Several Classifiers for Intruder Detection Applications

Elena Roxana BUHUȘ, **Lăcrimioara GRAMA**, Corneliu RUSU

Technical University of Cluj-Napoca
Faculty of Electronics, Telecommunications and Information Technology
Basis of Electronics Department
Signal Processing Group

SpeD 2017
Bucharest, Romania
July 6-9, 2017

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS/CCCDI–UEFISCDI, project number PNIII-P2-2.1-BG-2016-0378, 54BG/2016, within PNCDI III. A part of the work was also supported by Grant PAV3M PN-II-PT-PCCA-2013-4-1762.

Outline

- Research aim
- Acoustic Wildlife Intruder Detection System
- Wildlife Database
- Feature extraction – Linear Predictive Coding
- Classification
- Results
- Conclusion

Research Aim

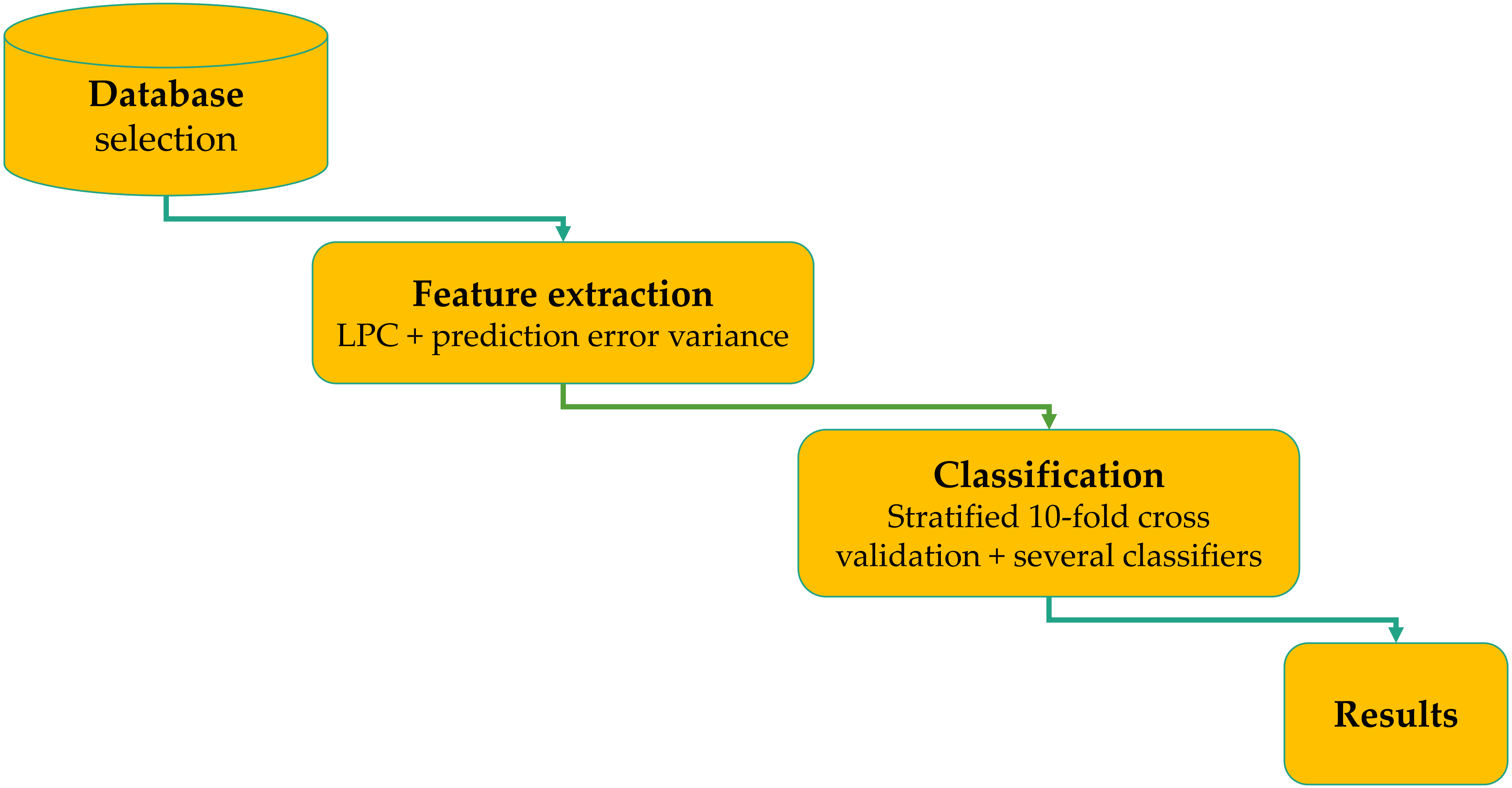
- To present some possible intruder detection systems and the influence of impulse-like signals upon the overall classification accuracy
  - Acoustic wildlife intruder detection system (WIDS)
- Two different scenarios are used
  - *Scenario 1*: five sound classes are considered (last class belongs to impulsive sounds – gunshots)
  - *Scenario 2*: we dropped out the impulsive sound class




