

**ANIMAL**

Modeling potential masking of echolocating sperm whales exposed to continuous 1–2 kHz naval sonar

**COMPUTATIONAL**

Sensitivity analysis of pinna morphology on head-related transfer functions simulated via a parametric pinna model

**ENGINEERING**

Development of an ultrasound level meter for use in occupational safety and health

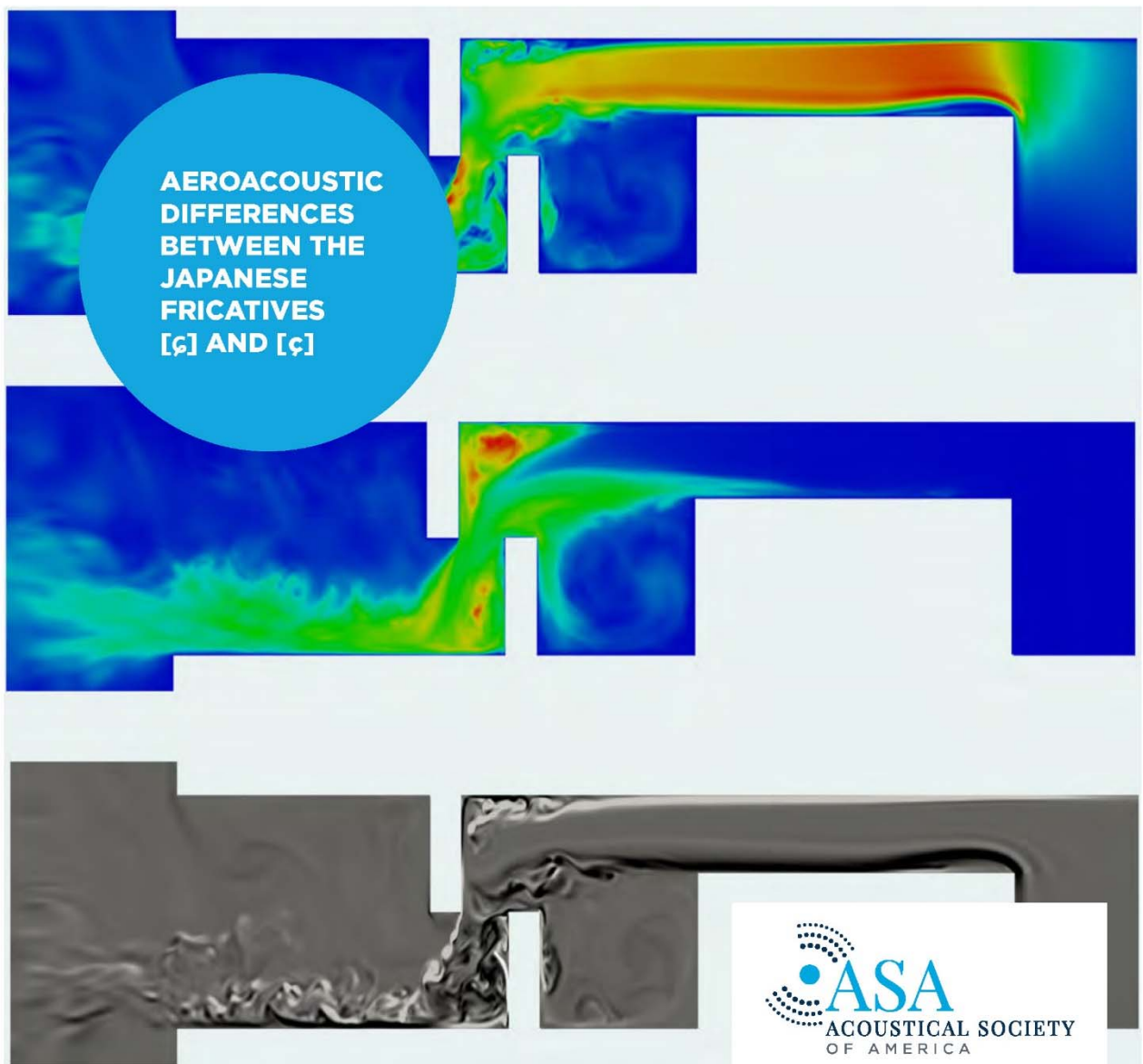
**MUSICAL**

Absolute pitch is disrupted by a memory illusion

# JASA

THE JOURNAL OF THE  
ACOUSTICAL SOCIETY OF AMERICA

Vol. 149 • No. 4 • 04.2021



AVAILABLE ONLINE: [asa.scitation.org/journal/jas](https://asa.scitation.org/journal/jas)

Published by the Acoustical Society of America through AIP Publishing LLC

# Selective monitoring of noise emitted by vehicles involved in road traffic

**Andrzej Czyżewski (1), Tomasz Śmiałkowski (2)**

(1) Gdansk University of Technology, Multimedia Systems Department, 80-233 Gdansk, Poland. [www.multimed.org](http://www.multimed.org), e-mail: [ac@pg.edu.pl](mailto:ac@pg.edu.pl)

(2) SILED Co. Ltd. , 83-011 Gdańsk Poland, <http://siled.pl/en/> e-mail: [biuro@siled.pl](mailto:biuro@siled.pl)

The aim of the project carried out by a Gdansk University of Technology in cooperation with an electronics company is to conduct industrial research, development, and pre-implementation works on a new product, namely an intelligent lighting platform. This kind of street lamp system called infoLIGHT using a new generation of LEDs will become a smart city access point to various city services (Fig. 1).



Figure 1 Intelligent lighting platform – infoLIGHT project website

The research focuses on the electronics built in the street lamp using multiple sensors (Fig. 2),

including an acoustic intensity probe that measures the sound intensity in three orthogonal directions, making it possible to calculate the azimuth and elevation angles, describing the sound source position.



