# Scuola di Dottorato in Ingegneria dell'Informazione XVII Ciclo n.s., 3° anno di corso (2017/2018)



#### Studente: Diego Droghini

Università Politecnica delle Marche **Progetto Eureka** 



# Ambient Intelligence: Computational Audio Processing For Human Fall Detection

#### Outline



- Introduction
- Dataset FAS A3FALL Dataset
- Supervised Approaches Multi-class SVM Binary SVM
- Unsupervised Approach OCSVM
   End-To-End CNN-AF

- Weakly-supervised Approach OCSVM + Template Matching User-Aided Few-shot Siamese Neural Networks OneShot Siamese Autoencoders
- Other Contributions
- Conclusions
- Ditattica

# Fall Detection Systems



# State-Of-The-Art



# Motivations and Contributions





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### The floor acoustic sensor





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# The fall events dataset: A3Fall



# The recording setup



# Description



# Signal analysis





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#### • Weakly-supervised Approach

OCSVM + Template Matching User-Aided Few-shot Siamese Neural Networks

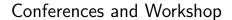
#### OneShot Siamese Autoencoders

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# End-to-End Unsupervised Network for Audio Timbrerche Transfer

# Conclusions







- WIRN 2016: 26th Italian Workshop on Neural Networks, May 18-20 2016, Vietri sul Mare, Salerno, Italy [1 oral presentation]
- **EUSIPCO 2017**: 25th European Signal Processing Conference, 28 Ago.-2 Sept. 2017, Kos Island, Greece [1 oral presentation]
- WIRN 2018: 28th Italian Workshop on Neural Networks, 13-15 June 2018, Vietri sul Mare, Salerno, Italy [1 oral presentation]
- **EUSIPCO 2018**: 28th edition of the European Signal Processing Conference, Sept. 3-7 2018, Rome, Italy [1 poster]

#### In addition:

 Speaker: "Le nuove applicazioni dell'Intelligenza Artificiale in ambito musicale", workshop at Acusmatiq XII - international festival of electronic, electro-acoustic and experimental music, 28 - 30 July 2017, Ancona, Italy

# Training Activity



#### Courses:

- o "Progettare la ricerca: i progetti europei", Prof. Nicola Paone
- o "Economia e Management del Trasferimento Tecnologico", Prof. Donato Iacobucci

#### • Seminars:

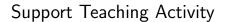
- "Automated Prominent Nucleoli Detection in Cancer Cells", Dr. Hwee Kuan Lee
- "Tecniche di Elaborazione Numerica dei Segnali Applicata alla Sintesi della Canna d'Organo", Ing. Carlo Zinato
- "Robustness Analysis of Binaural Loudspeaker Reproduction", Prof. Risheng Xia - Feb. 21 2017
- "From signal representations to musical creation: a geometric approach", Dott. Carmine Cella - Mar. 16 2017
- "Tecnologie Elettroniche nei Centri Dati di Google", Dott. Anthony Tonizzo - May 17 2017

# Training Activity



#### Other:

- Corso di Perfezionamento post laurea in Computer Music Production organized by UnivPm - Awarded Certificate
- Integrative activity organized by the "Contamination LAB" concerning self-entrepreneurship - Best Pitch Winner (Team)
- Reviewer for international journals (IEEE Transactions on Emerging Topics in Computational Intelligence, Information Processing in Agriculture) and international conferences (WIRN2016, IJCNN 2017, IJCNN 2018, ICONIP 2018).





- Exam supervision for "Macchine e Reti Elettriche" (C.d.L. Ing. Meccanica)
- Exam supervision and teaching material for "Circuiti ed Algoritmi per Digital Signal Processing" (C.d.L. Ing. Elettronica) and "Digital Adaptive Circuits and Learning Systems" (DAC-LS) (C.d.LM. Ing. Elettronica)
- Tutoring activity for master thesis projects DAC-LS students
- Lectures on "Computational Audio Processing" at DAC-LS and post-graduate course on "Tecnico per l'applicazione di tecnologie domotiche per gli ambienti di vita"

# Publications List (1)



#### International Journal:

[3 articles, 2 first author]



[1] E. Marchi, F. Vesperini, S. Squartini, and B. Schuller, "Deep recurrent neural network-based autoencoders for acoustic novelty detection," *Computational Intelligence and Neuroscience*, 2016.



[2] F. Vesperini, P. Vecchiotti, E. Principi, S. Squartini, and F. Piazza, "Localizing speakers in multiple rooms by using deep neural networks," *Computer Speech and Language*, 2017.

#### International Journal (submitted):

[1 article, 1 first author]



[1] F. Vesperini, L. Gabrielli, E. Principi, and S. Squartini, "Polyphonic sound event detection by using capsule neural networks," *Journal of Selected Topics in Signal Processing*, 2018, submitted.

