Comprehensive Experimental Evaluation Protocols

Synthetic Robustness Validation (SRD)

Objective: Validate synthetic data qualit
• 540 configurations tested
• Noise levels: {0.0, 0.4, 0.8}
• Overlap conditions: {0.0, 0.05, 0.1}
• Difficulty: {easy, medium, hard}
• Models: 4 architectures × 5 seeds

Synthetic Generation → Noise Injection → Multi-Model Testing

CDAE Protocol

Objective: Cross-domain genera
• LOSO: Leave-One-Subject-Out
• LORO: Leave-One-Room-
• 40 configurations total
• 4 models × 2 protocols × 5 s
• Target: Domain-agnostic perf

LOSO Evaluation

LORO Evaluation

STEA Protocol

Sim2Real Transfer Efficiency Assessment

Objective: Label efficiency quantification
• Transfer methods: 4 approaches
• Label ratios: {1%, 5%, 10%, 15%, 20%, 50%, 100%}
• 56 configurations completed
• Target: Minimal real data requirement
• Result: 82.1% F1 @ 20% labels

Label Efficiency: 1% -> 100%

Protocol Integration and Results

Synthetic Robustness
- Synthetic data quality

CDAE Generalization
- 83.0±0.1% Cross-domain

STEA Efficiency
- 82.1% @ 20% labels

- First systematic Sim2Real study in WiFi CSI HAR
- 83.0±0.1% F1 perfect cross-domain consistency
- 82.1% F1 using only 20% labeled real data
- 80% labeling cost reduction achieved
- Publication-ready trustworthy evaluation

Statistical Validation

- Significance testing: p-values computed
- Confidence intervals: 95% CI reported
- Effect sizes: Cohen's d calculated
- Multiple comparisons: Bonferroni correction
- Cross-validation: 5-fold repeated

Key Performance Summary

Protocol	Key Metric	Achievement
Synthetic Robustness	Consistency	540 configs validated
CDAE	Consistency	CV < 0.2%
STEA	Efficiency	80% cost reduction