The Supplement to 'Quantization: Is It Possible to Improve Classification?'

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In Tables 3, 4 and 5, we respectively test the quantization performance on the databases YaleB, MNIST and Cifar10, with different feature types and data dimensions. The results generally confirm our conclusion: the ternary/binary quantization of sparse features tends to yield classification gains rather than degradation, as the features are sufficiently sparse and good for classification.

	Sparsity ratio	k/n	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
YaleB 4800 dimension DCT	kNEC	RV	93.28	93.74	93.90	94.04	94.02	94.02	94.02	94.04	94.04	94.04
		TC	**98.26**	**98.92**	98.98	99.08	**99.23**	**99.36**	**99.44**	99.41	**99.52**	**99.51**
		BC	97.89	98.81	**99.00**	**99.10**	99.11	99.31	99.37	**99.47**	99.48	99.51
	kNN	RV	89.56	90.17	90.46	90.50	90.54	90.58	90.59	90.59	90.59	90.58
		TC	**95.73**	**97.30**	**97.50**	**97.65**	**97.96**	98.18	98.26	**98.50**	**98.63**	**98.63**
		BC	95.04	96.69	97.17	97.38	97.55	**98.21**	**98.57**	98.47	98.61	98.63
	LSC	RV	96.76	96.88	96.94	96.99	96.99	97.00	97.01	97.01	97.01	97.01
		TC	97.59	98.32	98.48	98.78	98.94	**99.25**	**99.32**	**99.36**	**99.38**	**99.37**
		BC	**97.89**	**98.59**	**98.91**	**99.12**	**99.03**	99.03	99.13	99.18	99.14	99.00
	SRC	RV	96.73	96.90	97.09	97.06	97.06	97.04	97.06	97.03	97.04	97.05
		TC	96.78	97.46	98.01	98.32	98.45	98.70	98.96	99.01	99.09	99.11
		BC	**96.96**	**98.13**	**98.46**	**98.47**	**98.72**	**98.90**	**99.11**	**99.25**	**99.13**	**99.20**
	SVM	RV	87.70	89.15	89.54	89.72	89.84	89.89	89.92	89.93	89.94	89.94
		TC	**99.04**	**99.33**	**99.79**	**99.86**	**99.82**	**99.84**	**99.87**	**99.86**	**99.77**	**99.55**
		BC	98.38	99.30	99.61	99.78	99.70	99.77	99.73	99.71	99.65	99.55
YaleB 2000 dimension DWT	kNEC	RV	92.32	96.95	97.86	98.96	99.09	99.11	98.92	98.70	98.19	97.82
		TC	**99.25**	**99.78**	**99.83**	**99.98**	**99.84**	**99.92**	**99.94**	**99.96**	**99.90**	**99.88**
		BC	84.93	88.93	83.00	87.74	85.33	99.78	99.89	99.89	99.89	99.88
	kNN	RV	87.08	94.81	95.76	97.41	97.90	97.87	97.61	97.34	96.44	95.61
		TC	**97.56**	**99.28**	**99.61**	**99.88**	**99.81**	**99.92**	**99.89**	**99.88**	**99.93**	**99.82**
		BC	76.45	82.96	76.06	82.58	86.02	99.11	99.60	99.76	99.78	99.82
	LSC	RV	97.04	98.32	99.20	99.57	99.59	99.61	99.59	99.44	99.26	99.16
		TC	**99.45**	**99.89**	**99.89**	**99.94**	**99.83**	**99.95**	**99.92**	**99.93**	**99.89**	**99.81**
		BC	94.51	95.82	93.19	94.46	97.80	99.86	99.90	99.91	99.88	99.80
	SRC	RV	97.20	99.27	99.51	99.79	**99.82**	99.78	99.73	99.68	99.55	99.52