Research Aim

- Several classification algorithms were used
  - To determine the effect of different number of features (LPC coefficients and prediction error variance) towards the classification accuracy
  - To determine the effect of impulsive sounds (gunshots) in the classification accuracy
- Noise coming from human activity has become a common addition to natural soundscapes and has the potential to harm wildlife and erode human enjoyment of nature
- Such noise can be sounds originate from heavy cars, chainsaws, gunshots, human voice, etc. $\Rightarrow$ a WIDS is a need

Acoustic Wildlife Intruder Detection System



Wildlife Database

Birds dataset – 654 audio files originated from 70 different species of birds (Internet)

Chainsaws dataset – 356 audio files originated from 18 different types of chainsaws (SPG)

Tractors dataset – 260 audio files originated from 17 different types of tractors (SPG)

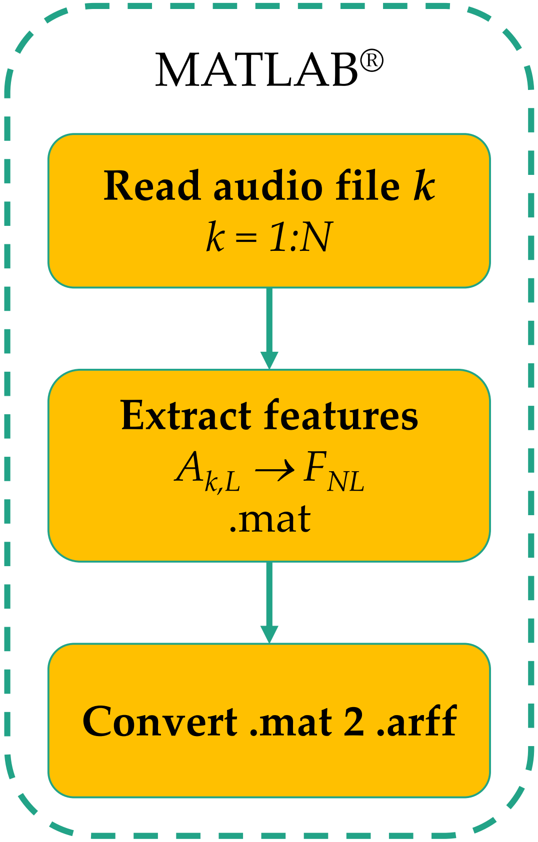
Human voice dataset – 207 speech sounds originated from 50 different former students from the TUCN

Gunshots dataset – 120 audio files originated from 40 different types of guns (Internet)

- 16 kHz, 16-bit
- None of the audio signals are studio recordings ⇒ they are subject to some additive noise from surroundings