## Road lamp design

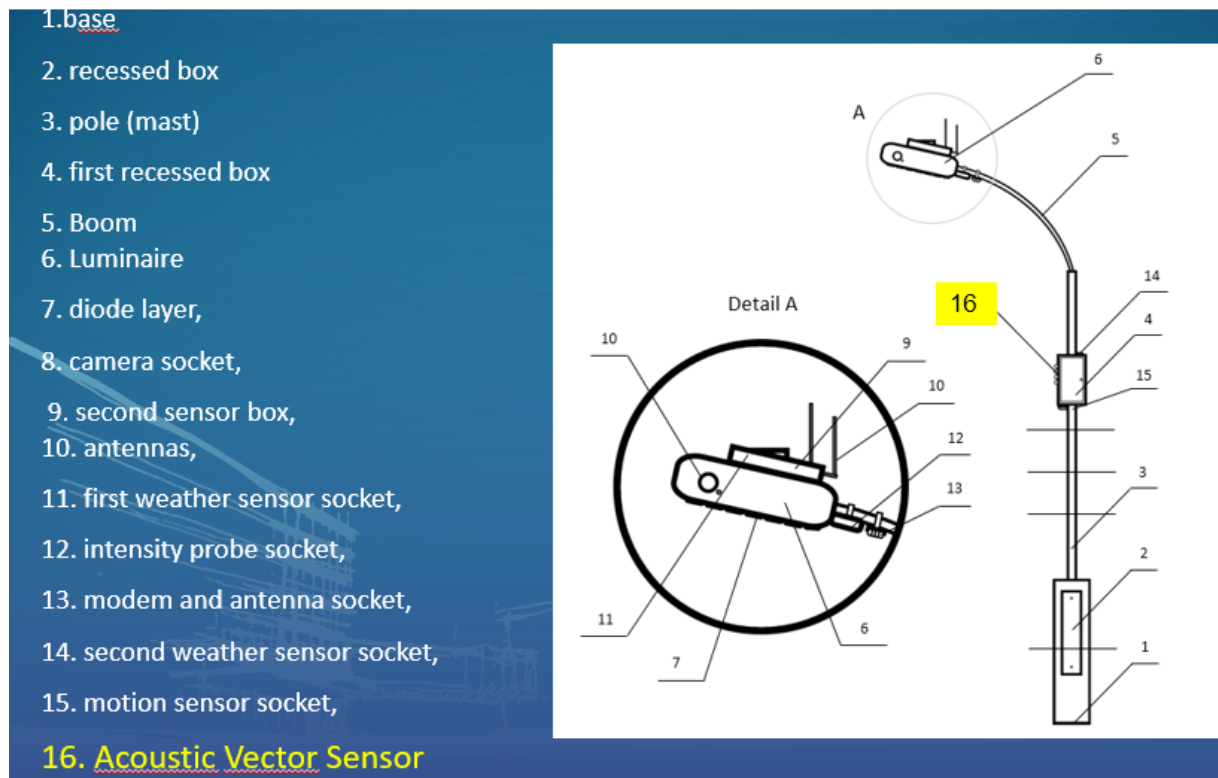


Figure 2 – Road lamp design

The acoustic sensor is made in the form of a cube with a side of 10 mm, on the inner surfaces of which the digital MEMS microphones are mounted (Fig. 3). The acoustic probes were mounted on the lamp posts that illuminate the roadways depending on the volume of traffic.

The Vector Acoustic Sensor module consists of 3 main elements:  
(1) acoustic sensor, the housing containing the sensor power supply and systems for data transmission, and (3) wind protection housing

