Use of Uncertainty with Autoencoder Neural Networks for Anomaly Detection

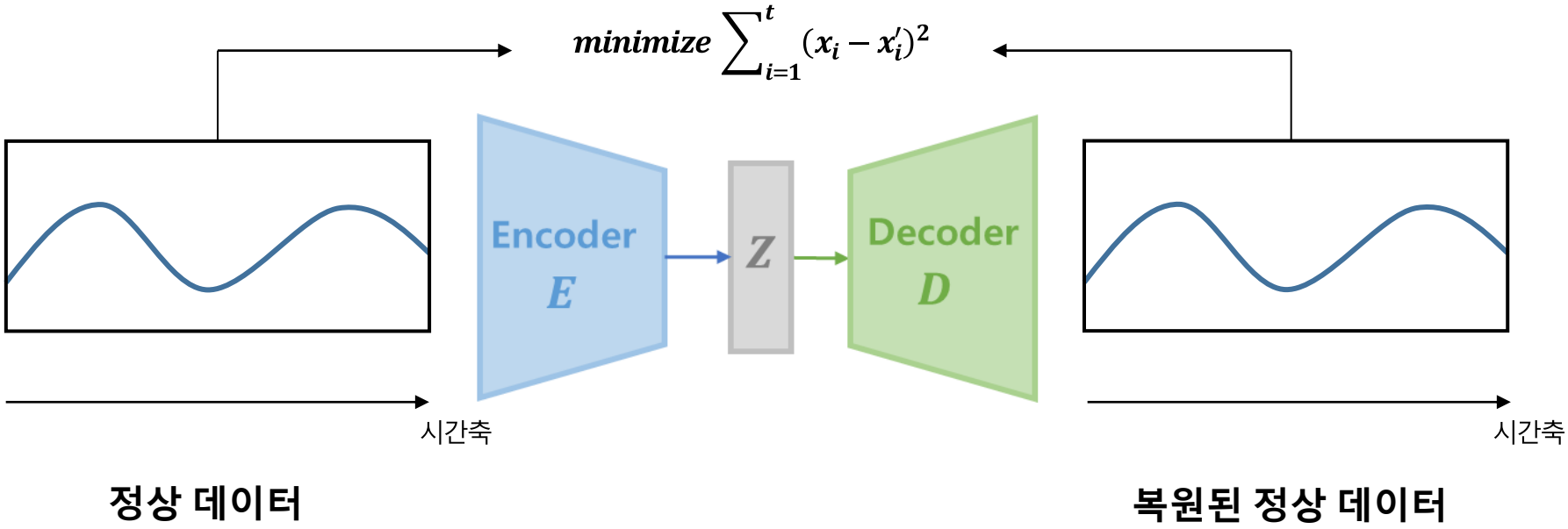
23.05.02

이정민

연구 배경

❖ 재구축 기반 이상치 탐지(Autoencoder)

- Dimensionality reduction
- Feature learning



기여점

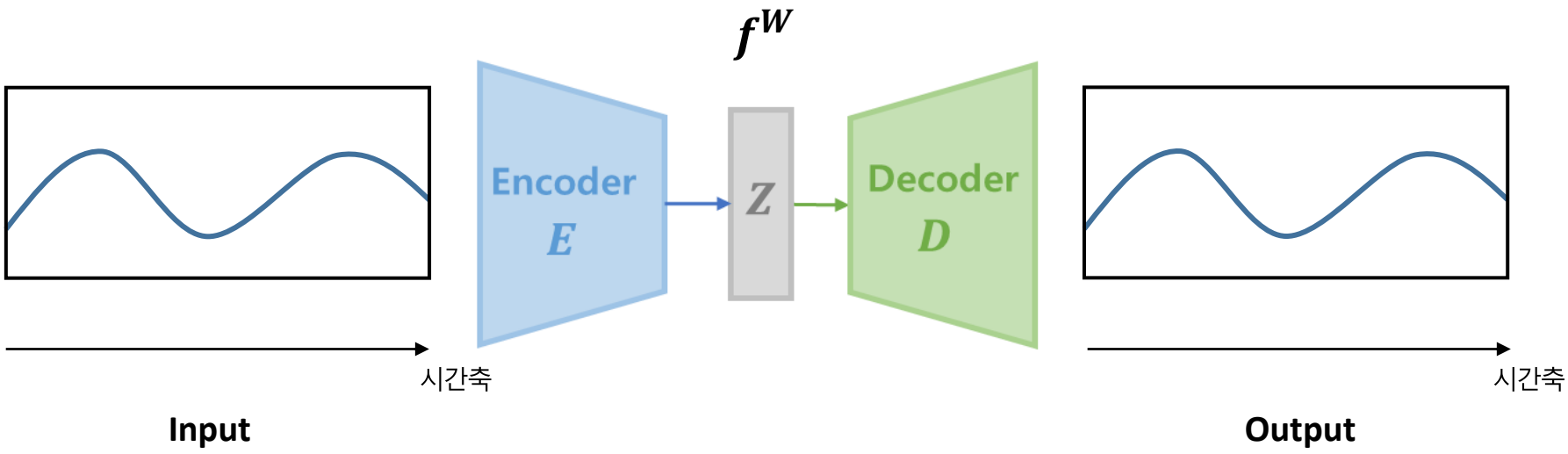
❖ **Use of Prediction Uncertainty in Anomaly Detection**