Feature extraction – LPC

- Features vector $A_k = \begin{bmatrix} \sigma_k^2 & a_{k,1} & a_{k,2} & \dots & a_{k,n} \end{bmatrix}$
  - σ_k^2 – prediction error variance
  - $a_{k,i}$ – last n LPC coefficients
- Features matrices $F_{N\times(L+1)} = \begin{bmatrix} A_{1,L} \\ A_{2,L} \\ \vdots \\ A_{N,L} \end{bmatrix}$
  - N = 1 597/ 1 477 – total number of audio files
  - L = 10, 50, 100, 150, 200, 250, 300 – orders for the prediction filter
- .mat files (binary MATLAB® files that store workspace variables)
- .arff files (attribute relation file format – ASCII text file which describes a list of instances sharing a set of attributes)



ARFF File Example

```
@relation LPC_10

@attribute Error numeric
@attribute A1 numeric
@attribute A2 numeric
…
@attribute A10 numeric
@attribute Class {Bird, Chainsaw, Tractor, Human, Gunshot}

@data
0.00006,-1.4444,1.4813,-1.431,1.1014,-0.44335,0.88751,-1.0135,0.9789,
-0.75417,0.33759,Bird
…
0.031915,-0.70952,0.36178,-0.12324,0.051033,-0.09611,0.1399,
-0.090546,0.085472,-0.10761,0.20698,Chainsaw
…
0.003796,-1.4047,0.85599,-0.40377,0.21798,-0.41251,0.37959,-0.12573,0.059844,
-0.095607,0.053729,Tractor
…
0.000006,-3.8437,5.5964,-2.4234,-3.2081,4.7916,-1.2946,-2.1592,2.4153,
-1.0561,0.18461,Human
…
0.007638,-1.2239,0.64029,-0.43115,0.30726,-0.23148,0.20273,-0.17043,0.18041,
-0.18936,0.12204,Gunshot
…
```

Dataset name

Attributes **(name + type)**

Target/Class variables

Data values
(for each attribute)

