Quantile-Based Maximum Likelihood Training for Outlier Detection

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Motivation

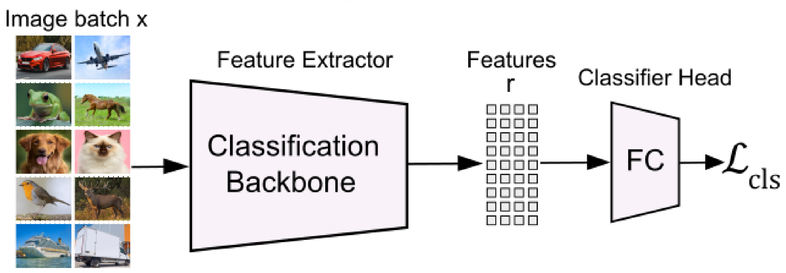
- Discriminative Learning often results in false positive for outliers.
- Prior methods train image classifiers with actual outlier data or synthesize outliers under self-supervised learning.
- Unsupervised generative modelling of inliers in pixel space has shown limited success for outlier detection.

Method

- A quantile-based maximum likelihood objective to enhance outlier detection in an inlier image classification setup.
- Our approach fits a normalizing flow to pre-trained discriminative features, detecting outliers based on log-likelihood.

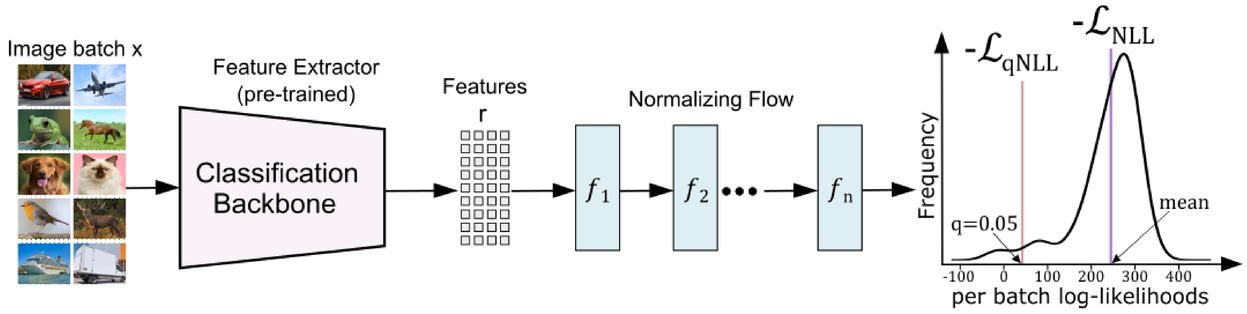
Stage 1: Discriminative Training

- Train an image classifier using multi-class cross-entropy loss.

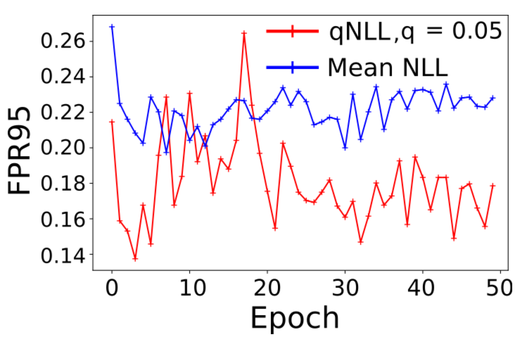


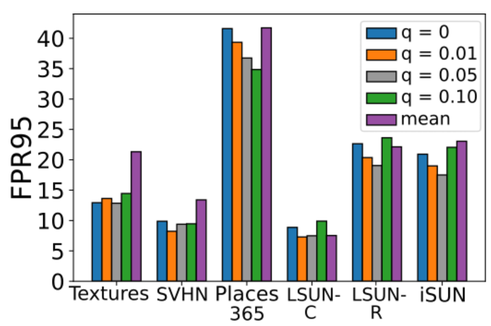
Stage 2: Generative Training

- Estimate the distribution of inlier features by training normalizing flow on the quantile-based negative log-likelihood loss.



