

Securing IoT devices using Ensemble Machine Learning in Smart Home Management System

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I. INTRODUCTION

This document is meant to be used alongside the article “Securing IoT devices using Ensemble Machine Learning in Smart Home Management System”. In this document, we have added the appendix section of the original paper. Here, we have listed the hyper parameters in a Table that are used to build our models using various machine learning algorithm and ensemble algorithm. Furthermore, the detailed results of our experiments using NSL-KDD, UNSW-NB15, CICIDS2017 and DS2OS datasets are listed here.

TABLE I
HYPER-PARAMETER VALUES USED FOR DIFFERENT INDIVIDUAL AND ENSEMBLE CLASSIFIERS.

	Classifier	Short Names	Hyper-parameter Values
Supervised Models	Logistic Regression	LR	random_state=0, solver='lbfgs', multi_class='multinomial'
	Decision Tree	DT	default parameters
	Naïve Bayes	NB	alpha=1.0, binarize=0.0, fit_prior=True, class_prior=None
	Neural Network	NN	solver='lbfgs', alpha=1e-5, hidden_layer_sizes=(5, 2), random_state=1
	Support Vector Machine	SVM	C=1.0, kernel='rbf', degree=3, gamma='scale', coef0=0.0, shrinking=True, probability=True
Ensemble Models	Majority Voting	Ens_MV	none
	Decision Tree	Ens_DT	default parameters
	Naïve Bayes	Ens-NB	alpha=1.0, binarize=0.0, fit_prior=True, class_prior=None
	Logistic Regression	Ens_LR	random_state=0, solver='lbfgs', multi_class='multinomial'
	Neural Network	Ens_NN	solver='lbfgs', alpha=1e-5, novelty=True, hidden_layer_sizes=(5, 2), random_state=1
	Support Vector Machine	Ens_SVM	C=1.0, kernel='rbf', degree=3, gamma='scale', coef0=0.0, shrinking=True, probability=True

TABLE II
COMPARATIVE PERFORMANCE ANALYSIS OF ELEVEN MODELS USING NSL-KDD DATASET

Classifier	F-1	Accuracy	Precision	Sensitivity	Specificity	FPR	ROC_auc	Elp_time
LR	0.732	0.746	0.915	0.611	0.925	0.075	0.889	4.431
NB	0.751	0.768	0.965	0.615	0.970	0.030	0.927	0.323
NN	0.786	0.795	0.967	0.662	0.971	0.029	0.824	7.975
DT	0.790	0.798	0.968	0.668	0.970	0.030	0.820	0.803
SVM	0.778	0.789	0.971	0.649	0.975	0.025	0.910	1031.116
Ens_MV	0.766	0.779	0.969	0.633	0.973	0.027	N/A	2.372
Ens_LR	0.887	0.881	0.959	0.826	0.954	0.046	0.898	0.278
Ens_NB	0.887	0.881	0.959	0.826	0.954	0.046	0.892	0.234
Ens_NN	0.887	0.881	0.959	0.826	0.954	0.046	0.896	0.386
Ens_DT	0.887	0.880	0.959	0.825	0.954	0.046	0.900	0.243
Ens_SVM	0.887	0.881	0.959	0.826	0.954	0.046	0.886	12.174

TABLE III
COMPARATIVE PERFORMANCE ANALYSIS OF ELEVEN MODELS USING UNSW-NB15 DATASET

Classifier	F-1	Accuracy	Precision	Sensitivity	Specificity	FPR	ROC_AUC	Elapsed Time
LR	0.665	0.643	0.627	0.707	0.580	0.420	0.643	5.511
NB	0.616	0.558	0.544	0.710	0.406	0.594	0.558	0.31
NN	0.815	0.788	0.724	0.932	0.645	0.355	0.788	13.586
DT	0.867	0.856	0.802	0.944	0.767	0.233	0.856	1.196
SVM	0.762	0.735	0.692	0.847	0.624	0.376	0.735	2537.329
Ens_MV	0.765	0.737	0.692	0.854	0.621	0.379	N/A	2.315
Ens_LR	0.866	0.857	0.810	0.93	0.785	0.215	0.857	1.143
Ens_NB	0.798	0.798	0.791	0.805	0.791	0.209	0.798	0.246
Ens_NN	0.867	0.857	0.808	0.935	0.78	0.22	0.858	6.019
Ens_DT	0.866	0.857	0.811	0.928	0.786	0.214	0.857	0.238
Ens_SVM	0.866	0.857	0.811	0.928	0.786	0.214	0.857	174.102

TABLE IV
COMPARATIVE PERFORMANCE ANALYSIS OF ELEVEN MODELS USING CICIDS2017 DATASET

Classifier	F-1	Accuracy	Precision	Sensitivity	Specificity	FPR	ROC_AUC	Elapsed Time
LR	0.868	0.851	0.785	0.970	0.730	0.270	0.940	1.172
NB	0.431	0.591	0.723	0.307	0.880	0.120	0.816	0.115
NN	0.899	0.89	0.836	0.974	0.805	0.195	0.958	2.973
DT	0.994	0.994	0.993	0.996	0.993	0.007	0.994	0.448
SVM	0.9	0.89	0.833	0.978	0.800	0.200	0.966	311.716
Ens_MV	0.911	0.903	0.854	0.975	0.831	0.169	N/A	2.053
Ens_LR	0.995	0.995	0.994	0.996	0.993	0.007	0.998	0.150
Ens_NB	0.987	0.986	0.997	0.977	0.996	0.004	0.998	0.095
Ens>NN	0.995	0.995	0.995	0.996	0.994	0.006	0.998	0.286
Ens_DT	0.995	0.995	0.995	0.995	0.995	0.005	0.998	0.100
Ens_SVM	0.995	0.995	0.994	0.996	0.993	0.007	0.993	0.537

TABLE V
COMPARATIVE PERFORMANCE ANALYSIS OF ELEVEN MODELS USING DS2OS DATASET

Classifier	F-1	Accuracy	Precision	Sensitivity	Specificity	FPR	ROC_AUC	Elapsed Time
LR	0.855	0.832	0.757	0.983	0.678	0.322	0.917	1.139
NB	0.435	0.595	0.735	0.309	0.887	0.113	0.768	0.116
NN	0.866	0.853	0.802	0.941	0.764	0.236	0.936	2.888
DT	0.933	0.929	0.892	0.979	0.879	0.121	0.971	0.446
SVM	0.87	0.853	0.783	0.98	0.724	0.276	0.946	418.727
Ens_MV	0.889	0.876	0.809	0.986	0.764	0.236	N/A	2.055
Ens_LR	0.936	0.931	0.9	0.974	0.884	0.116	0.96	0.16
Ens_NB	0.928	0.923	0.901	0.955	0.888	0.112	0.958	0.097
Ens>NN	0.936	0.931	0.9	0.974	0.884	0.116	0.96	0.461
Ens_DT	0.994	0.995	0.995	0.995	0.995	0.005	0.961	0.103
Ens_SVM	0.937	0.932	0.899	0.978	0.883	0.117	0.947	4.404