GENERATING ADAPTIVE AND ROBUST FILTER SETS USING AN UNSUPERVISED LEARNING FRAMEWORK

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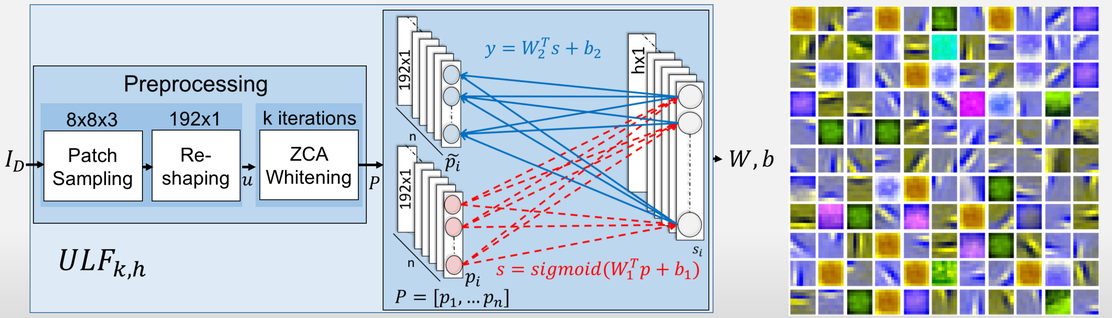
INTRODUCTION

- We introduce an adaptive unsupervised learning framework, which utilizes natural images to train filter sets.
- The framework is shown alongside and consists of a preprocessing stage and an autoencoder stage.
- A novel extension to ZCA whitening is proposed in the preprocessing stage, where the natural scene statistics of the input data are eliminated, so that the learnt filters are domain-unspecific.
- We use sparsity in the objective function of the autoencoder stage to force the filter responses onto the non-linear region of the sigmoid activation.



RESULTS AND CONTRIBUTIONS

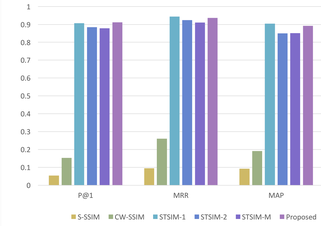
IMAGE QUALITY ASSESSMENT

Performance Evaluation on LIVE and TID 2013 database

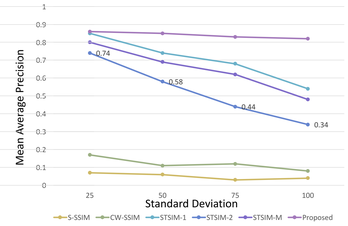
Methods	PSNR-HMA	MS-SSIM	SR-SSIM	FSIMc	UNIQUE	MS-UNIQUE
Outlier Ratio						
TID13	0.670	0.697	0.632	0.727	0.640	0.611
Root Mean Square Error						
LIVE	6.58	7.43	7.54	7.20	6.76	6.61
TID13	0.69	0.68	0.61	0.68	0.60	0.57
Pearson Correlation Coefficient						
LIVE	0.958	0.946	0.945	0.950	0.956	0.958
TID13	0.827	0.832	0.866	0.832	0.870	0.884
Spearman Correlation Coefficient						
LIVE	0.944	0.951	0.955	0.959	0.952	0.949
TID13	0.817	0.785	0.807	0.851	0.860	0.870

TEXTURE RETRIEVAL

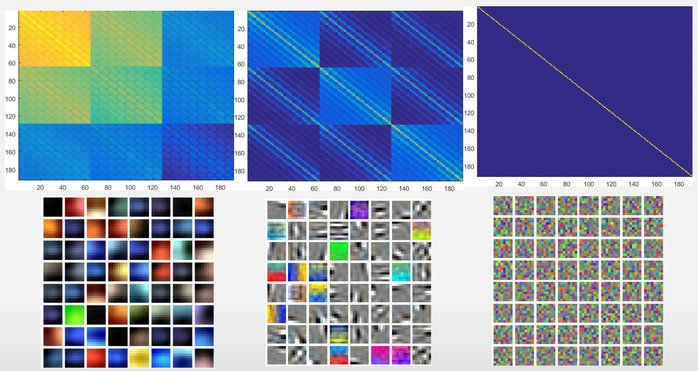
Performance Evaluation on CuRET database



