Pure SWAE 3D Reconstruction Architecture

Based on "Exploring Autoencoder-based Error-bounded Compression for Scientific Data"

3D Scientific Data
(40×40×40)

Block Partitioning
8×8×8 blocks
(125 blocks total)

Input Block
(B,1,8,8,8)

Conv3D+BN+ReLU
1→32 ch, s=2
4×4×4

Conv3D+BN+ReLU
32→64 ch, s=2
2×2×2

Conv3D+BN+ReLU
64→128 ch, s=2
1×1×1

Flatten+FC
128→16

Latent Code z
(B, 16)
Compressed
Representation

Prior Samples
z_prior ~ N(0,I)
(B, 16)

Output Block
(B,1,8,8,8)

DeConv3D (final)
32→1 ch, s=2
8×8×8

DeConv3D+BN+ReLU
64→32 ch, s=2
4×4×4

DeConv3D+BN+ReLU
128→64 ch, s=2
2×2×2

FC+Reshape
16→128
(B,128,1,1,1)

Block Assembly
125 blocks →
40×40×40 volume

Reconstruction Loss
L_recon = MSE(x, x̂)
= ||x - x̂||²

Sliced Wasserstein Distance
L_SW = E[||sort(θᵀz) - sort(θᵀz_prior)||²]
θ ~ Uniform(S^(d-1))

Reconstructed
3D Data
(40×40×40)

Total Loss
L = L_recon + λ·L_SW
λ = 10.0

Implementation Specifications:
• Block Size: 8×8×8 (as per paper Table VI)
• Latent Dimension: 16 (compression ratio ~32:1)
• Architecture: [32, 64, 128] channels
• Regularization: λ = 10.0, 50 projections

Key Equations:
• Encoder: φ(x) → z ∈ ℝ¹⁶
• Decoder: ψ(z) → x̂ ∈ ℝ⁸ˣ⁸ˣ⁸
• SW Distance: SW(P_z, P_prior) = E[W₁(P_z^θ, P_prior^θ)]