Acoustic Transient Classification using a Template Correlation Processor

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September 4, 1999

2nd European Workshop on Neuromorphic Systems
Stirling, Scotland

Acoustic Transient Classification using a Template Correlation Processor

- Template Correlation
- A Trinary-Trinary Correlator Algorithm
- Frontend Filterbank Hardware
- Template Correlation Hardware
- Experimental Results
- Conclusion

Problem:

Biologically-inspired models of acoustic signal classification

- Software-oriented
- Complex or arbitrary connectivity
- Intensive computations at every node

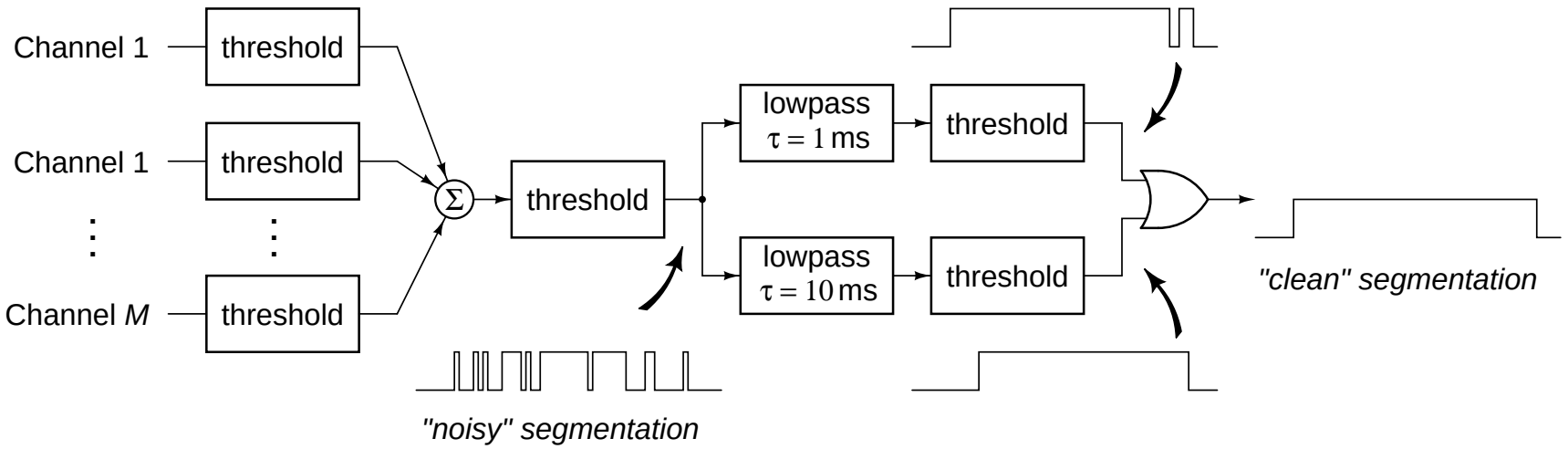
Template correlation has been presented as a neural network model for acoustic signal classification.

- Hardware-oriented
- Parallel architecture
- Simple computations
- Dense layout

Challenge:

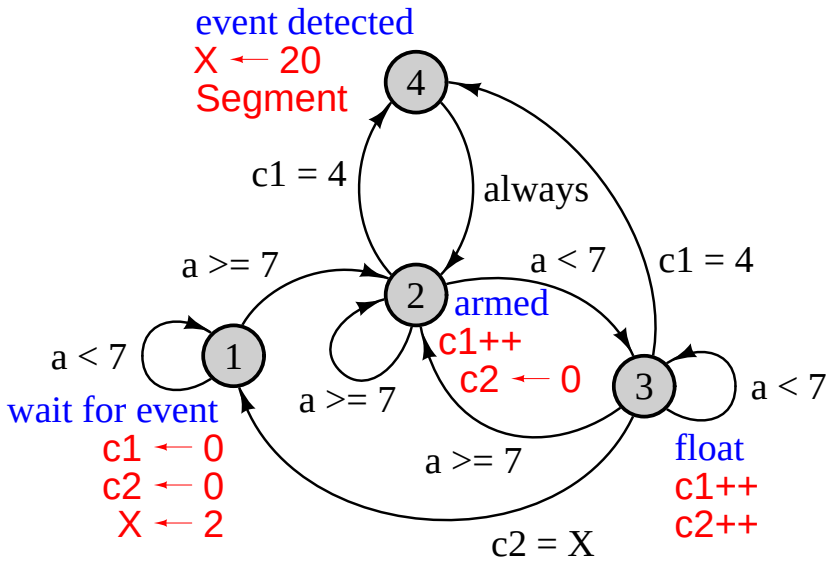
Produce working hardware implementing template correlation with simple arithmetic per node and high density.