Robustness analysis with AWGN



THEORY



Extended Zero Component Analysis (ZCA) Whitening Procedure on natural images

STANDARD ZCA

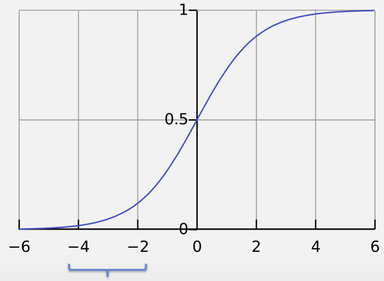
To obtain a whitened output P from an input u

$$W_z = (uu^T)^{-1/2}$$
$$W_z \propto V(\Lambda + \epsilon)^{-1/2} V$$
$$P = W_z u$$

EXTENDED ZCA

$$W_z^i = (u_{i-1} u_{i-1}^T)^{-1/2}$$
$$u_i = W_z^i u_{i-1}, \forall i \in [1, k], \forall k > 0$$
$$P = W_z^K u_{k-1}$$

SPARSITY BASED NON-LINEARITY

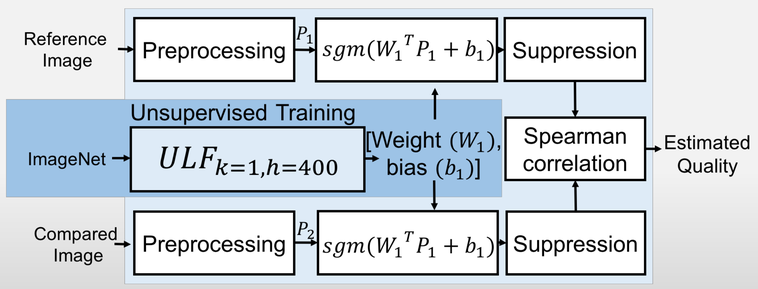


$$J(W,b) = \|\tilde{P} - P\|_2^2 + \beta \sum_{j=1}^{n} KL(\rho || \tilde{\rho_j}) + \lambda \|W\|_2^2$$

APPLICATIONS

IMAGE QUALITY ASSESSMENT

Objective : To estimate the quality of a given distorted image, as perceived by humans



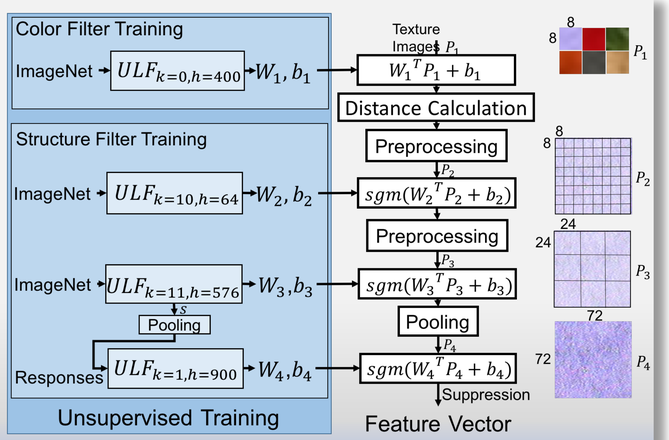
UNIQUE: Unsupervised Image Quality Estimation

TEXTURE RETRIEVAL

Objective : Given a query image, retrieve similar textures

Query Image :

Retrieval Results :



CONTRIBUTIONS

- We proposed the Unsupervised Learning Framework (ULF) to solve challenges which lack sufficient domain-specific data and annotations.
- An extension to the classical ZCA algorithm was proposed that would, in practice, orthogonalize the input vectors thereby eliminating all the lower order natural scene statistics.
- An autoencoder-based learning architecture was used as a tool to generate adaptive and robust filter sets.
- The filter sets spanned a response space in which a monotonicity-based metric can measure both the perceptual dissimilarity of natural images and the similarity of texture images.