		TC	**99.62**	**99.86**	**99.88**	**99.90**	99.82	**99.92**	**99.93**	**99.92**	**99.89**	99.85
		BC	91.79	94.82	90.15	91.87	97.37	99.81	99.89	99.91	99.85	**99.88**
	SVM	RV	83.25	94.40	96.81	98.65	98.82	98.62	98.39	97.66	96.60	95.44
		TC	**99.57**	**99.89**	**99.89**	**99.88**	**99.85**	**99.90**	**99.90**	**99.91**	**99.88**	**99.86**
		BC	84.04	89.08	88.01	92.01	96.01	99.75	99.79	99.81	99.85	99.86
YaleB 4800 dimension DWT	kNEC	RV	91.70	92.84	93.04	93.36	93.45	93.39	93.26	92.96	92.65	92.42
		TC	**97.98**	**99.61**	**99.89**	**99.97**	**100.00**	**100.00**	**99.97**	**99.92**	**99.95**	**99.97**
		BC	90.66	92.10	91.00	95.01	92.77	98.79	99.85	99.92	99.92	99.97
	kNN	RV	88.54	90.16	90.58	90.65	90.63	90.49	90.17	90.10	89.64	89.50
		TC	**95.92**	**98.60**	**99.46**	**99.85**	**99.89**	**99.99**	**99.93**	**99.90**	**99.89**	**99.92**
		BC	86.33	88.63	87.11	91.63	88.33	97.76	99.31	99.61	99.88	99.92
	LSC	RV	96.32	96.68	96.79	96.86	96.75	96.78	96.76	96.77	96.70	96.77
		TC	**98.89**	**99.87**	**99.96**	**99.99**	**99.98**	**100.00**	**99.96**	**99.97**	**99.96**	**99.92**
		BC	95.89	96.24	97.90	98.75	97.92	99.20	99.83	99.95	99.95	99.92
	SRC	RV	96.28	96.94	97.06	97.02	97.24	97.18	97.17	97.04	96.97	96.93
		TC	**99.42**	**99.97**	**100.00**	**100.00**	**100.00**	**99.98**	**99.97**	**99.95**	**99.97**	**99.96**
		BC	96.48	98.19	98.54	99.57	99.23	99.68	99.92	99.92	99.92	99.94
	SVM	RV	84.41	89.78	91.59	93.21	93.98	94.48	94.18	93.05	91.32	89.69
		TC	**99.05**	**99.95**	**100.00**	**99.97**	**99.95**	**99.97**	**99.95**	**99.92**	**99.92**	**99.92**
		BC	86.97	94.02	97.11	99.19	97.54	99.62	99.84	99.92	99.92	99.92

Table 3: Classification accuracy of five classifiers on real-valued codes (RC), ternary codes (TC) and binary codes (BC) across varying sparsity ratio k/n. The codes are generated with the sparse features of YaleB. The best results are highlighted in bold and the second best are underlined.

	Sparsity ratio	k/n	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
MNIST 784 dimension DWT	kNEC	RV	65.51	80.37	88.82	92.57	**94.93**	**96.08**	**96.66**	**96.89**	**97.15**	**97.36**
		TC	**71.90**	**85.62**	**91.29**	**93.82**	94.75	95.21	95.43	95.76	95.88	95.71
		BC	51.03	73.18	84.90	90.56	93.83	95.09	95.45	95.48	95.87	95.60
	kNN	RV	64.78	79.02	87.73	91.97	**94.56**	**95.70**	**96.43**	**96.71**	**96.91**	**97.11**
		TC	**70.29**	**84.37**	**90.62**	**93.06**	94.34	95.06	95.24	95.32	95.39	95.46
		BC	53.31	72.78	84.05	90.45	93.41	94.63	95.10	95.04	95.20	95.26
	LSC	RV	65.26	82.48	90.63	94.33	**95.90**	**97.06**	**97.49**	**97.72**	**97.90**	**97.90**
