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Project 4 Report

Consensus Filters for Sensor Networks

Project Overview: The objective of this project was to implement consensus filters for sensor networks, specifically focusing on two cases: static sensor networks and dynamic sensor networks. The consensus filters aim to estimate values based on noisy sensor measurements while leveraging communication and collaboration among neighboring nodes.

Project Specifications:

- Sensor network with n = 50 nodes.
- Each sensor node measures $z_i = 40 + \text{Noise}$, where Noise is Gaussian noise with zero mean.
- Two consensus algorithms were implemented: Consensus 1 and Consensus 2.
- Consensus 1 involves selecting a step rate ϵ
- The project is divided into two cases:
    1. Static sensor network
    2. Dynamic sensor network, where the network topology changes over time/iteration by adjusting the active range.

Case 1: Static Sensor Network:

1. Plot the estimated error between the estimated value and the ground truth (40) for all sensor nodes.
2. Plot the estimated error between the estimated value and the average of all measurements for all sensor nodes.
3. Plot the initial measurements versus the final estimates for all sensor nodes.

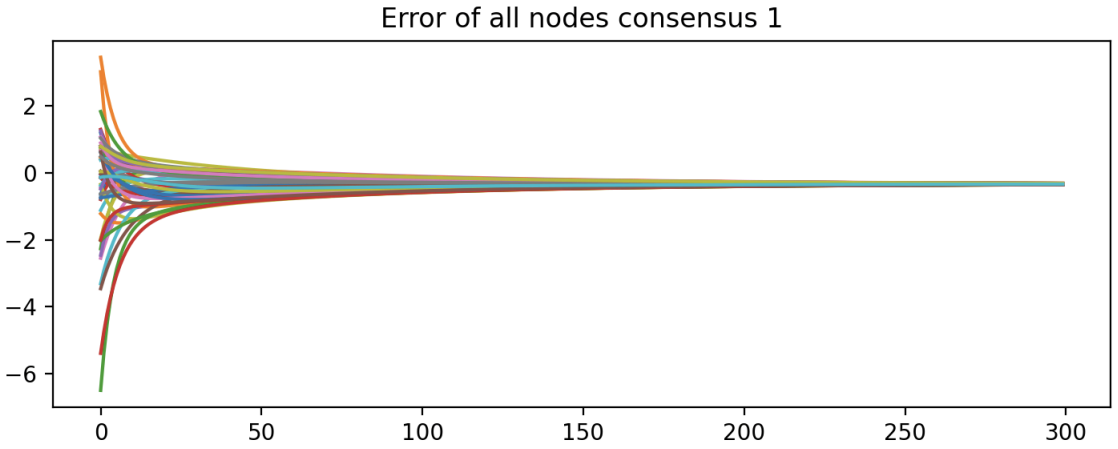
Case 2: Dynamic Sensor Network:

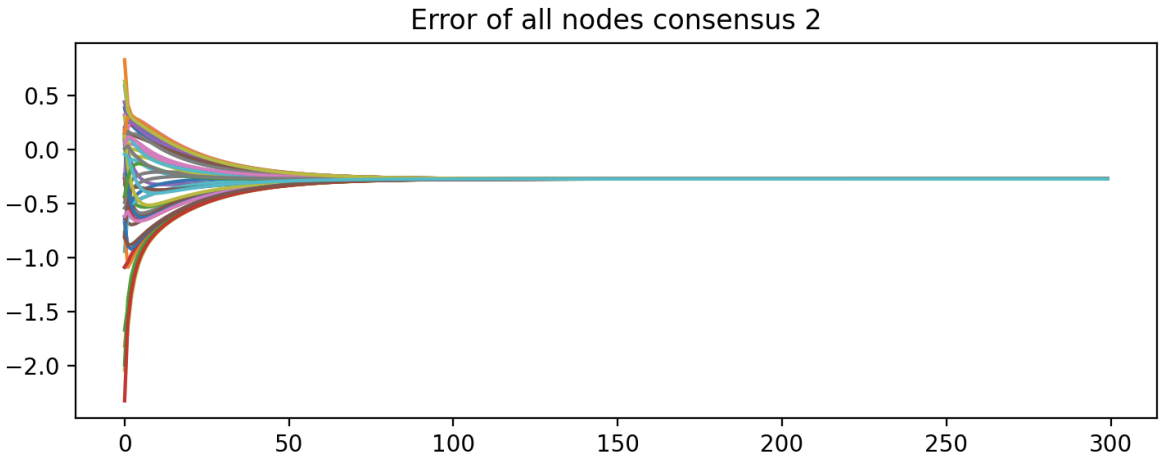
1. Plot the estimated error between the estimated value and the ground truth (40) for all sensor nodes.
2. Plot the estimated error between the estimated value and the average of all measurements for all sensor nodes.
3. Plot the initial measurements versus the final estimates for all sensor nodes.