Method of input segmentation



An integer method for automatically segmenting input

Count a, the number of inputs with amplitude bit = 1

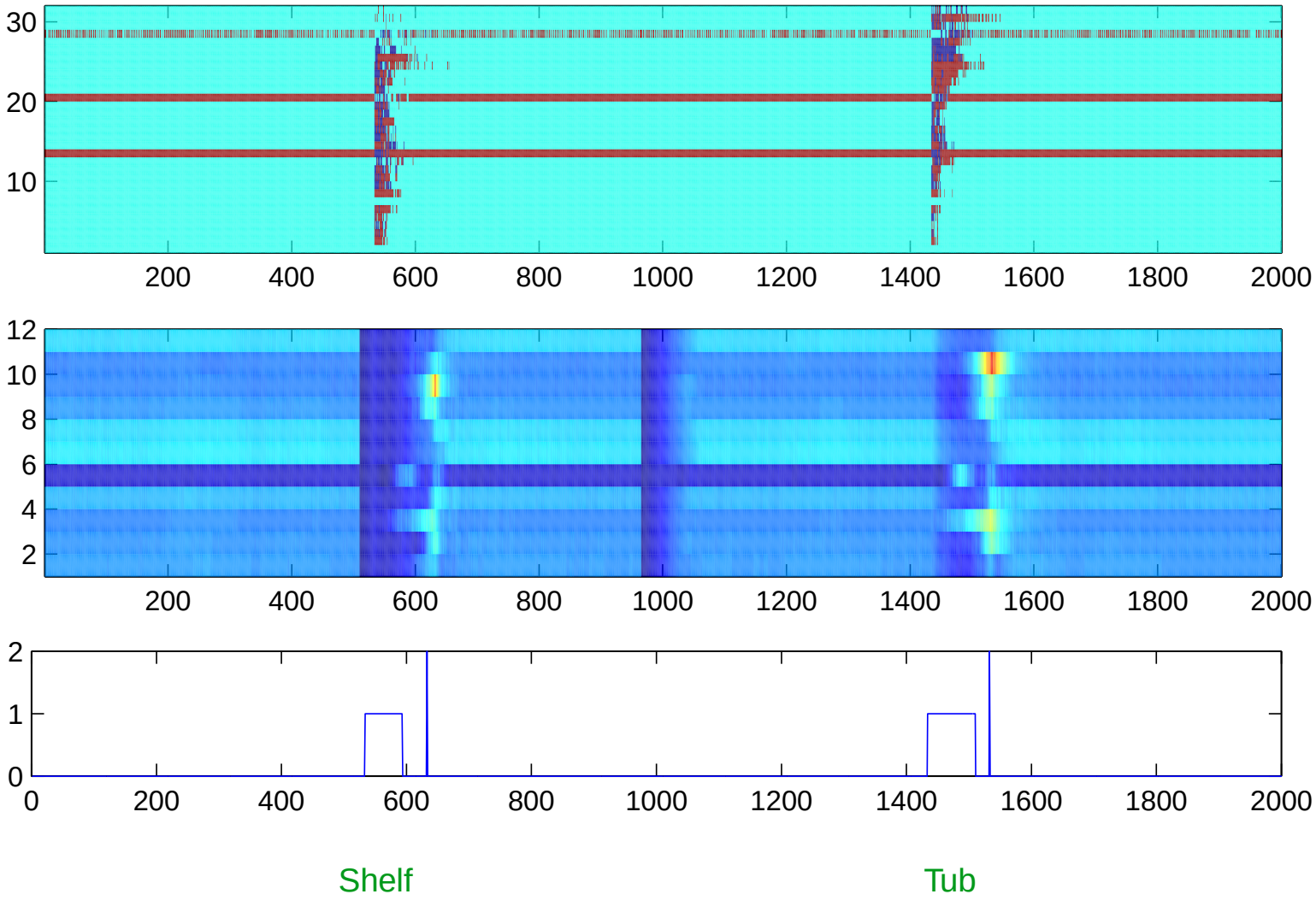


Method for automatically generating templates

1. Align training data on tags; fill to length of template
2. Sum all aligned instances of each class using relations:
3. For each template location, limit to $+1$, 0, -1

ampl	sign	trinary
0	X	0
1	0	-1
1	1	$+1$

Example Correlation on Transient Data



Experimental Results of the Trinary Transient Classifier Hardware

Cross-Validation with Non-Real-Time Segmenter

Event	Bar	Book	Can	Dink	Door	Finger	Hand	Mallet	Shelf	Tub
Bar	20	0	0	0	0	0	0	0	0	0
Book	0	20	0	0	0	0	0	0	0	0
Can	0	0	20	0	0	0	0	0	0	0
Dink	0	0	0	20	0	0	0	0	0	0
Door	0	0	0	0	20	0	0	0	0	0
Finger	0	0	0	0	0	20	0	0	0	0
Hand	0	0	0	0	0	1	18	0	0	0