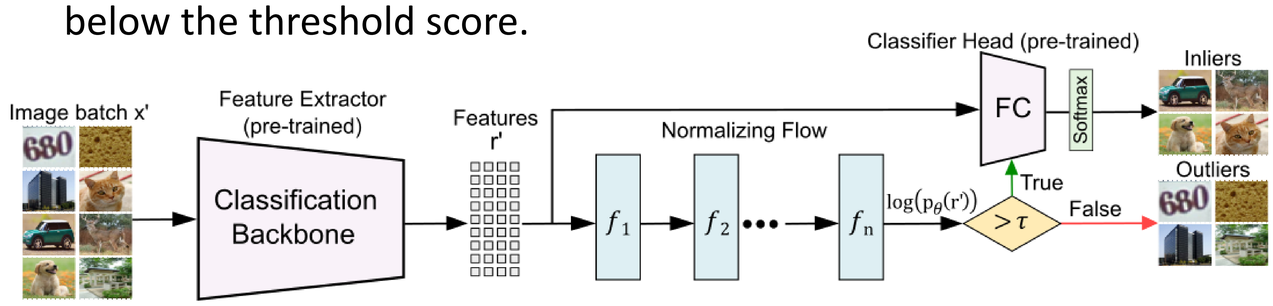
- Generally, quantile-based loss outperforms the mean-based loss.





Stage 3: Model Inference

- The test feature is labelled an outlier if its log-likelihood score is below the threshold score.



Results

- Our method outperforms the state-of-the-art unsupervised methods for outlier-aware image classification.

Inlier: CIFAR-10

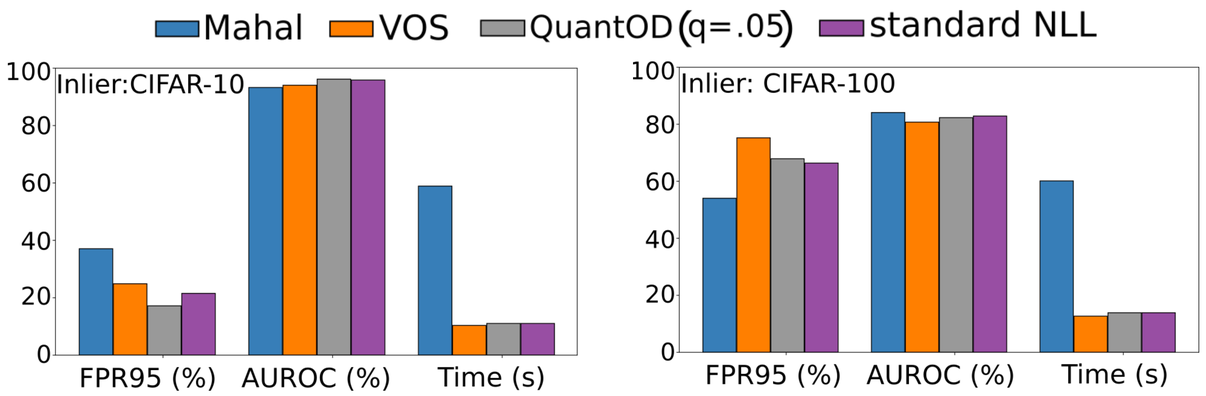
Method	FPR95	AUROC	AUPR
MSP	51.04	90.91	97.92
ODIN	35.71	91.09	97.62
Energy	33.01	91.88	97.83
QuantOD	**17.17**	**96.19**	**99.15**

Inlier: CIFAR-100

Method	FPR95	AUROC	AUPR
MSP	80.41	75.53	93.93
ODIN	74.64	77.43	94.23
Energy	73.60	79.56	94.87
QuantOD	**67.90**	**82.32**	**95.48**

Class-conditional Gaussians

- We report better outlier detection performance than approaches that estimate class-conditional Gaussians on CIFAR-10.
- Mahalanobis based class-conditional Gaussian modelling performs better than our approach on CIFAR-100.



Conclusion

- A new maximum likelihood objective for outlier-aware image classification without needing outlier-awareness during training.
- Our approach outperforms other unsupervised methods and is competitive with approaches that rely on per-class modelling.

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