Scuola di Dottorato in Ingegneria dell'Informazione

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Università Politecnica delle Marche
Progetto Eureka

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Ambient Intelligence: Computational Audio Processing For Human Fall Detection

Outline

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Human fall: a real problem for society

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"And why do we fall, Bruce? So we can learn to pick ourselves up" cit. Batman Begins

- 62% of injury-related hospitalizations for the people over 65 years are the result of a fall [1]
- main cause of death due to accidents for people over 65 [2]
- can lead to psychophysical repercussions on people [3]

What can be done whit FCS

- Monitoring of the elderly or people who live alone
- Assistance time reduction

Fall Classification System Challenge [4]

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- Try to collect sufficient human fall data
  - Supervised methods (SVM): HF in training
    - difficulty in retrieving examples that represent human falls
- Deal with no human fall data
  - Novelty detection approach (OCSVM)
    - good description of "normality"

Related Work

- Wearable
  - Accelerometers
  - Gyroscopes
- Ambient
  - Vision System
  - Audio microphone
  - Radar doppler

Fall Event

Motivations and Contributions

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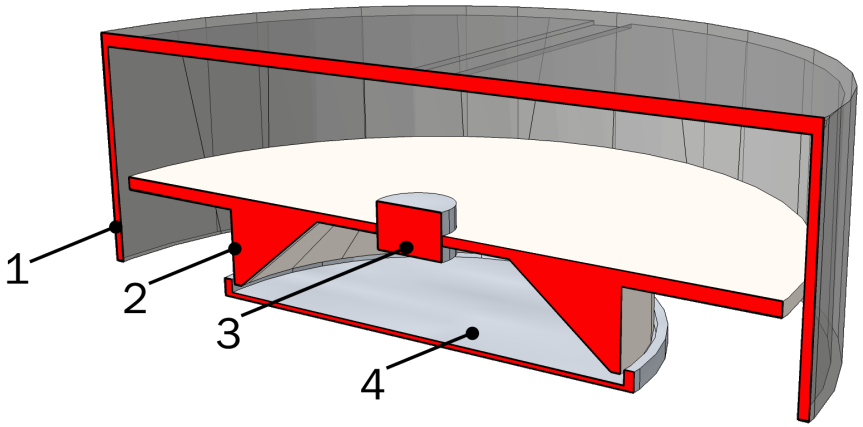
Floor Acoustic Sensor[5]

1. The outer container
2. The inner container
3. The microphone slot
4. The membrane touching the floor



Advantage

- Easily integrated into the environment
- More sensitive to signals related to falls

3D printed prototype

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The fall events dataset: A3Fall

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motivazione: mancaza di dataset audio adeguati descrizione generale: descrizione 3 stanze

The recording setup

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strumentazione: microfoni (fas e aerei + randy + sceda audio + marche microfoni)

Description

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aggingere qualcosa sulla sinistra

Class	**R0**	**R1**	**R2**
	Nr. of occurrences		
Basket	64	40	40
Fork	64	40	40
Ball	64	40	40
Book	64	40	40
Bag	64	30	40
Chair	96	40	40
Table	0	40	40
Guitar Slide	0	40	40
Nipper	0	40	40
Keys	0	40	40
Hook	0	40	40
Coat Hook	0	40	40
Manikin Doll	44	0	0
Human Fall	0	40	40
	Total length (s)		
Background	2530	9055	5550

Signal analysis

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confronto mel channel e SNR tra fas e aereal

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End-to-End Unsupervised Network for Audio Timbre Transfer

Conclusions

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Conferences and Workshop

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- **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**:
  - "Progettare la ricerca: i progetti europei", Prof. Nicola Paone
  - "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).

References (1)


R. J. Gurley, N. Lum, M. Sande, B. Lo, and M. H. Katz,
"Persons found in their homes helpless or dead,"
New England Journal of Medicine, vol. 334, no. 26, pp. 1710–1716, 1996.


M. Mubashir, L. Shao, and L. Seed,
"A survey on fall detection: Principles and approaches,"
Neurocomputing, vol. 100, pp. 144–152, 2013.


S. Abbate, M. Avvenuti, P. Corsini, J. Light, and A. Vecchio,
"Monitoring of human movements for fall detection and activities recognition in elderly care using wireless sensor network: a survey,"
in *Wireless Sensor Networks: Application-Centric Design*. InTech, 2010.


S. S. Khan and J. Hoey,
"Review of fall detection techniques: A data availability perspective,"
Medical engineering and physics, vol. 39, pp. 12–22, 2017.


E. Principi, D. Droghini, S. Squartini, P. Olivetti, and F. Piazza,
"Acoustic cues from the floor: a new approach for fall classification,"
Expert Systems with Applications, vol. 60, pp. 51–61, 2016.

References (2)

S. Chopra, R. Hadsell, and Y. LeCun,
"Learning a similarity metric discriminatively, with application to face verification,"
in *Computer Vision and Pattern Recognition, 2005. CVPR 2005. IEEE Computer Society Conference on*. IEEE, 2005, vol. 1, pp. 539–546.

D. Droghini, E. Principi, S. Squartini, P. Olivetti, and P. F.,
"Human fall detection by using an innovative floor acoustic sensor,"
in *Proc. of WIRN*. Vietri sul Mare, Italy, May, 18-20 2016,
(8 pages), to appear.

J. Bromley, I. Guyon, Y. LeCun, E. Säckinger, and R. Shah,
"Signature verification using a" siamese" time delay neural network,"
in *Advances in Neural Information Processing Systems*, 1994, pp. 737–744.

G. Koch, R. Zemel, and R. Salakhutdinov,
"Siamese neural networks for one-shot image recognition,"
in *ICML Deep Learning Workshop*, 2015, vol. 2.

References (3)

D. Droghini, D. Ferretti, E. Principi, S. Squartini, and F. Piazza,
"A combined one-class svm and template matching approach for user-aided human fall detection by means of floor acoustic features,"
Computational Intelligence and Neuroscience, vol. 2017, 2017,
Article ID 1512670.

Publications List (1)

UNIVERSITÀ POLITECNICA DELLE MARCHE

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)

UNIVERSITÀ POLITECNICA DELLE MARCHE

[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)

UNIVERSITÀ POLITECNICA DELLE MARCHE

[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)

UNIVERSITÀ POLITECNICA DELLE MARCHE

[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)

UNIVERSITÀ POLITECNICA DELLE MARCHE

[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.