- Prediction Uncertainty를 포함한 새로운 score function 제안
- 기존 score function들과의 성능 비교

방법론

❖ Standard score functions

- Input과 output 사이의 거리 기반



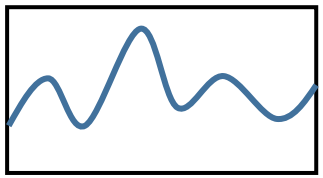
$$Score_S(x) = \frac{1}{d}\sum_{i=1}^{n}\left(x_i - f^W(x)_i\right)^2$$

방법론

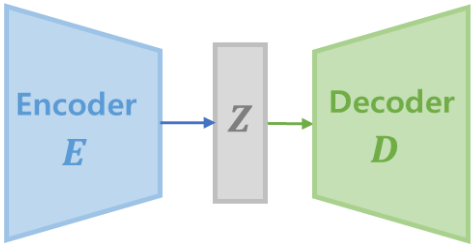
$$\bar{\hat{x}}_i = \frac{1}{B}\sum_{b=1}^{B} \hat{x}_b^*$$

❖ Baeysian approximation based score functions

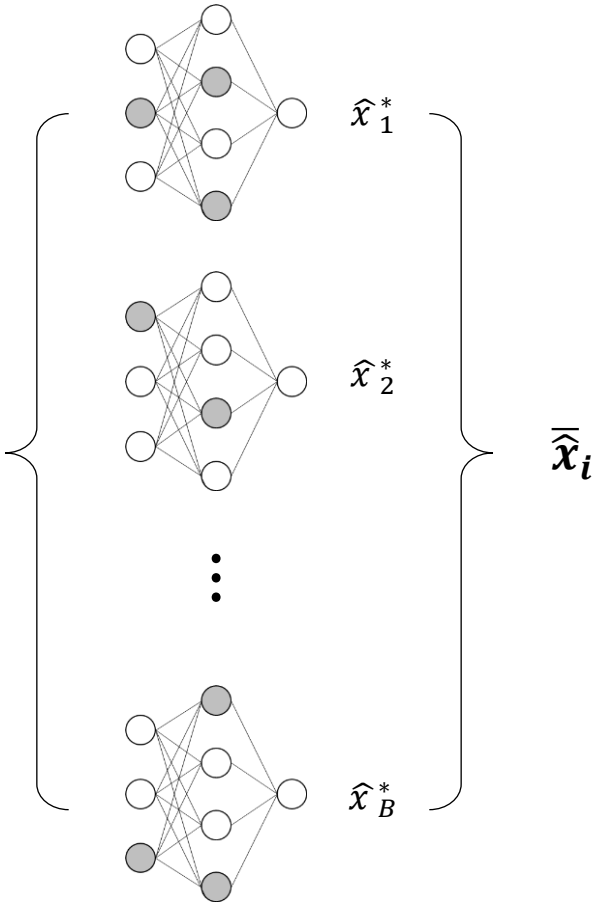
- MC dropout 사용



Input



Model



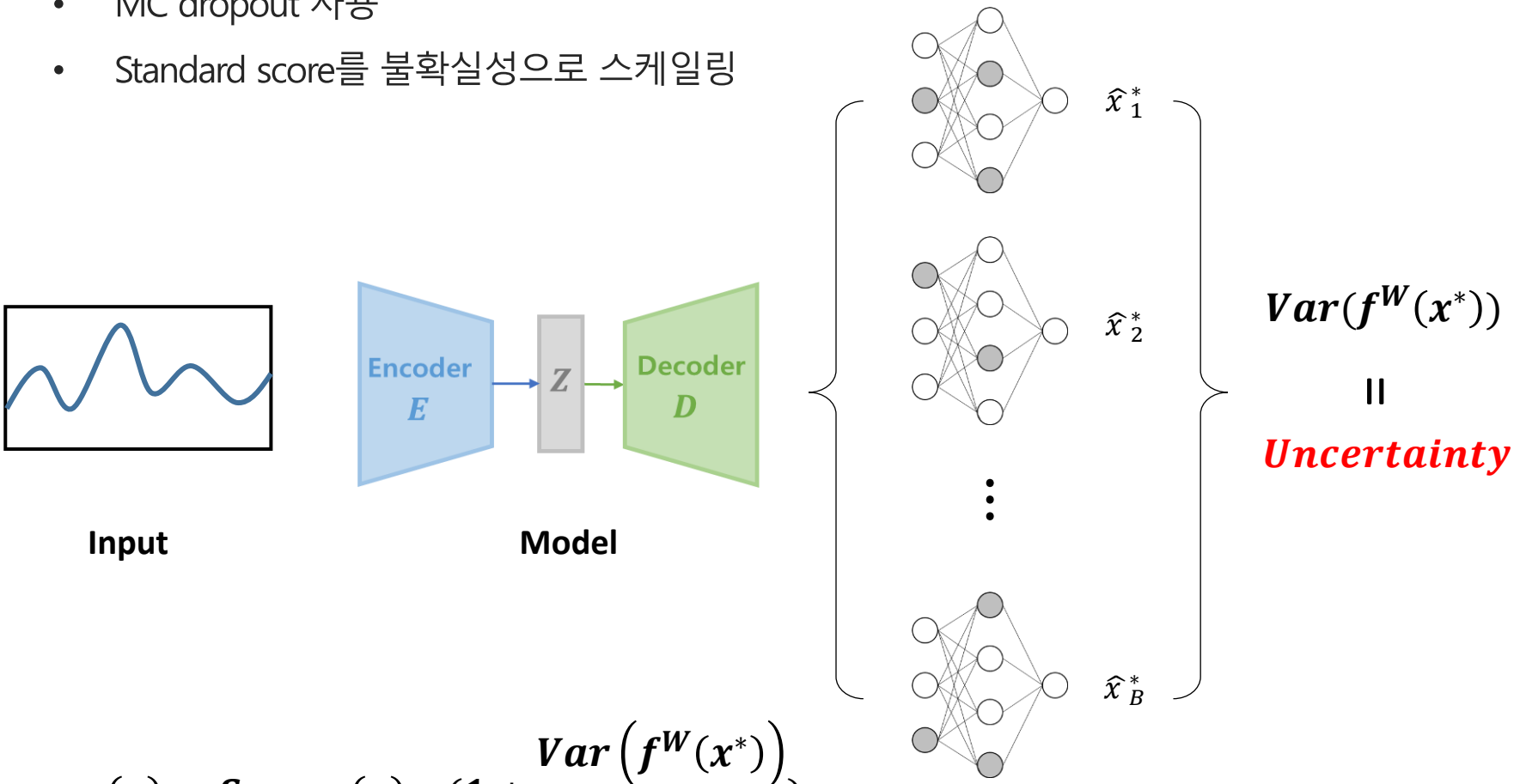
$$\boldsymbol{Score_{BA}(x) = \frac{1}{d}\sum_{i=1}^{n}\left(x_i - \bar{\hat{x}}_i\right)^2}$$