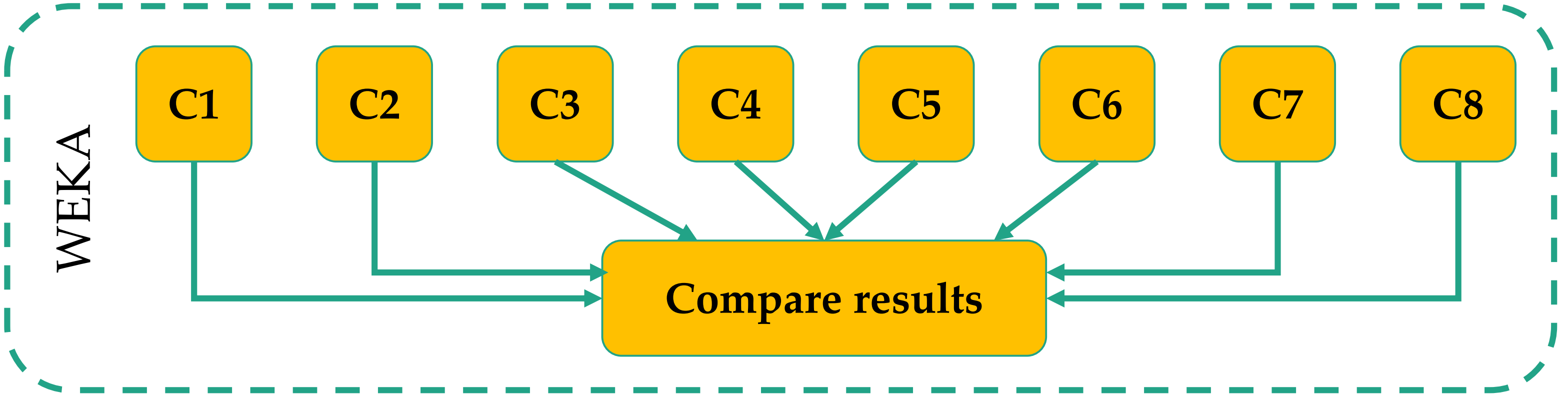
Classification

1. Simple Logistic (C1): builds linear logistic regression models
2. Sequential Minimal Optimization (C2): fast training of SVM using SMO
3. J48 (C3): generates a pruned or unpruned C4.5 decision tree
4. J48 + Attribute Selected Classifier (C4): dimensionality of training and test data is reduced by attribute selection before being passed on to J48 classifier
5. J48 + Filtered Classifier (C5): runs J48 classifier on data that has been passed through a filter which discretizes a range of numeric attributes in the dataset into nominal attributes; is based only on the training data and test instances will be processed by the filter without changing their structure
6. Decision Table (C6): builds + uses a simple decision table majority classifier
7. JRip (C7): implements a propositional rule learner, Repeated Incremental Pruning to produce error reduction
8. REPTree (C8): fast decision tree learner; builds a decision tree using information gain/variance and prunes it using reduced-error pruning (with backfitting)

Classification

- Stratified 10-fold cross validation
- Two scenarios
  - *Scenario 1*: 1 597 audio files (all five classes)
  - *Scenario 2*: 1 477 audio files (no gunshots class)

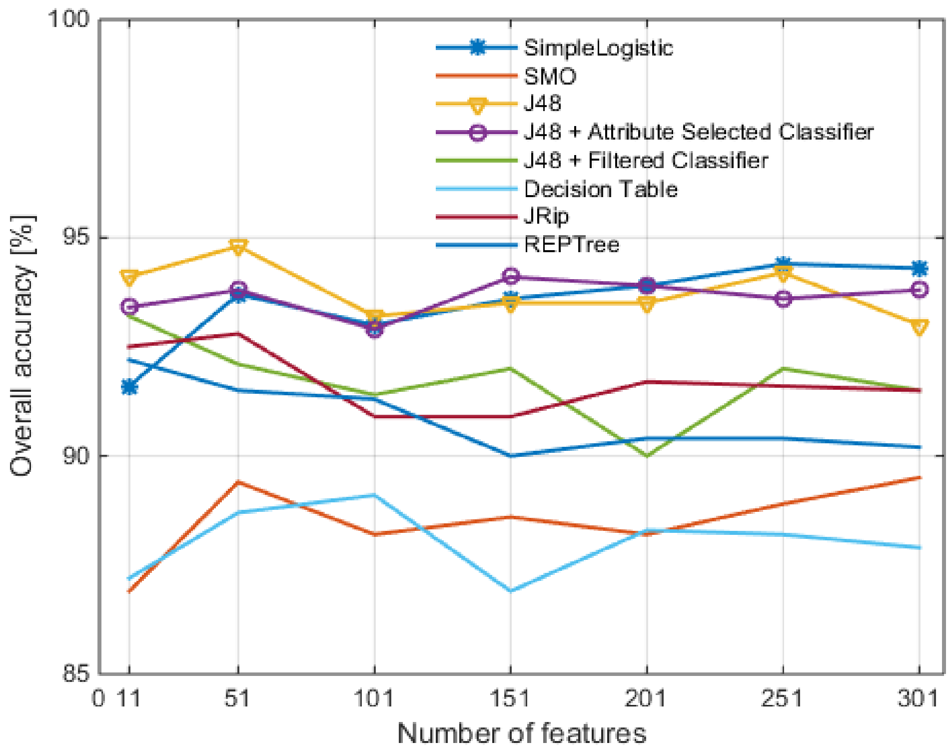
  ⇒112 experiments: 2 scenarios x 7 different orders for the prediction filter x 8 classifiers