Project Results:

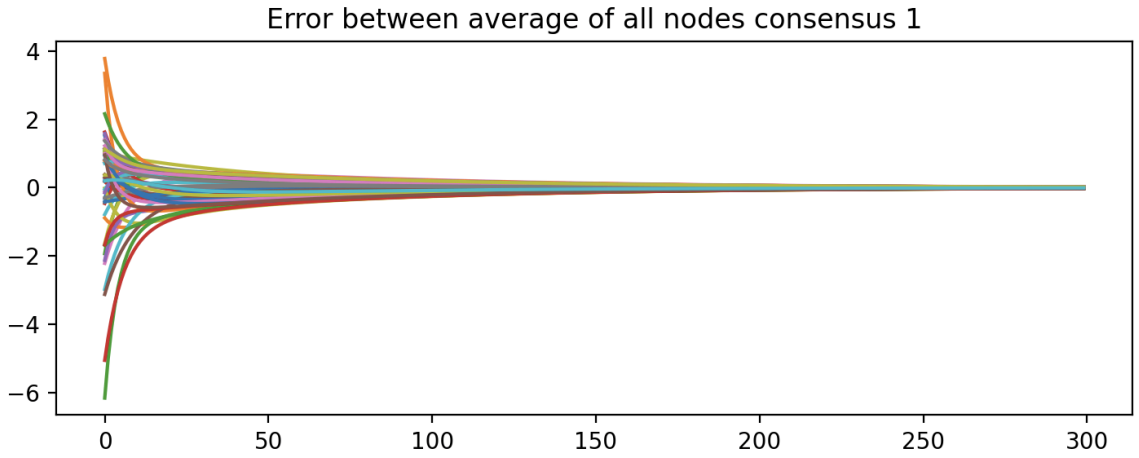
- **Case 1: Static Sensor Network:**

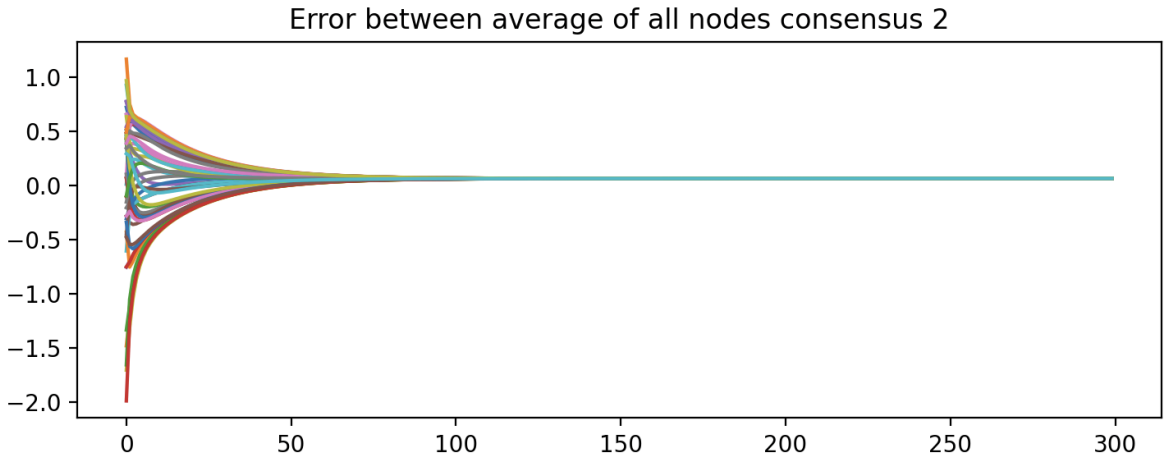
a. The estimated error between the estimated value and the ground truth was plotted, demonstrating the convergence of estimates to the true value. We notice that the error for consensus 1 is closer to zero than for consensus 2, but consensus 2 converges faster than consensus 1.