방법론

$$Score_S(x) = \frac{1}{d}\sum_{i=1}^{n}\left(x_i - f^W(x)_i\right)^2$$

❖ Score functions weighted by uncertainty

- MC dropout 사용
- Standard score를 불확실성으로 스케일링



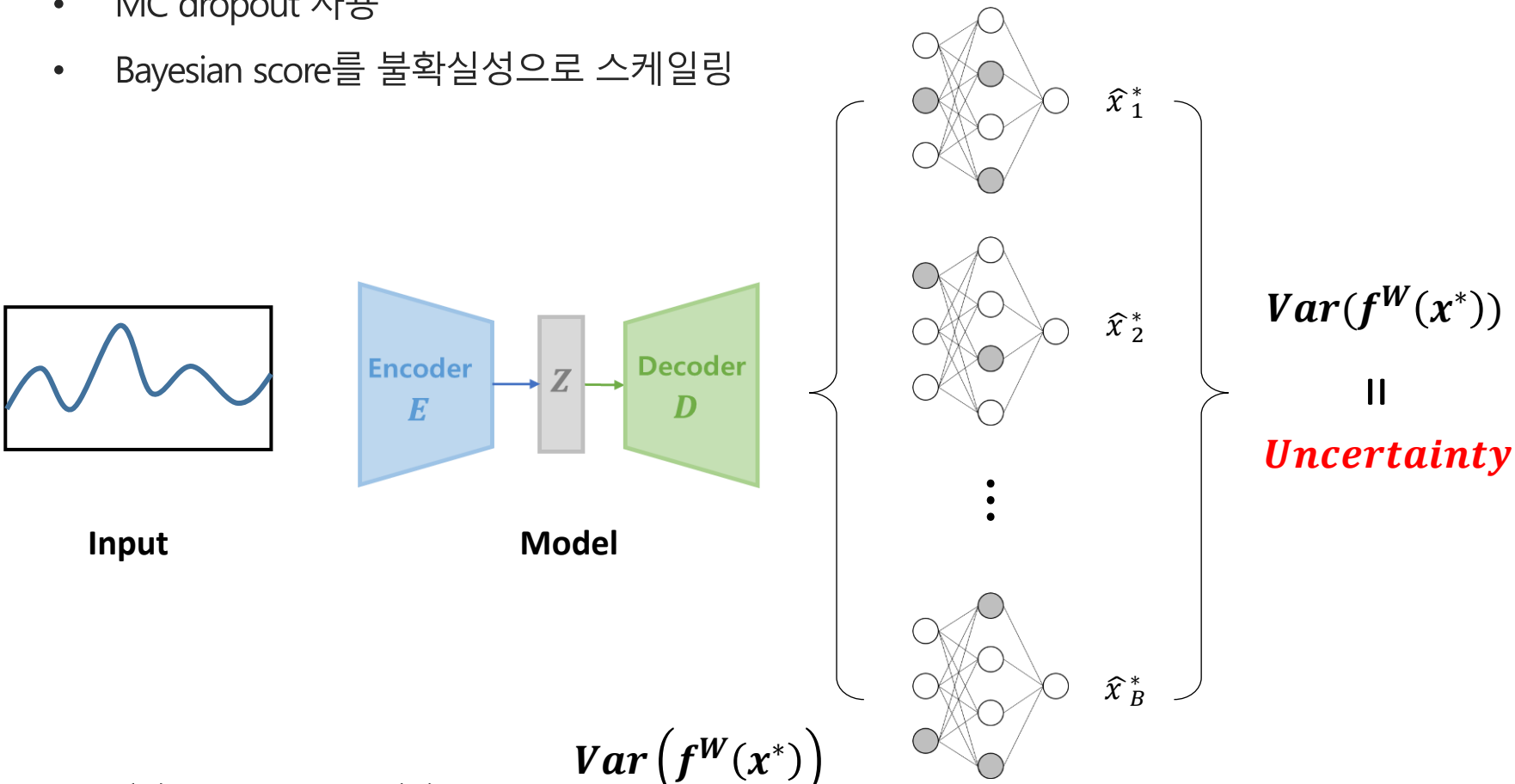
$$Score_{WS}(x) = Score_S(x) * (1 + \frac{Var\left(f^W(x^*)\right)}{reg})$$

방법론

$$Score_{BA}(x) = \frac{1}{d}\sum_{i=1}^{n}\left(x_i - \bar{\hat{x}}_i\right)^2$$