Results – Scenario 1

No. of features / Classifier	Overall classification accuracy [%]						
	11	**51**	**101**	**151**	**201**	**251**	**301**
Simple Logistic	91.6	93.7	93.0	93.6	93.9	94.4	94.3
SMO	86.9	89.4	88.2	88.6	88.2	88.9	89.5
J48	94.1	**94.8**	93.2	93.5	93.5	94.2	93.0
J48+Attribute Selected Classif.	93.4	93.8	92.9	94.1	93.9	93.6	93.8
J48+Filtered Classif.	93.2	92.1	91.4	92.0	90.0	92.0	91.5
Decision Table	87.2	88.7	89.1	86.9	88.3	88.2	87.9
JRip	92.5	92.8	90.9	90.9	91.7	91.6	91.5
REPTree	92.2	91.5	91.3	90.0	90.4	90.4	90.2

Results – Scenario 1



Scenario 1 – Accuracy classification evolution for all experiments

Class	Classification accuracy		
	(C3, 51) 94.8%	(C1, 251) 94.4%	(C4, 151) 94.1%
Birds	97.0%	97.3%	95.3%
Chainsaws	96.9%	95.9%	97.1%
Tractors	91.7%	86.3%	91.1%
Human voices	99.0%	99.5%	99.0%
Gunshots	75.2%	79.5%	76.4%

- Lowest precision: gunshots
- The acoustical detection for gunshot depends on the muzzle blast that generates an impulse wave with a sound wave pressure level of 140 dB or louder

Results – Scenario 1

=== Confusion Matrix (C3, 51) ===					
B	C	T	H	G	<-- classified as
638	2	3	0	11	| Bird (B)
2	346	3	0	5	| Chainsaw (C)
4	1	244	0	11	| Tractor (T)
2	0	0	205	0	| Human (H)
12	8	16	2	82	| Gunshot (G)

=== Confusion Matrix (C1, 251) ===					
B	C	T	H	G	<-- classified as
646	1	2	0	5	| Bird (B)
1	348	3	0	4	| Chainsaw (C)
2	2	251	0	5	| Tractor (T)
0	0	0	206	1	| Human (H)
15	12	35	0	58	| Gunshot (G)

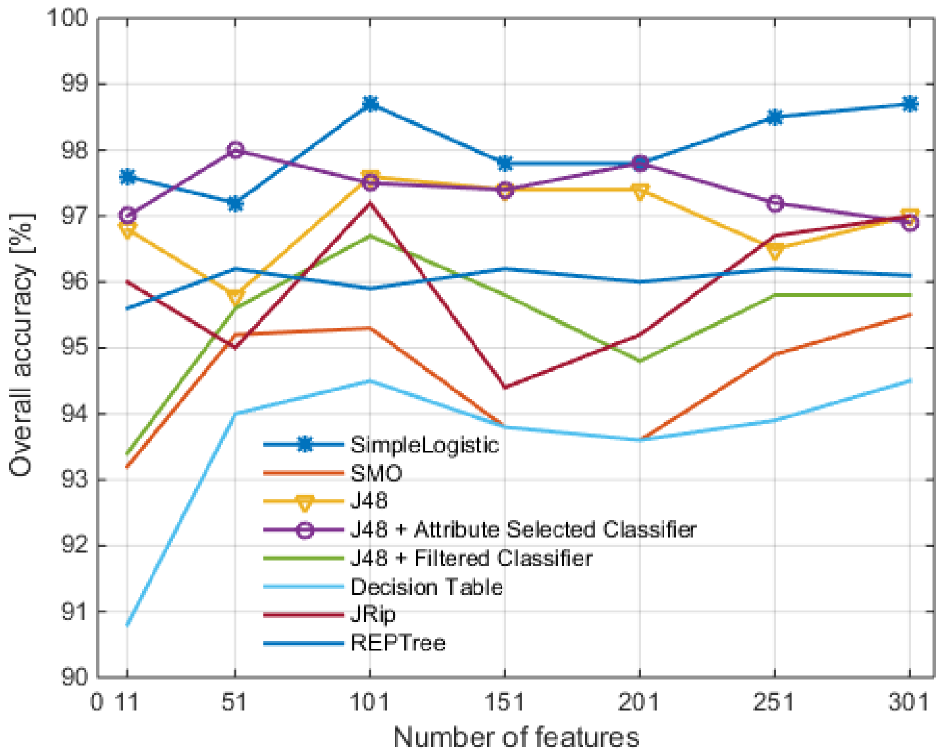
=== Confusion Matrix (C4, 151) ===					
B	C	T	H	G	<-- classified as
642	1	6	0	9	| Bird (B)
9	337	6	0	4	| Chainsaw (C)
9	2	236	0	13	| Tractor (T)
2	0	0	205	0	| Human (H)
12	7	15	15	84	| Gunshot (G)