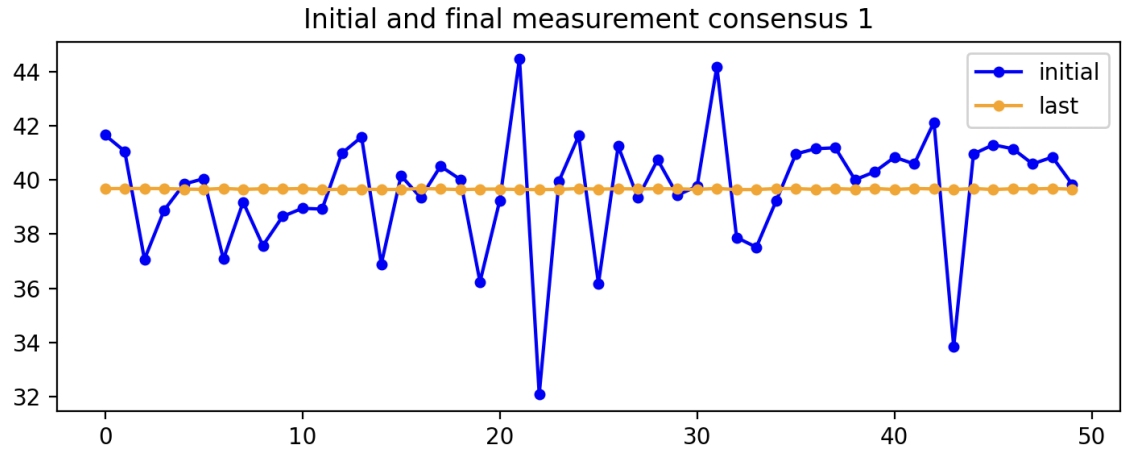


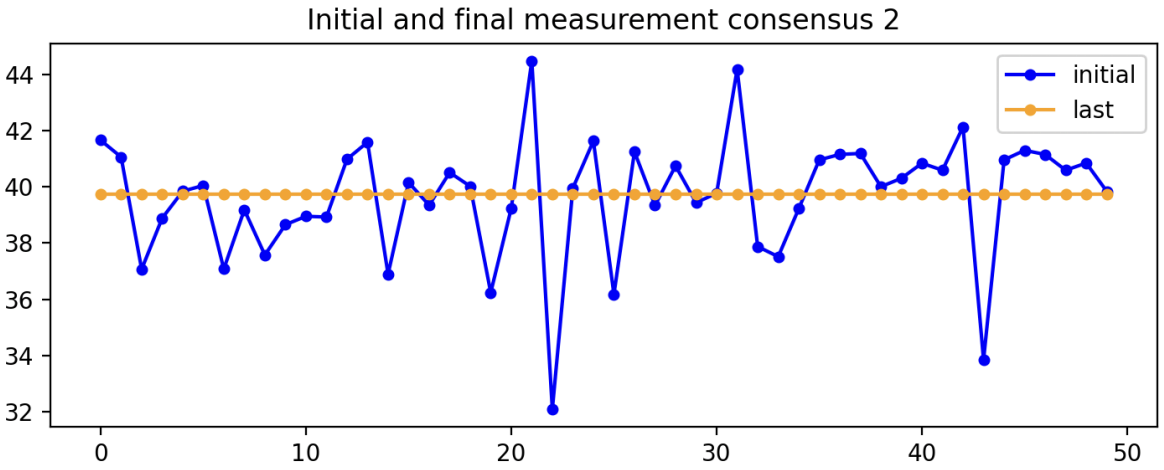
b. Similarly, the error between the estimated value and the average of all measurements was plotted, indicating the consensus achieved among the sensor nodes. This time the error between the average of all nodes for consensus 2 was closer to 0 zero than it was for consensus 1. Consensus 2 converges faster.