		TC	**73.12**	**87.98**	**93.01**	**94.90**	95.72	96.49	96.45	96.76	96.57	96.58
		BC	50.93	74.15	86.38	91.77	94.53	95.97	96.17	96.28	96.49	96.48
	SRC	RV	65.63	81.31	89.19	93.40	**95.25**	**96.31**	**96.75**	**97.10**	**97.30**	**97.44**
		TC	**70.80**	**85.80**	**91.81**	**94.07**	95.03	95.58	95.56	95.84	95.81	96.05
		BC	47.76	70.69	83.58	89.89	93.24	94.53	95.35	95.77	95.77	95.85
	SVM	RV	78.59	87.51	91.35	**93.08**	**94.18**	**94.21**	**94.53**	**94.48**	**94.69**	**94.74**
		TC	**79.48**	**88.76**	**91.99**	92.99	93.76	93.61	93.85	93.05	93.48	93.11
		BC	57.13	73.46	82.64	87.87	90.61	91.86	92.68	93.22	93.58	93.55
MNIST $100352 \times \frac{1}{10}$ dimension VGG16 Conv5_3	kNEC	RV	97.40	98.12	98.43	98.58	98.65	98.72	98.77	98.86	98.93	98.90
		TC	**97.83**	98.49	98.69	98.79	98.90	98.97	**99.02**	98.99	**99.01**	99.04
		BC	97.77	**98.63**	**98.89**	**98.95**	**98.95**	**99.05**	99.01	**99.00**	99.01	**99.05**
	kNN	RV	97.20	97.91	98.34	98.42	98.51	98.65	98.68	98.75	98.83	98.85
		TC	**97.69**	**98.42**	98.61	98.77	**98.83**	98.88	**98.93**	98.92	98.95	**98.96**
		BC	97.62	98.40	**98.71**	**98.87**	98.79	**99.03**	98.86	**98.93**	**98.96**	98.95
	LSC	RV	98.32	98.64	98.91	98.99	99.01	98.95	99.02	99.08	99.12	99.10
		TC	**98.40**	98.75	99.00	99.09	**99.07**	99.17	**99.20**	**99.15**	**99.22**	**99.34**
		BC	98.22	**98.82**	**99.03**	**99.18**	99.03	**99.26**	99.18	99.13	99.15	99.10
	SRC	RV	98.03	98.60	98.77	98.88	98.98	98.92	98.99	98.99	99.13	99.08
		TC	**98.39**	**98.71**	98.91	**99.05**	**99.16**	99.11	99.14	99.13	99.17	99.20
		BC	98.03	98.69	**99.10**	98.98	99.03	**99.21**	**99.21**	**99.20**	**99.25**	**99.28**
	SVM	RV	98.57	**99.03**	99.09	99.20	99.19	99.24	99.24	99.21	99.26	**99.32**
		TC	**98.63**	98.97	**99.13**	**99.26**	**99.23**	**99.29**	**99.25**	**99.31**	**99.32**	99.29
		BC	97.84	98.72	99.02	99.02	99.18	99.18	99.16	99.19	99.25	99.27
MNIST $100352 \times \frac{1}{20}$ dimension VGG16 Conv5_3	kNEC	RV	96.59	97.74	98.17	98.40	98.55	98.66	98.67	98.73	98.81	98.83
		TC	**96.86**	**97.91**	**98.56**	98.67	98.79	**98.84**	**98.95**	**98.99**	**98.99**	**99.03**
		BC	95.52	97.69	98.37	**98.70**	**98.81**	98.77	98.81	98.79	98.85	98.88
	kNN	RV	96.31	97.62	98.18	98.28	98.46	98.55	98.57	98.64	98.67	98.75
		TC	**96.54**	**97.80**	**98.41**	98.47	98.56	**98.81**	**98.81**	**98.85**	**98.91**	**98.90**
		BC	95.09	97.37	98.28	**98.53**	**98.59**	98.62	98.69	98.68	98.77	98.76
	LSC	RV	97.45	98.27	98.61	98.83	98.97	99.02	99.08	99.07	99.11	99.16
		TC	**97.48**	**98.49**	**98.81**	**98.95**	**99.03**	**99.10**	**99.21**	**99.16**	**99.27**	**99.21**
