

ISO/IEC TS 4213:2022-10 (E)

Information technology - Artificial intelligence - Assessment of machine learning classification performance

Contents		Page
Foreword		v
Introduction		vi
1	Scope	1
2	Normative references	1
3	Terms and definitions	1
3.1	Classification and related terms	1
3.2	Metrics and related terms	1
4	Abbreviated terms	3
5	General principles	4
5.1	Generalized process for machine learning classification performance assessment	4
5.2	Purpose of machine learning classification performance assessment	4
5.3	Control criteria in machine learning classification performance assessment	5
5.3.1	General	5
5.3.2	Data representativeness and bias	5
5.3.3	Preprocessing	5
5.3.4	Training data	5
5.3.5	Test and validation data	6
5.3.6	Cross-validation	6
5.3.7	Limiting information leakage	6
5.3.8	Limiting channel effects	6
5.3.9	Ground truth	7
5.3.10	Machine learning algorithms, hyperparameters and parameters	7
5.3.11	Evaluation environment	8
5.3.12	Acceleration	8
5.3.13	Appropriate baselines	8
5.3.14	Machine learning classification performance context	8
6	Statistical measures of performance	8
6.1	General	8
6.2	Base elements for metric computation	9
6.2.1	General	9
6.2.2	Confusion matrix	9
6.2.3	Accuracy	9
6.2.4	Precision, recall and specificity	9
6.2.5	F1 score	9
6.2.6	F	9
6.2.7	Kullback-Leibler divergence	10
6.3	Binary classification	10
6.3.1	General	10
6.3.2	Confusion matrix for binary classification	11
6.3.3	Accuracy for binary classification	11
6.3.4	Precision, recall, specificity, F1 score and F for binary classification	11
6.3.5	Kullback-Leibler divergence for binary classification	11
6.3.6	Receiver operating characteristic curve and area under the receiver operating characteristic curve	11

6.3.7	Precision recall curve and area under the precision recall curve	11
6.3.8	Cumulative response curve	12
6.3.9	Lift curve	12
6.4	Multi-class classification	12
6.4.1	General	12
6.4.2	Accuracy for multi-class classification	12
6.4.3	Macro-average, weighted-average and micro-average	12
6.4.4	Distribution difference or distance metrics	13
6.5	Multi-label classification	14
6.5.1	General	14
6.5.2	Hamming loss	14
6.5.3	Exact match ratio	15
6.5.4	Jaccard index	15
6.5.5	Distribution difference or distance metrics	15
6.6	Computational complexity	16
6.6.1	General	16
6.6.2	Classification latency	16
6.6.3	Classification throughput	17
6.6.4	Classification efficiency	17
6.6.5	Energy consumption	17
7	Statistical tests of significance	18
7.1	General	18
7.2	Paired Student's t-test	18
7.3	Analysis of variance	19
7.4	Kruskal-Wallis test	19
7.5	Chi-squared test	19
7.6	Wilcoxon signed-ranks test	19
7.7	Fisher's exact test	19
7.8	Central limit theorem	20
7.9	McNemar test	20
7.10	Accommodating multiple comparisons	20
7.10.1	General	20
7.10.2	Bonferroni correction	20
7.10.3	False discovery rate	21
8	Reporting	21
Annex A (informative)	Multi-class classification performance illustration	22
Annex B (informative)	Illustration of ROC curve derived from classification results	24
Annex C (informative)	Summary information on machine learning classification benchmark tests ..	29
Annex D (informative)	Chance-corrected cause-specific mortality fraction	31
Bibliography	32