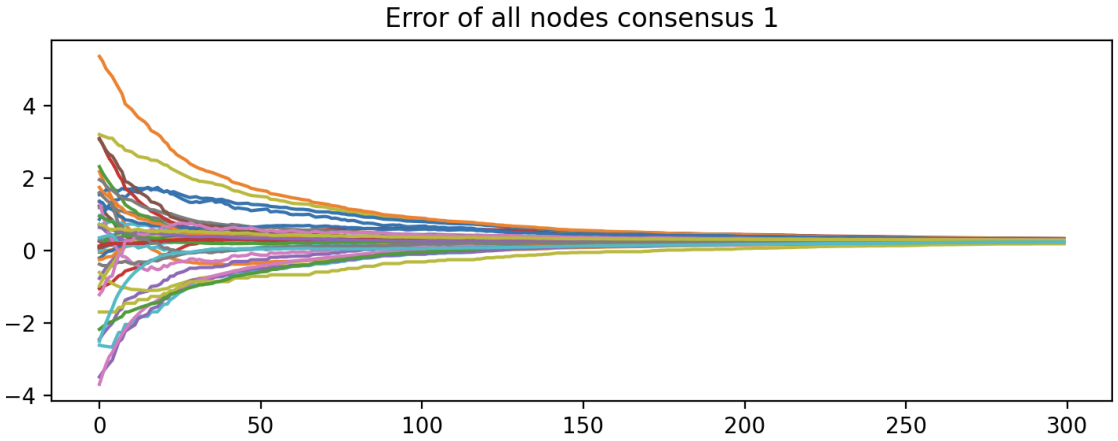
c. Initial measurements versus final estimates were visualized, showcasing the filtering process and convergence. We notice that the final measurement of consensus 2 was closer to the ground truth of 40 than consensus 1.

