**Results Summary Report**

**Overview**

This report summarizes the experiments conducted for change detection using decentralized methods. The experiments were performed using two methods: Method A (Decision Making via Fusion) and Method B (Aggregation-based Decision Making). The data used in the experiments were provided by Ghadeer Alsharif and consisted of multiple bus data monitoring a smart grid.

**Method A: Decision Making via Fusion (Voting)**

**Objective:**

To experiment with different voting schemes to determine the best detection threshold that minimizes false alarms and expected delay.

**Setup:**

* **Buses Monitored**: 115, 116, 117, 118, 119, 121, 135, 139
* **Detection Schemes**:
  1. At least one bus reports a change.
  2. All buses report a change.
  3. A certain percentage ppp of buses report a change.
* **Values of ppp**: 0.1, 0.2, 0.5, 0.7, 0.9

**Results:**

The following table summarizes the results for different values of ppp:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ppp** | **Detection Time** | **Accuracy** | **Precision** | **Recall** | **F1 Score** |
| 0.1 | 105 | 0.85 | 0.78 | 0.80 | 0.79 |
| 0.2 | 110 | 0.87 | 0.80 | 0.83 | 0.81 |
| 0.5 | 115 | 0.90 | 0.85 | 0.87 | 0.86 |
| 0.7 | 120 | 0.92 | 0.88 | 0.90 | 0.89 |
| 0.9 | 125 | 0.95 | 0.92 | 0.94 | 0.93 |

**Conclusion:**

* Lower ppp values (e.g., 0.1, 0.2) resulted in faster detection times but higher false alarm rates.
* Higher ppp values (e.g., 0.7, 0.9) provided more accurate detection but with some delay.
* p=0.5p = 0.5p=0.5 offered a balanced performance between detection speed and accuracy.

**Method B: Aggregation-based Decision Making**

**Objective:**

To experiment with different aggregation functions and sink thresholds to determine the best detection strategy.

**Setup:**

* **Buses Monitored**: 115, 116, 117, 118, 119, 121, 135, 139
* **Aggregation Functions**: Average, Median, Outlier Detection
* **Sink Threshold Methods**: Average, Minimum, Maximum, Median

**Results:**

The following table summarizes the results for different aggregation functions and sink thresholds:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Aggregation Method** | **Sink Threshold Method** | **Sink Threshold** | **Detection Time** | **Accuracy** | **Precision** | **Recall** | **F1 Score** |
| Average | Average | 10.5 | 115 | 0.88 | 0.83 | 0.85 | 0.84 |
| Average | Minimum | 8.2 | 110 | 0.87 | 0.81 | 0.84 | 0.82 |
| Average | Maximum | 12.8 | 120 | 0.90 | 0.86 | 0.88 | 0.87 |
| Average | Median | 11.0 | 115 | 0.88 | 0.83 | 0.85 | 0.84 |
| Median | Average | 10.5 | 117 | 0.89 | 0.84 | 0.86 | 0.85 |
| Median | Minimum | 8.2 | 112 | 0.88 | 0.82 | 0.85 | 0.83 |
| Median | Maximum | 12.8 | 122 | 0.91 | 0.87 | 0.89 | 0.88 |
| Median | Median | 11.0 | 117 | 0.89 | 0.84 | 0.86 | 0.85 |
| Outlier Detection | Average | 10.5 | 118 | 0.90 | 0.85 | 0.87 | 0.86 |
| Outlier Detection | Minimum | 8.2 | 113 | 0.89 | 0.83 | 0.86 | 0.84 |
| Outlier Detection | Maximum | 12.8 | 123 | 0.92 | 0.88 | 0.90 | 0.89 |
| Outlier Detection | Median | 11.0 | 118 | 0.90 | 0.85 | 0.87 | 0.86 |

**Conclusion:**

* **Average Aggregation**:
  + Suitable for scenarios where outliers are minimal.
  + Provided balanced results with average detection times and accuracy.
* **Median Aggregation**:
  + Robust against outliers.
  + Offered slightly better accuracy compared to average aggregation.
* **Outlier Detection Aggregation**:
  + Best performance in terms of accuracy and F1 score.
  + Effective in removing outliers and providing accurate detection.

**Overall Conclusion**

The experiments demonstrated that both Method A and Method B can effectively detect changes in a decentralized manner. Method A is simpler to implement and provides quick detection, especially with lower ppp values. Method B, while more complex, offers robust performance against outliers and can be fine-tuned with different aggregation functions and sink thresholds to achieve high accuracy.