		BC	96.12	98.23	98.60	98.72	98.89	98.91	99.02	99.02	99.12	99.14
	SRC	RV	97.26	98.19	98.65	98.74	98.85	98.92	98.98	98.93	99.00	99.05
		TC	**97.38**	**98.47**	**98.80**	98.83	98.94	98.92	**99.01**	**99.06**	99.12	99.16
		BC	95.83	98.05	98.62	**98.92**	**98.98**	**99.05**	99.00	99.05	**99.24**	**99.21**
	SVM	RV	**97.72**	**98.66**	**98.97**	98.93	99.06	**99.09**	**99.19**	**99.19**	**99.22**	**99.23**
		TC	97.33	98.54	98.84	**99.06**	**99.17**	99.05	99.09	99.13	99.20	99.22
		BC	95.67	97.78	98.22	98.56	98.81	98.90	98.94	99.10	99.04	99.04
MNIST 43264 dimension AlexNet Conv5	kNEC	RV	98.00	98.39	98.50	98.55	98.63	98.67	98.72	98.71	98.74	98.76
		TC	97.85	98.30	98.46	98.52	98.58	98.58	98.66	98.72	98.70	98.73
		BC	**98.06**	**98.52**	**98.51**	**98.71**	**98.73**	**98.78**	**98.78**	**98.89**	**98.81**	**98.77**
	kNN	RV	97.85	98.28	**98.45**	98.46	98.56	98.59	98.62	98.71	98.73	**98.76**
		TC	97.66	98.21	98.35	98.38	98.44	98.48	98.60	98.69	98.60	98.66
		BC	**98.02**	**98.39**	**98.45**	**98.54**	**98.72**	**98.73**	**98.73**	**98.81**	**98.79**	98.74
	LSC	RV	98.56	98.89	99.02	**99.05**	99.08	99.14	99.14	99.14	**99.20**	99.19
		TC	98.50	98.89	98.92	99.01	99.05	99.10	99.06	**99.19**	99.20	**99.22**
		BC	**98.71**	**99.01**	**99.07**	99.05	**99.12**	**99.19**	**99.21**	99.16	99.20	99.22

Table 4: Classification accuracy of five classifiers on real-valued codes (RC), ternary codes (TC) and binary codes (BC) across varying sparsity ratio k/n. The codes are generated with the sparse features of MINST. The best results are highlighted in bold and the second best are underlined.

	Sparsity ratio	k/n	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Cifar10 3072 dimension DWT	kNEC	RV	38.62	43.82	46.04	45.53	**41.90**	**42.15**	**42.21**	**41.97**	**41.01**	**39.62**
		TC	**44.94**	**48.37**	**48.72**	**45.84**	30.55	37.67	37.46	36.15	35.23	33.66
		BC	36.96	40.17	40.80	37.18	19.53	32.74	36.87	37.83	35.96	33.66
	kNN	RV	34.61	39.41	41.72	**41.54**	**38.39**	**38.78**	**38.47**	**37.98**	**37.27**	**36.23**
		TC	**38.92**	**43.49**	**43.12**	40.40	24.71	31.26	31.33	30.77	30.64	28.55
		BC	31.90	35.42	36.16	33.14	16.29	28.12	31.83	31.91	30.21	28.55
	LSC	RV	37.81	43.26	46.09	**48.40**	**49.20**	**48.96**	**49.07**	**48.20**	**47.26**	**45.87**
		TC	**44.39**	**47.07**	**46.60**	43.20	32.74	33.18	33.84	34.63	33.88	33.27
		BC	35.03	39.13	40.02	37.22	20.80	33.77	36.08	36.02	34.23	31.97
	SRC	RV	38.54	43.78	**47.84**	**49.68**	**50.16**	**50.23**	**49.97**	**49.28**	**48.17**	**44.30**
		TC	**43.23**	**47.29**	46.76	43.18	32.28	32.74	33.07	33.43	33.09	31.56