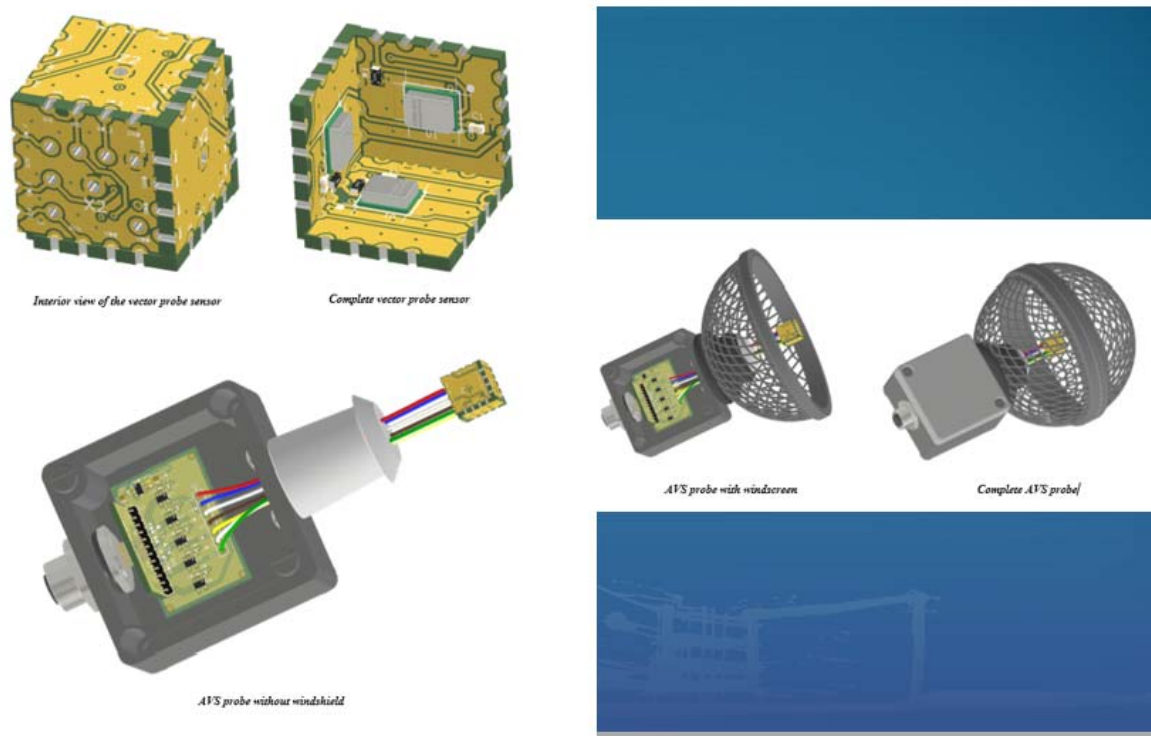


Figure 3 Acoustical vector sensor - construction

The algorithm works in two stages. The first stage is the analysis of sound intensity signals to detect acoustic events. The second stage analyses acquired signals based on the normalized source position; its task is to determine whether the acoustic event represents what kind of a vehicle passing the sensor and detecting its movement direction. A neural network was applied for selective analysis of traffic noise (Fig. 4). The neural network depicted in Figure 4 is the so-called 