Mallet	0	0	1	0	0	0	0	19	0	0
Shelf	0	0	0	0	0	0	0	0	20	0
Tub	0	0	0	0	0	0	0	0	0	20

Statistics:

Total instances presented:	199
Correct:	197
Incorrect:	2
Accuracy:	99.0%

Experimental Results of the Trinary Transient Classifier Hardware

Cross-Validation with Real-Time Segmenter

Event	Bar	Book	Can	Dink	Door	Finger	Hand	Mallet	Shelf	Tub
Bar	20	0	0	0	0	0	0	0	0	0
Book	0	20	0	0	0	0	0	0	0	0
Can	0	0	19	0	0	0	0	1	0	0
Dink	0	0	0	18	0	0	3	0	0	0
Door	0	0	4	0	20	13	6	4	0	0
Finger	0	0	0	0	0	19	1	0	0	0
Hand	0	0	0	0	0	5	14	0	0	0
Mallet	0	0	1	0	0	0	1	17	1	0
Shelf	0	0	0	0	0	0	0	0	19	0
Tub	0	0	0	0	0	0	0	0	0	20

Statistics:

Total instances presented:	199
Total events found:	226
Correct:	186
Incorrect:	11
Missed:	2
Extra event inserted:	25
Correctly identified:	93.5%
Incorrectly identified:	5.5%
Missed:	1.0%
Insertions:	12.6%