❖ Score functions weighted by uncertainty

- MC dropout 사용
- Bayesian score를 불확실성으로 스케일링

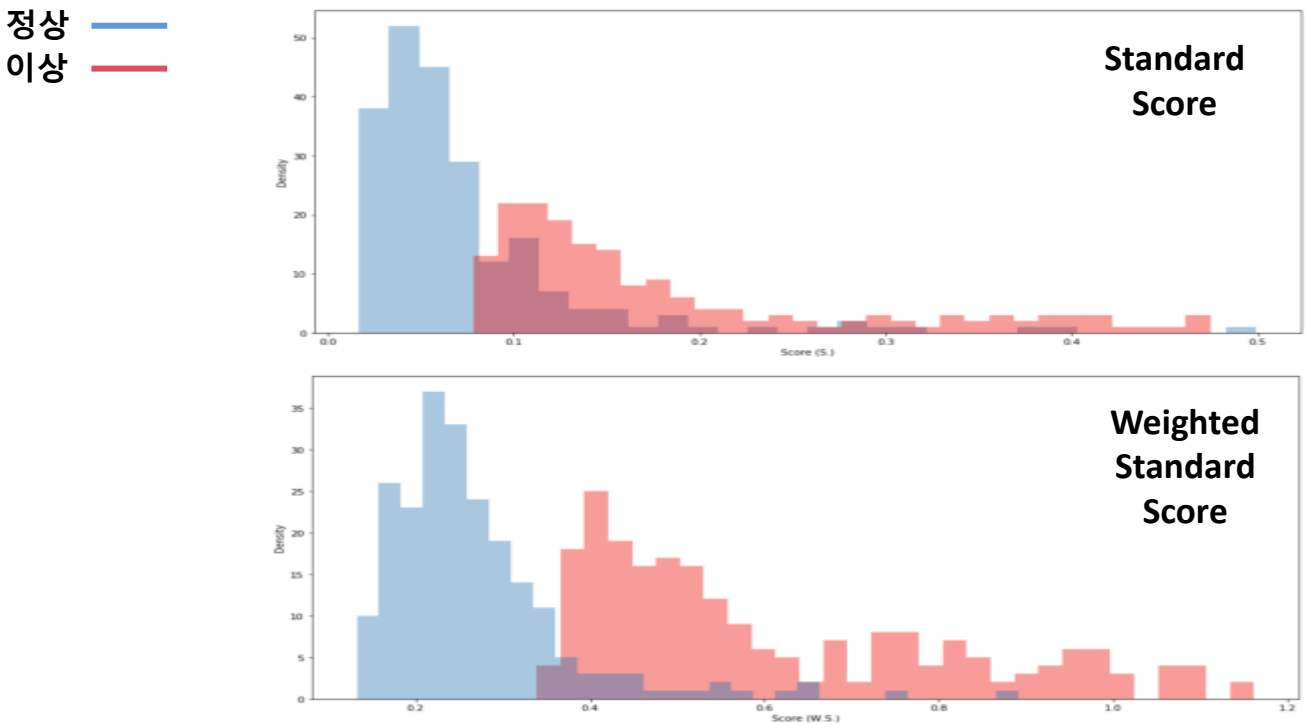


$$Score_{WBA}(x) = Score_{BA}(x) * \left(1 + \frac{Var\left(f^W(x^*)\right)}{reg}\right)$$

실험 결과

❖ Score 분포 비교

- 불확실성으로 score를 스케일링 한 경우 이상과 정상의 score 차이가 더 명확해짐



https://hal.science/hal-03233919

실험 결과

❖ 실험 결과

- 불확실성으로 score를 스케일링 할 경우가 대부분 좋은 성능을 보임

TABLE II
EVALUATION OF THE DIFFERENT SCORE FUNCTION.

Dataset		AUC ROC for given score function			
Name	% Anomaly	S.	B.A.	W.S.	W.B.A.
LRS	2.2	0.7557	0.7571	0.7561	**0.7577**
	5.4	0.6959	0.6932	**0.6971**	0.6942
	10	0.6408	**0.6506**	0.6375	0.6458
Isolet	1.2	0.9075	0.909	0.914	**0.9148**
	3.5	0.8743	0.8718	**0.8814**	0.8807
	6.8	0.8115	0.8101	**0.8193**	0.8173
Satimage	2.9	0.9386	0.936	**0.966**	0.9645
	5.7	0.9159	0.9061	**0.9469**	0.9383
	10.8	0.824	0.805	**0.8607**	0.8447
Ionosphere	4.6	0.9927	**0.9930**	0.9924	0.9913
	10.6	**0.9743**	0.9725	0.9718	0.9706
	18.8	0.985	**0.9868**	0.9831	0.9837
WBC	5.2	0.9212	0.9188	0.9268	**0.9316**
	9.7	0.9184	0.918	0.9212	**0.9236**
	15	0.7748	0.7796	0.788	**0.8036**
Musk	7.2	0.9868	**0.9871**	0.9854	0.9854
	10.1	0.9288	0.9277	**0.931**	0.93
	16.3	0.9269	0.9263	0.9285	**0.9289**
Letter Recognition	1.9	**0.8887**	0.887	0.8884	0.8866
	3.3	0.8572	**0.8583**	0.847	0.8463
	6.3	0.8327	**0.834**	0.8247	0.8256