Table 1: Performance Comparison: No Normalization

| Metric | NMF | OPNMF |
|---|---|---|
| Accuracy | 0.9798 | **0.9899** |
| F1 Score (macro) | 0.9798 | **0.9899** |
| AUC (OVO) | 0.2548 | **0.9971** |
| Reconstruction Error | **0.3627** | 0.3885 |
| Mean Squared Error | **0.0827** | 0.0949 |
| | 33 0 0 | 33 0 0 |
| Confusion Matrix | 0 33 0 | 0 33 0 |
| | 2 0 31 | 1 0 32 |
| Component-to-Mask Correlations | 0.74, 0.67, 0.69 | 0.71, 0.62, 0.63 |
| Dice Scores | **0.83, 0.68, 0.63** | 0.46, 0.44, 0.44 |

Table 2: Performance Comparison: Global Normalization

| Metric | NMF | OPNMF |
|---|---|---|
| Accuracy | 0.9596 | **0.9798** |
| F1 Score (macro) | 0.9597 | **0.9796** |
| AUC (OVO) | 0.5111 | 0.4976 |
| Reconstruction Error | **0.4476** | 0.4531 |
| Mean Squared Error | **0.0550** | 0.0564 |
| | 31 2 0 | 33 0 0 |
| Confusion Matrix | 0 33 0 | 0 33 0 |
| | 1 1 31 | 1 1 31 |
| Component-to-Mask Correlations | 0.75, 0.68, 0.78 | 0.74, 0.67, 0.77 |
| Dice Scores | **0.84, 0.72, 0.86** | 0.49, 0.45, 0.44 |

Table 3: Performance Comparison: Per-Entry Normalization

| Metric | NMF | OPNMF |
|---|---|---|
| Accuracy | 0.9596 | **0.9798** |
| F1 Score (macro) | 0.9597 | **0.9796** |
| AUC (OVO) | 0.5111 | 0.4976 |
| Reconstruction Error | **0.4476** | 0.4531 |
| Mean Squared Error | **0.0550** | 0.0564 |
| | 31 2 0 | 33 0 0 |
| Confusion Matrix | 0 33 0 | 0 33 0 |
| | 1 1 31 | 1 1 31 |
| Component-to-Mask Correlations | 0.75, 0.68, 0.78 | 0.74, 0.67, 0.77 |
| Dice Scores | **0.84, 0.72, 0.86** | 0.49, 0.45, 0.44 |

Table 4: Performance Comparison: PLS Normalization

| Metric | NMF | OPNMF |
|---|---|---|
| Accuracy | 0.9596 | **0.9798** |
| F1 Score (macro) | 0.9595 | **0.9796** |
| AUC (OVO) | 0.5116 | 0.4991 |
| Reconstruction Error | **0.4487** | 0.4543 |
| Mean Squared Error | **0.0556** | 0.0569 |
| | 32 1 0 | 33 0 0 |
| Confusion Matrix | 0 33 0 | 0 33 0 |
| | 1 2 30 | 1 1 31 |
| Component-to-Mask Correlations | 0.75, 0.68, 0.78 | 0.74, 0.67, 0.77 |
| Dice Scores | **0.83, 0.72, 0.86** | 0.49, 0.45, 0.44 |

Table 5: Shared Experimental Settings for All Runs

| Parameter | Value |
|---|---|
| Max Iterations | 50000 |
| Tolerance | $1 \times 10^{-9}$ |
| Batch ID | 5d46b9a7a50d9ed7 |
| Torus Variables | Thickness + Second Bump ("both") |