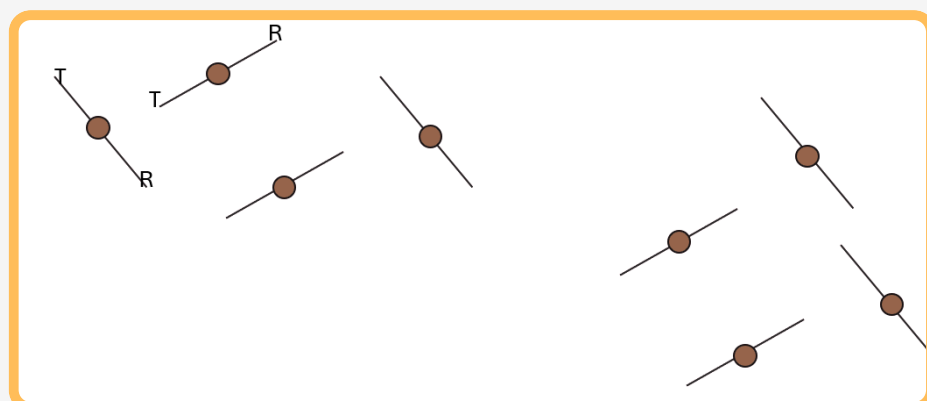
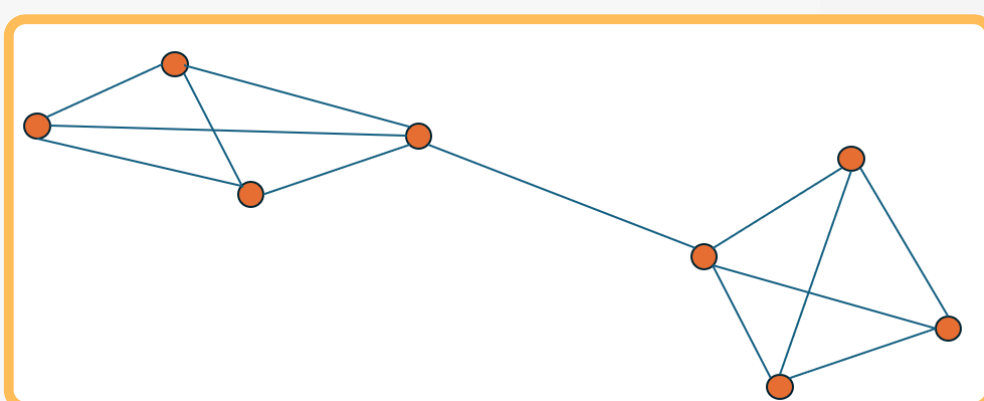
1. Intro

- Opportunistic sensing is essential for optimizing existing data in research and weather warning systems.
- This study builds on previous work linking CML information with rainfield monitoring.
- Integrating signal attenuation-based rain estimation with graph signal processing can enhance rainfield monitoring and uncover natural phenomena through graph connections.

2. How we connect CML to the Graph?

Recent studies using CML data reference the midpoint of the link for calculations. Key points include:

- Graph vertices represent receiver measurements at the midpoint, acting as single-point rain sensors.
- Edges and weights are determined by geographic proximity.
- $W_{mn} = \frac{a}{r^2}$