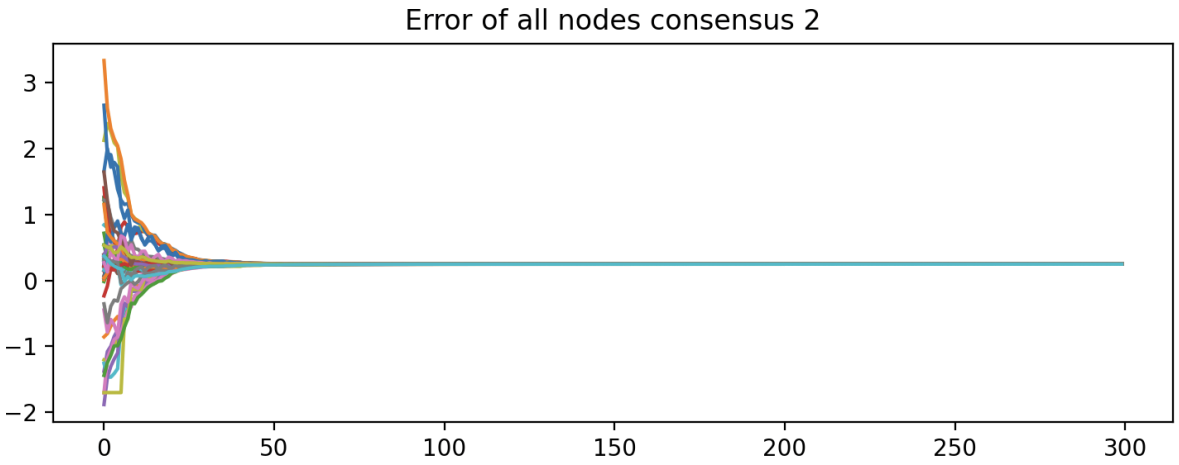




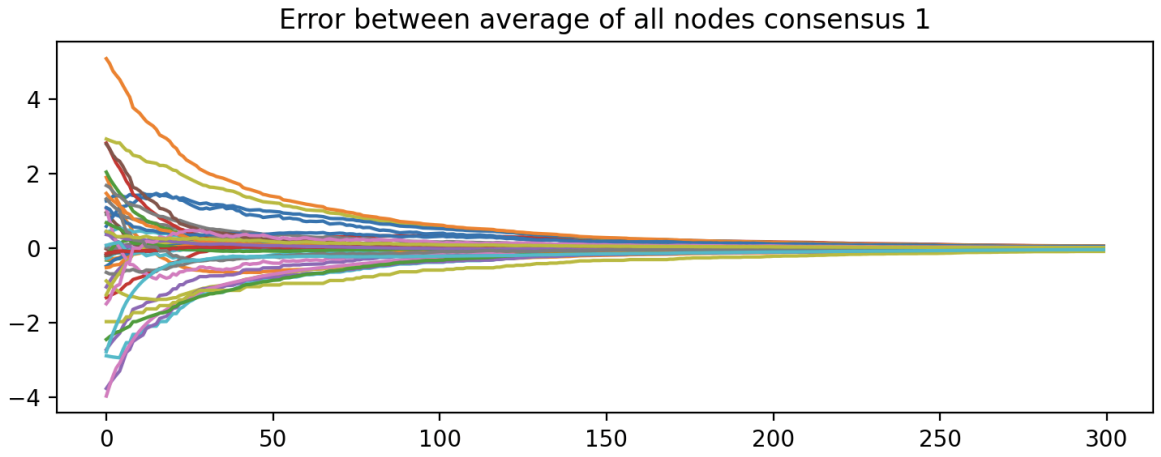
- **Case 2: Dynamic Sensor Network:**

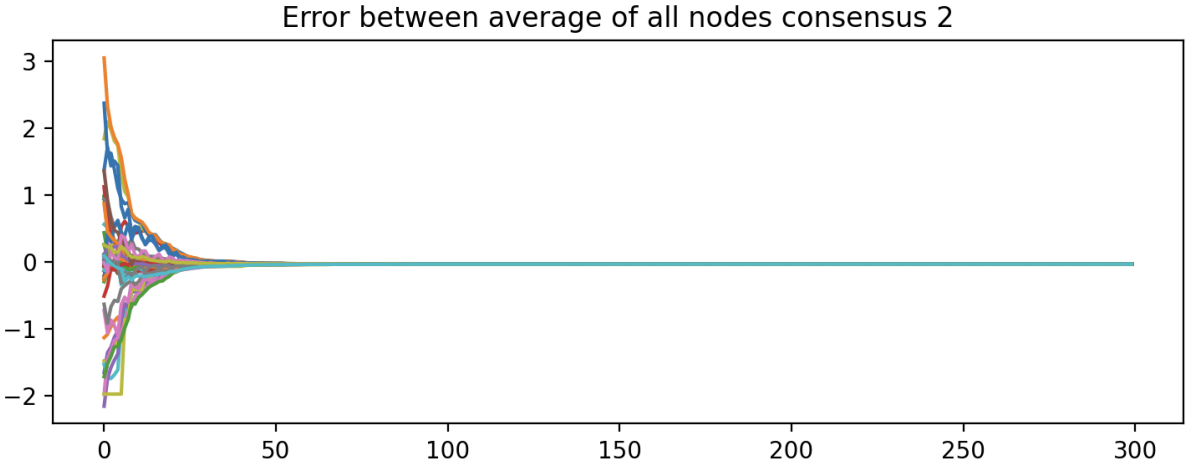
a. The same analyses were conducted for the dynamic sensor network, with the added complexity of changing network topology. We notice that both of the plots are unstable due to dynamic changes to the active range r. As we can see Consensus 2 converges faster than Consensus 1. Consensus 1's error is closer to zero.