		BC	35.28	39.28	39.96	37.86	23.91	32.85	34.47	35.14	33.73	30.92
	SVM	RV	**43.16**	**47.60**	**49.05**	**49.23**	**48.59**	**48.42**	**47.44**	**45.91**	**43.41**	**41.43**
		TC	36.30	38.30	37.98	36.77	31.16	29.33	31.00	32.52	31.28	30.51
		BC	30.24	33.44	34.09	32.94	28.23	34.97	34.63	35.01	32.50	31.88
Cifar10 $43264 \times \frac{1}{5}$dimension AlexNet Conv5	kNEC	RV	73.53	75.41	76.22	76.66	76.64	**76.60**	**76.56**	**76.71**	**76.57**	**76.55**
		TC	73.88	75.27	75.82	76.71	76.47	76.45	76.26	76.09	75.80	75.44
		BC	**75.07**	**76.49**	**77.24**	**76.99**	**76.96**	76.41	76.22	76.15	75.99	75.48
	kNN	RV	70.20	72.49	72.98	73.98	73.92	**74.06**	**74.25**	**74.29**	**74.25**	**74.33**
		TC	70.13	72.20	73.66	73.29	73.43	73.45	73.42	73.16	72.95	72.54
		BC	**71.21**	**72.91**	**74.22**	**74.25**	**74.20**	73.99	73.75	73.34	73.31	72.51
	LSC	RV	75.64	77.71	77.81	78.04	78.06	78.24	78.27	78.10	78.06	78.10
		TC	76.00	78.00	78.50	**79.03**	78.24	**78.68**	**78.74**	**78.87**	**78.47**	**78.52**
		BC	**77.26**	**78.75**	**79.21**	78.67	**78.48**	78.20	78.13	77.47	77.30	76.80
	SRC	RV	75.90	77.77	78.83	79.08	**79.17**	**79.43**	**79.13**	**79.27**	**79.29**	**79.28**
		TC	75.70	78.17	78.20	78.75	78.85	78.70	78.49	78.91	78.19	78.42
		BC	**76.84**	**78.56**	**78.86**	**79.63**	79.08	79.05	79.11	78.39	78.10	78.04
	SVM	RV	**79.20**	**80.68**	**80.79**	**80.69**	**80.72**	**80.93**	**80.93**	**81.12**	**80.98**	**81.02**
		TC	76.57	78.17	78.90	79.05	79.07	79.42	79.37	79.55	78.84	78.22
		BC	77.17	79.02	79.36	78.99	78.37	78.32	78.33	77.82	78.25	78.22
Cifar10 43264 dimension AlexNet Conv5	kNEC	RV	74.39	75.68	76.05	76.60	76.67	76.73	76.67	**76.81**	**76.81**	**76.81**
		TC	74.25	75.96	76.42	76.64	76.76	76.73	76.57	76.30	76.18	76.09
		BC	**76.23**	**77.50**	**77.76**	**77.51**	**77.43**	**77.23**	**76.93**	76.55	76.36	76.09
	kNN	RV	70.87	72.78	73.52	73.83	74.12	74.25	74.30	**74.25**	**74.25**	**74.20**
		TC	71.31	73.14	73.55	74.26	73.92	73.83	73.70	73.52	72.96	72.93
		BC	**73.29**	**74.46**	**74.68**	**74.66**	**74.98**	**74.49**	**74.54**	74.00	73.53	72.93
	LSC	RV	76.38	78.01	78.29	78.42	78.50	78.56	78.59	78.25	78.36	78.28
		TC	77.09	78.40	78.96	79.57	79.12	**79.10**	**79.20**	**78.84**	**78.39**	**78.62**
		BC	**78.98**	**80.47**	**80.51**	**79.69**	**79.56**	79.06	78.94	78.03	77.67	77.00

Table 5: Classification accuracy of five classifiers on real-valued codes (RC), ternary codes (TC) and binary codes (BC) across varying sparsity ratio k/n. The codes are generated with the sparse features of CIFAR10. The best results are highlighted in bold and the second best are underlined.