#### International Conference:

[14 articles, 5 first author]



[1] E. Marchi, F. Vesperini, F. Eyben, S. Squartini, and B. Schuller, "A Novel Approach for Automatic Acoustic Novelty Detection Using a Denoising Autoencoder with Bidirectional LSTM Neural Networks," in *Proc. of ICASSP*, Brisbane, Australia, 19-24 Apr. 2015, IEEE.

# Publications List (2)





[2] E. Marchi, F. Vesperini, F. Weninger, F. Eyben, S. Squartini, and B. Schuller, "Non-Linear Prediction with LSTM Recurrent Neural Networks for Acoustic Novelty Detection,"

in Proc. of IJCNN, Killarney, Ireland, 12-16 Jul. 2015, IEEE.



[3] F. Vesperini, P. Vecchiotti, E. Principi, S. Squartini, and F. Piazza, "Deep neural networks for multi-room voice activity detection: Advancements and comparative evaluation,"

in Proc. of IJCNN, Vancouver, Canada, 24-29 Jul. 2016, IEEE, pp. 3391-3398.



[4] M. Gasparini, F. Vesperini, S. Cecchi, S. Squartini, F. Piazza, and R. Toppi, "Combining evolution strategies and neural network procedures for compression driver design,"

in *Proc. of IJCNN*, Vancouver, Canada, 24-29 Jul. 2016, IEEE, pp. 3385-3390.



[5] P. Vecchiotti, F. Vesperini, E. Principi, S. Squartini, and F. Piazza, "Convolutional neural networks with 3-D kernels for voice activity detection in a multiroom environment."

in Multidisciplinary Approaches to Neural Computing, pp. 161–170. Springer, 2018.

# Publications List (3)





[6] F. Vesperini, P. Vecchiotti, E. Principi, S. Squartini, and F. Piazza, "A neural network based algorithm for speaker localization in a multi-room environment,"

in Machine Learning for Signal Processing (MLSP), 2016 IEEE 26th International Workshop on. IEEE, 2016, pp. 1–6.



[7] E. Principi, F. Vesperini, S. Squartini, and F. Piazza, "Acoustic novelty detection with adversarial autoencoders," in *Proc. of IJCNN*, Anchorage, Alaska, 14-19 May 2017, IEEE, pp. 3324–3330.



[8] M. Valenti, D. Tonelli, F. Vesperini, E. Principi, and S. Squartini, "A neural network approach for sound event detection in real life audio," in *Proc. of EUSIPCO*, Kos, Greece, Sept. 2017, IEEE.



[9] L. Gabrielli, C. E. Cella, F. Vesperini, D. Droghini, E. Principi, and S. Squartini, "Deep learning for timbre modification and transfer: An evaluation study," in *Proc. of 144th AES*, Milan, Italy, 24-26 May 2018, Audio Engineering Society.

# Publications List (4)





[10] L. Ambrosini, L. Gabrielli, F. Vesperini, S. Squartini, and L. Cattani, "Deep neural networks for road surface roughness classification from acoustic signals,"

in Proc. of 144th AES, Milan, Italy, 24-26 May 2018, Audio Engineering Society.



[11] F. Vesperini, A. Galli, L. Gabrielli, E. Principi, and S. Squartini, "Snore sounds excitation localization by using scattering transform and deep neural networks."

in Proc. of IJCNN, Rio de Janeiro, Brasil, 8-13 Jul. 2018, IEEE.



[12] F. Vesperini, D. Droghini, E. Principi, L. Gabrielli, and S. Squartini, "Hierarchic ConvNets framework for rare sound event detection," in *Proc. of EUSIPCO*. IEEE, Sept. 3-7 2018.



[13] F. Vesperini, L. Romeo, E. Principi, A. Monteriù, and S. Squartini, "Convolutional recurrent neural networks and acoustic data augmentation for snore detection,"

in Proc. of WIRN, Vietri sul Mare, Italy, 13-15 Jun. 2018.

# Publications List (5)





[14] D. Droghini, F. Vesperini, E. Principi, S. Squartini, and F. Piazza,

"Few-shot siamese neural networks employing audio features for human-fall detection,"

in Proc. of The International Conference on Pattern Recognition and Artificial Intelligence, Union, NJ, USA, Aug. 15-17 2018.

#### Others:



F. Vesperini, D. Droghini, D. Ferretti, E. Principi, L. Gabrielli, S. Squartini, and F. Piazza.

"A hierarchic multi-scaled approach for rare sound event detection," Ancona, Italy, 2017, DCASE Tech. Report, Copyright-free.



F. Vesperini, L. Gabrielli, E. Principi, and S. Squartini,

"A capsule neural networks based approach for bird audio detection," Ancona, Italy, 2018, DCASE Tech. Report. Copyright-free.



L. Gabrielli, F. Vesperini, D. Droghini, and S. Squartini,

"Rima Glottidis: Experimenting generative raw audio synthesis for a sound installation."

in XXII Colloquium of Musical Informatics, Udine, Italy, 20-23 Nov. 2018.