Scenario 1 – Confusion Matrix:
J48,
Simple Logistic,
J48+Attribute Selected Classifier

Results – Scenario 2

No. of features / Classifier	Overall classification accuracy [%]						
	11	51	101	151	201	251	301
Simple Logistic	97.6	97.2	**98.7**	97.8	97.8	98.5	98.7
SMO	93.2	95.2	95.3	93.8	93.6	94.9	95.5
J48	96.8	95.8	97.6	97.4	97.4	96.5	97.0
J48+Attribute Selected Classif.	97.0	98.0	97.5	97.4	97.8	97.2	96.9
J48+Filtered Classif.	93.4	95.6	96.7	95.8	94.8	95.8	95.8
Decision Table	90.8	94.0	94.5	93.8	93.6	93.9	94.5
JRip	96.0	95.0	97.2	94.4	95.2	96.7	97.0
REPTree	95.6	96.2	95.9	96.2	96.0	96.2	96.1

Results – Scenario 2



Scenario 2 – Accuracy classification evolution for all experiments

Class	Classification accuracy		
	(C1, 101) 98.7%	(C4, 51) 98.0%	(C3, 101) 97.6%
Birds	99.1%	99.5%	98.5%
Chainsaws	99.4%	98.5%	97.7%
Tractors	96.6%	91.9%	94.6%
Human voices	99.0%	100.0%	99.0%

Conclusion

- We have performed a study upon several classification algorithms to determine the effect of different number of features (LPC coefficients and prediction error variance) towards the classification accuracy
- The algorithms from our experiments can be used to detect sound sources in wildlife areas
- We have used two different scenarios
  - *Scenario 1*: five different sound classes (birds, chainsaws, tractors, human voices, and gunshots)
  - *Scenario* 2: four different sound classes (birds, chainsaws, tractors, and human voices)
    - The gunshots class was removed – to see the influence of impulsive signals in the overall accuracy of each classifier

Conclusion

- For each scenario, eight classifiers were exemplified
- The best results were obtained in *Scenario 2*, for Simple Logistic classifier, regardless the order used for the predictor – constant CCR greater than 97%
- From the detailed precision by class reports, we have noticed, for *Scenario 1*, that the overall lowest precision obtained is for gunshots class
- The experimental results prove that LPC coefficients can be used for different classifiers, in the context of source sound detection, with overall high correct classification rates

Conclusion

- A possible future work could be experimenting and analyzing more classifiers in WEKA
  - We consider that we can identify the best parameters configuration for each experimented classifier and evaluate the performance
  - This investigation might lead to new results of using efficiently classifiers in WEKA
  - Also we shall concentrate in future works in real-life experiments
- For this investigation, we have used a database just for five sound types
  - For future work we are planning to extend the database
  - Possible sound types could be dogs, bears and even wild cats

Several Classifiers for Intruder Detection Applications

Elena Roxana BUHUȘ, **Lăcrimioara GRAMA**, Corneliu RUSU

Technical University of Cluj-Napoca
Faculty of Electronics, Telecommunications and Information Technology
Basis of Electronics Department
Signal Processing Group

SpeD 2017
Bucharest, Romania
July 6-9, 2017

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS/CCCDI–UEFISCDI, project number PNIII-P2-2.1-BG-2016-0378, 54BG/2016, within PNCDI III. A part of the work was also supported by Grant PAV3M PN-II-PT-PCCA-2013-4-1762.