Experimental Results of the Trinary Transient Classifier Hardware

Cross-Validation with Real-Time Segmenter

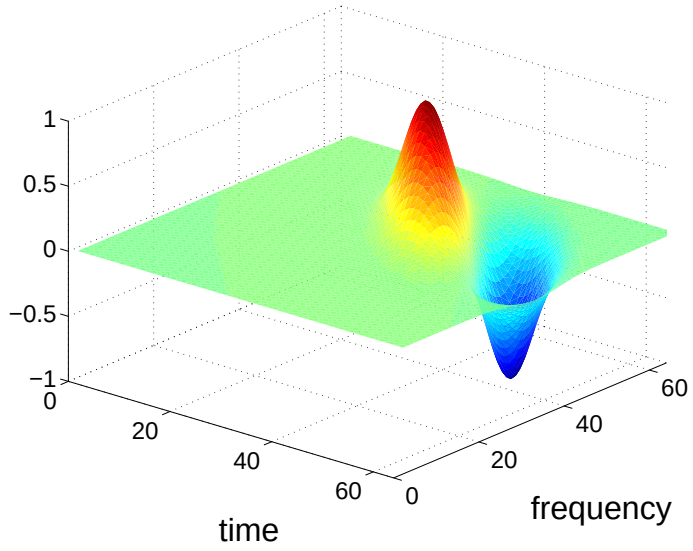
Hand-retagged data

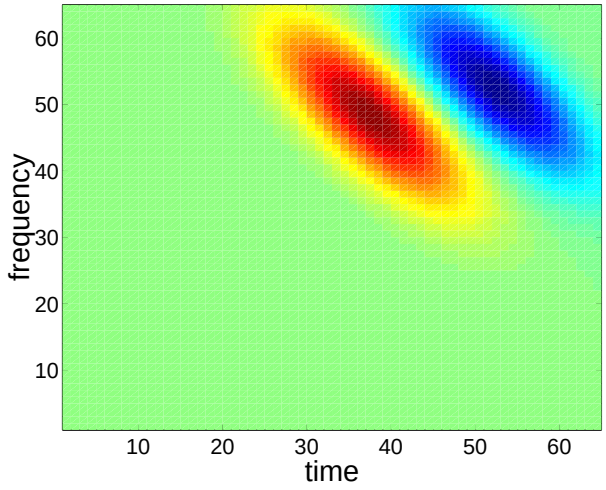
Event	Bar	Book	Can	Dink	Door	Finger	Hand	Mallet	Shelf	Tub	Unknown	Unknown
Bar	20	0	0	0	0	0	0	0	0	0	0	0
Book	0	20	0	0	0	0	0	0	0	0	0	0
Can	0	0	24	0	0	0	0	0	0	0	0	0
Dink	0	0	0	20	0	0	0	0	0	0	0	0
Door	0	0	0	0	20	0	0	0	0	0	0	0
Finger	0	0	0	0	0	17	1	0	0	0	0	2
Hand	0	0	0	0	0	1	19	0	0	0	0	0
Mallet	0	0	2	0	0	0	0	18	0	0	0	0
Shelf	0	0	0	0	0	0	0	0	20	0	0	0
Tub	0	0	0	0	0	0	0	0	0	20	0	0
Unknown	0	0	0	0	0	3	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0	7

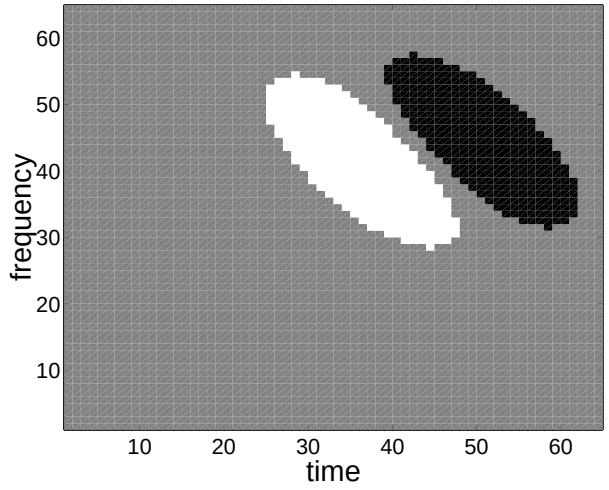
Statistics:

Total instances presented:	215
Total events found:	214
Correct:	205
Incorrect:	9
Missed:	1
Correctly identified:	95.3%
(In set of known targets):	97.2%
Incorrectly identified:	4.2%
Missed:	0.5%

The Correlator as a Model of the Auditory Cortex







Conclusion

A trinary-trinary template correlation algorithm and hardware

- Produces good results on simple acoustic transient classification
- Bears a resemblance to neural network approaches
- Compensates for lack of arbitrary connectivity with high density

Continuing research extends applications to biosonar classification.