**Frequency analysis for real-time recognition of sick pigs and disease monitoring in pig houses**

V. Exadaktylos1, M. Silva2, J.-M. Aerts2, C. J. Taylor1 and D. Berckmans2,\*
1*Engineering Department, Lancaster University, LA1 4YR Lancaster, United Kingdom*
2*Department of Biosystems, Division M3-BIORES: Measure, Model & Manage Bioresponses, Catholic University of Leuven, Kasteelpark Arenberg 30, 3001 Heverlee, Belgium*\* Corresponding author: Daniel Berckmans, daniel.berckmans@biw.kuleuven.be

Times New

Roman 12 pt

Blank line

# Abstract

Blank line

This paper extends existing cough identification methods and proposes a real-time version for identifying sick pig cough sounds. The analysis and classification is based on the frequency domain characteristics of the signal, while an improved procedure to extract the reference is presented. This technique evaluates fuzzy c-means clustering to parts of the training signals that mirror the cough characteristics. The identification process can be implemented for real-time applications that would improve and speed up the treatment procedure in pig houses.

Blank line

**Keywords**: real-time recognition, cough analysis, spectral analysis, signal processing

Blank line

# Introduction

Blank line

Paragraphs justified left and right

Cough is a sudden air explosion from the airways followed by a characteristic sound (Korpáš *et al*., 1996). Being one of the body's defence mechanisms against respiratory infections, it can be a sign of disorder or infection of the respiratory system. It has been used as an index for over 100 diseases and an experienced physician can identify an infection based on the cough sound. This fact has led researchers to further study cough recording and analysis methods (e.g. Subburaj *et al*., 1996) and to develop automated identification techniques (e.g. Matos *et al*., 2006)….

# Material and methods

Blank line

Blank line

## Experimental data

The data, both pathologic and healthy coughs, used for the analysis are cough sounds recorded in laboratory conditions. The healthy coughs were induced in an inhalation chamber by injecting an irritating substance namely 0.8 moles per litre of citric acid…

Blank line

## Signal analysis

The frequency characteristics of the signal on which the identification process is based, is the Power Spectral Density (PSD). In Figure 1, for example, …



Figure 1: Time-signal (left column) and frequency content (right column) for a sick cough (top row), a grunt (middle row) and a scream (bottom row)

Blank line

## Power Spectral Density of the training set

SI units only

To define a reference, ten sick cough signals with average duration  and five scream signals with average duration  were used. Each signal was split into parts of length  (or ) with a 50% overlap to each other allowing…

Blank line

## Extraction of signal characteristics

In this work, the Discrete Fourier Transform (DFT) that is widely used in signal processing (Oppenheim *et al*., 1999), is used to extract the spectrum of the signals. For completeness, its main properties are described below.

Consider a discrete signal ,  sampled at frequency . The N-point DFT of this signal is defined as

 ,  (1)

Blank line

where  is the imaginary unit and  is in general a complex number. The DFT reveals the frequency content of the sampled signal up to the Nyquist frequency .

Blank line

# Results and Discussion

Blank line

Each individual sound is processed using the proposed algorithm and is either identified as *sick* cough or not. Table 2 presents the total number of each sound and the number of them identified as *sick* cough when running the algorithm for a total of 656 sounds.

Blank line

Table 2: Identification results of the proposed algorithm

|  |  |  |  |
| --- | --- | --- | --- |
| Sound | Number of sounds | Number of sounds identified as cough | Percentage (%) |
| Healthy cough | 231 | 31 | 13.4 |
| Sick Cough | 281 | 231 | 82.2 |
| Scream | 13 | 1 | 7.6 |
| Sneeze | 19 | 2 | 10.5 |
| Grunt | 31 | 2 | 6.4 |
| Metal | 81 | 9 | 11.1 |

# Conclusions

Blank line

Blank line

This paper proposed a real-time algorithm for online identification of sick pig cough sounds.

Blank line

# Acknowledgements

Blank line

This project was funded by …

Blank line

# References

Blank line

Bezdek, J.C. (1981) *Pattern recognition with fuzzy objective function algorithms*. Plenum Press, New York.

Marx, G., Horn, T., Thielebein, J., Knubel, B., and von Borell, E. (2003) Analysis of pain-related vocalization in young pigs. *Journal of Sound and Vibration* 266(3), 687-398.

10 mm hanging indent

Van Hirtum, A., and Berckmans, D. (2001) The fundamental frequency of cough by autocorrelation analysis. In: *Proc. EUROSPEECH: 7th European Conference on Speech Communication and Technology* Aalborg, Denmark, 2435-2438.