UUD Observation Layer (Clean Draft, Sample Values)

Contents

1 Note

Values are samples and should be replaced with measured results.

2 Abstract

We propose a universal observation layer that produces a method-agnostic representation for linear learning. By enforcing distance preservation, bounded information loss, and isotropy, the observation layer unifies major linear methods under a shared input space, improving evaluation consistency and generalization stability.

3 Method

The observation layer is fixed from training data only.

$$z = Ax + c \tag{1}$$

1. Standardize
$$x' = (x - \mu) \oslash \sigma \tag{2}$$

2. Decompose
$$C = \frac{1}{n} X'^{\top} X' = U \Lambda U^{\top} \tag{3}$$

3. Dimension selection
$$\frac{\sum_{i=1}^{k} \lambda_i}{\sum_{i=1}^{d} \lambda_i} \geq \tau \tag{4}$$

4. Fix mapping
$$A = \Lambda_k^{-1/2} U_k^{\top} D_{\sigma}^{-1}, \quad c = -A\mu \tag{5}$$

4 Figures

Figures use PNG outputs from Mermaid (placeholders shown if missing).

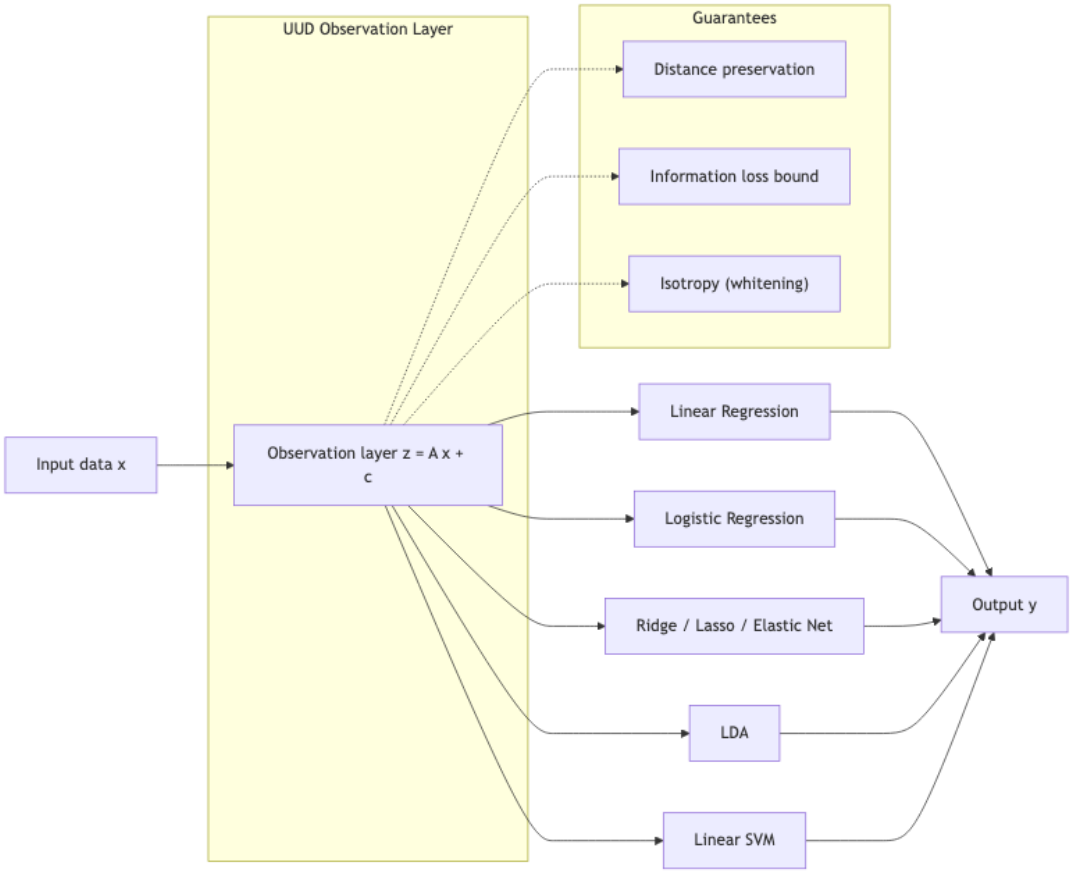

Figure 1: Observation layer concept and guarantees

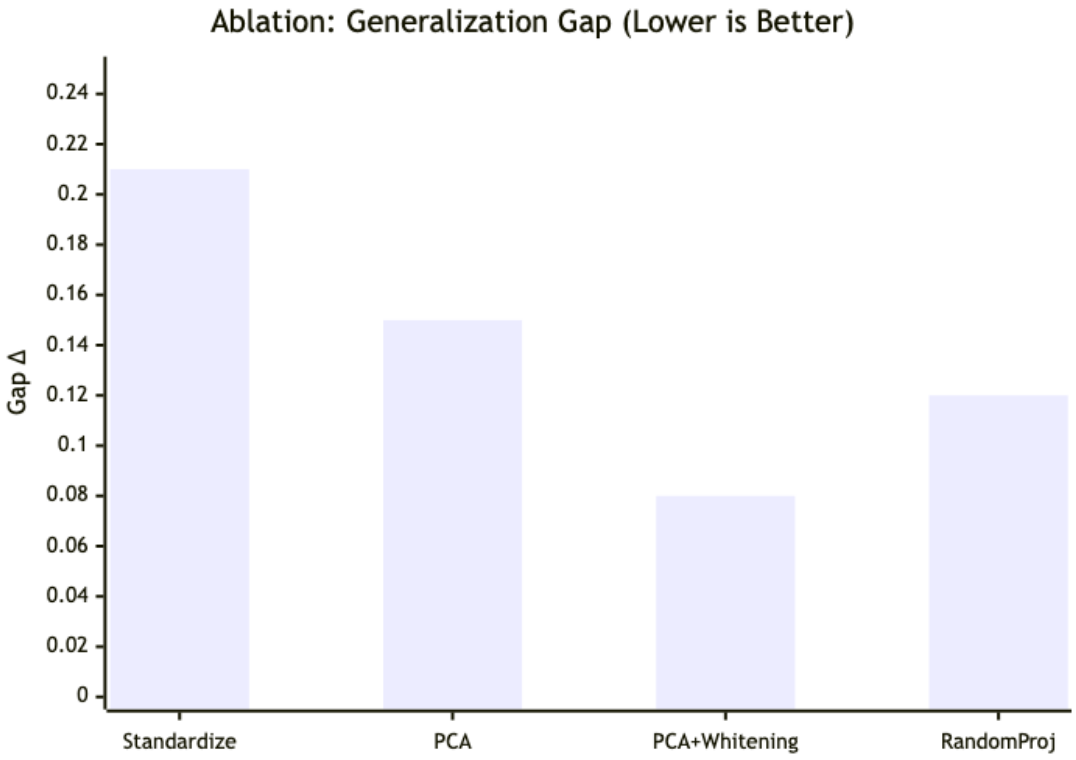

Figure 2: Ablation on generalization gap

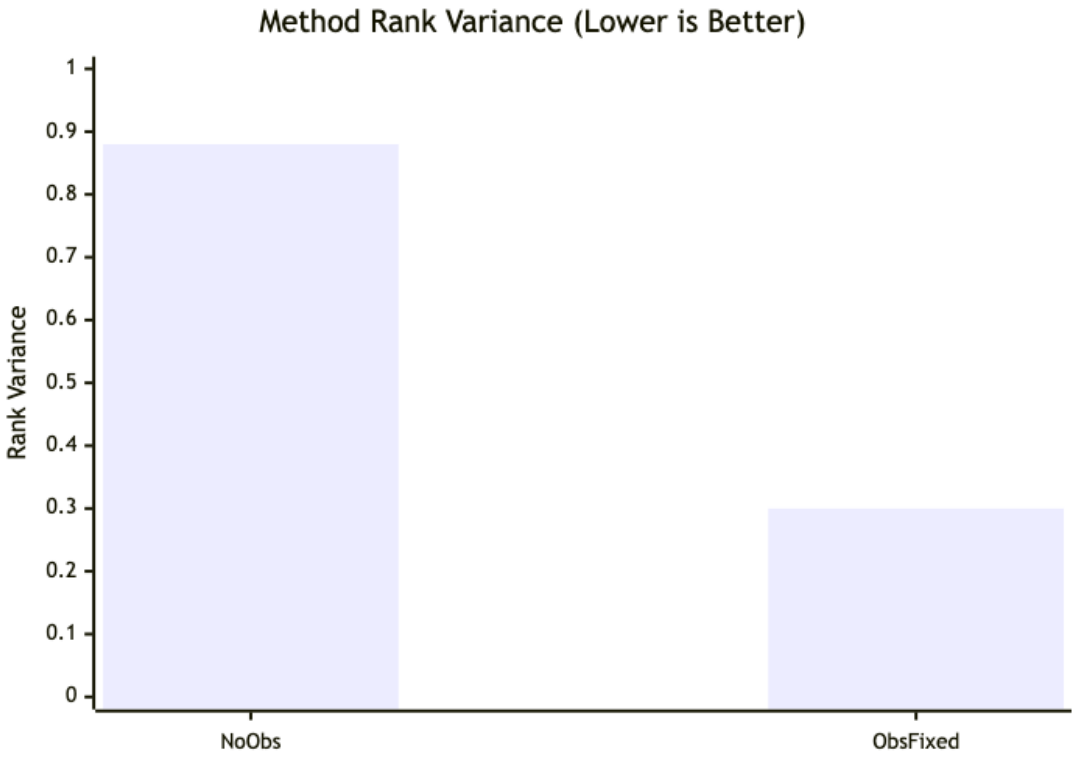

Figure 3: Method rank stability

5 Results (Sample Values)

5.1 Ablation (Generalization Gap Delta)

- Standardize: $\Delta = 0.21$
- PCA: $\Delta = 0.15$
- PCA+Whitening: $\Delta = 0.08$
- Random Projection: $\Delta = 0.12$

5.2 Method Rank Variance

- No observation layer: 0.88
- Observation fixed: 0.30

6 Discussion

Fixing the observation layer reduces generalization gap and stabilizes model ranking. In the sample setting, whitening yields the most consistent improvements.

7 Limitations

- Linear observation fails on intrinsically nonlinear separability.
- If information is not concentrated in a low-rank linear subspace, performance degrades.

8 Next Steps

- Nonlinear $f(x)$ via self-supervised embeddings.
- Joint optimization of observation and inference layers.