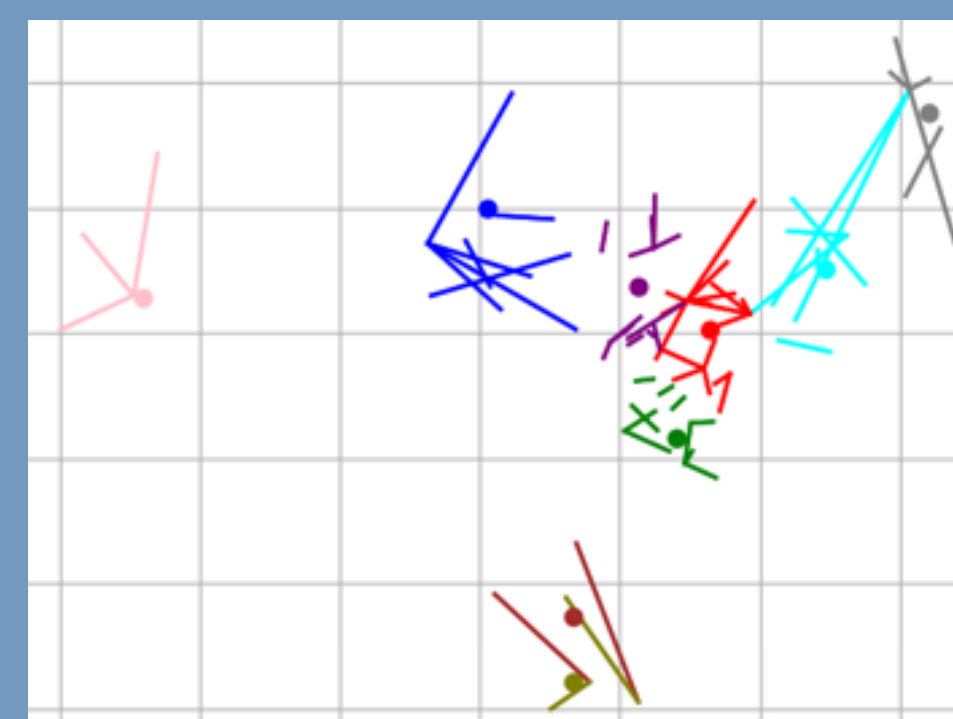
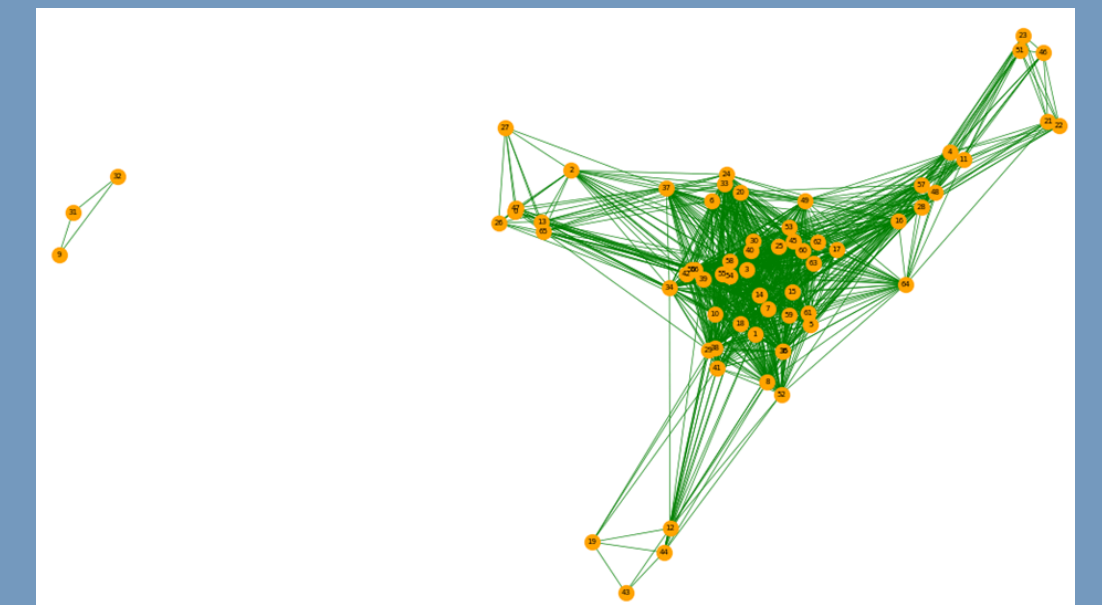
3. Graph Equations

- W – weights
- D - degree matrix elements, $D_{nn} = \sum_m W_{nm}$
- L - Laplacian matrix, $L = D - W$
- smoothness = $\lambda_{avg}^{-1} \frac{\sum_{m=1}^M x^T[m] L x[m]}{\sum_{m=1}^M \|x[m]\|^2} < 1$
- Smoothness evaluation in the graph – determine correlation between the measurements (nodes) and the weights (edges).

4. Graphics

This study uses OpenMRG data with 66 two-way links.