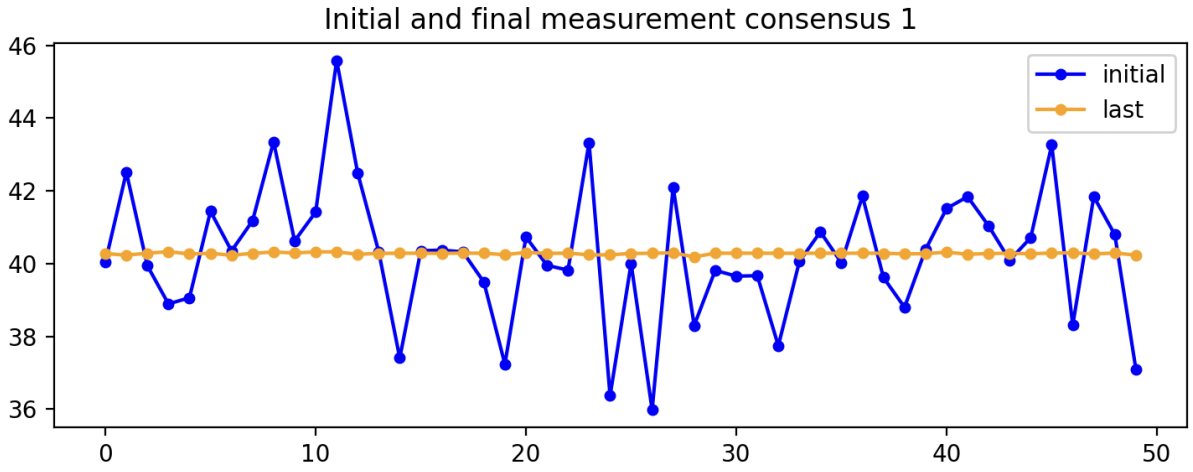


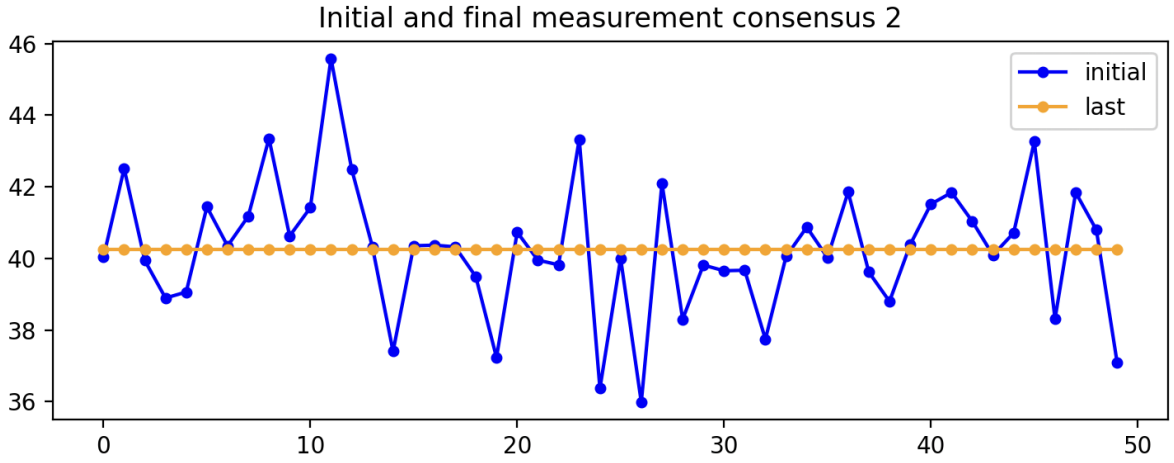
b. Despite the changing network structure, the consensus filters adapted and continued to converge toward the true value and the average of measurements. Again Consensus 1's error is closer to zero.





c. The plots of initial measurements versus final estimates illustrate the performance of the consensus filters in dynamic environments. Both Consensus 1 and Consensus 2 have similar final measurements.





Conclusion: In conclusion, this project successfully implemented consensus filters for both static and dynamic sensor networks. Visualizations and analyses demonstrated that the consensus filters effectively estimate values while mitigating noise and adapting to changing network topologies.