Graph uses the links as middle point
smoothness=0.41



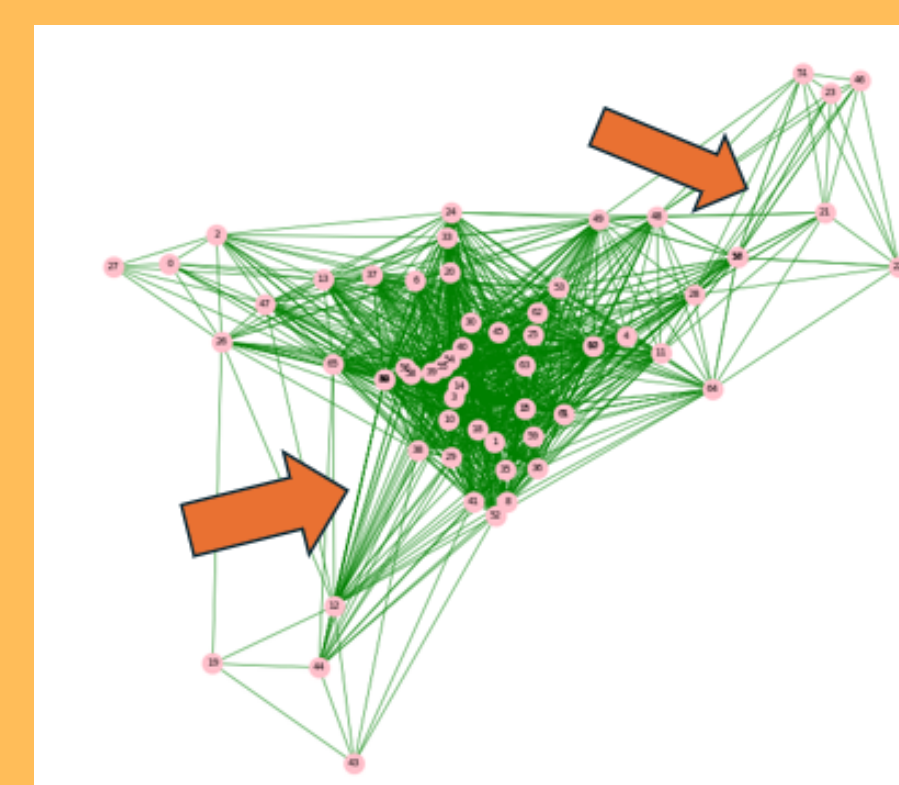
Lines represent the links and dots show the locations of rain gauges

5. Coverage/Correctness Model

Extracting missing data by 2 models:

1. Coverage model:

Each link has a radius of influence. By preserving graph smoothness, covering more area and estimate missing data from the graph.

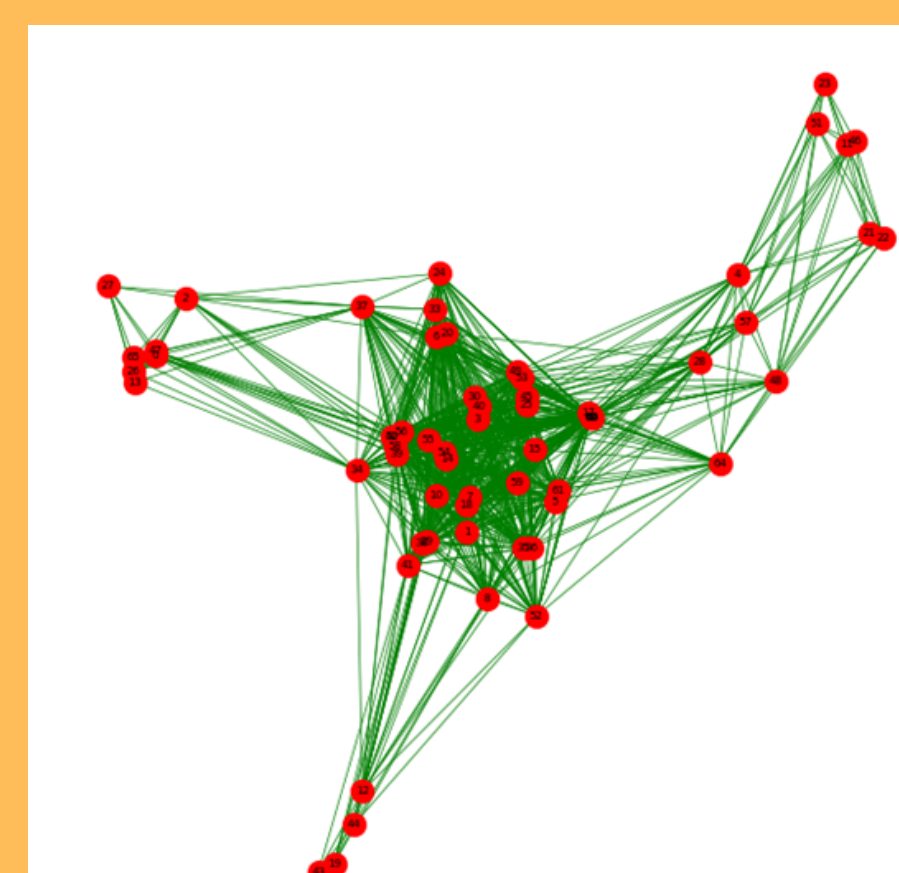


Arrows mark areas with increased connection coverage in the graph.
smoothness = 0.71

2) Correctness model:

This model aims to find the rain's origin along a link for more precise results.

The node can be placed anywhere along the link.



smoothness = 0.23