1D (one-dimensional) convolution neural network. It was trained to count vehicles passing by through the analysis of noise emitted by them.

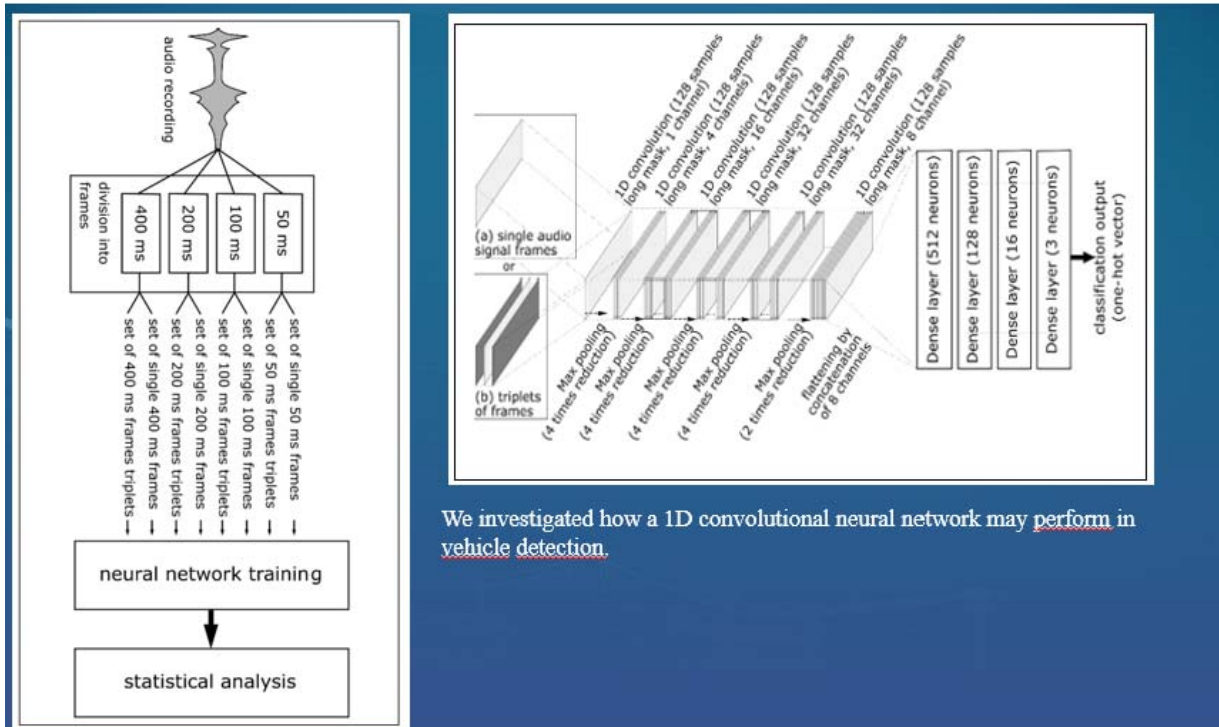


Figure 4 Neural network applied for selective analysis of traffic noise

The paper explains how accurately traffic can be monitored through directional noise analysis emitted by vehicles and shows the resulting application to smart cities (see Fig. 5). It provides an extension of a previous papers devoted to application of acoustic probe and other sensors in the Intelligent road signs [

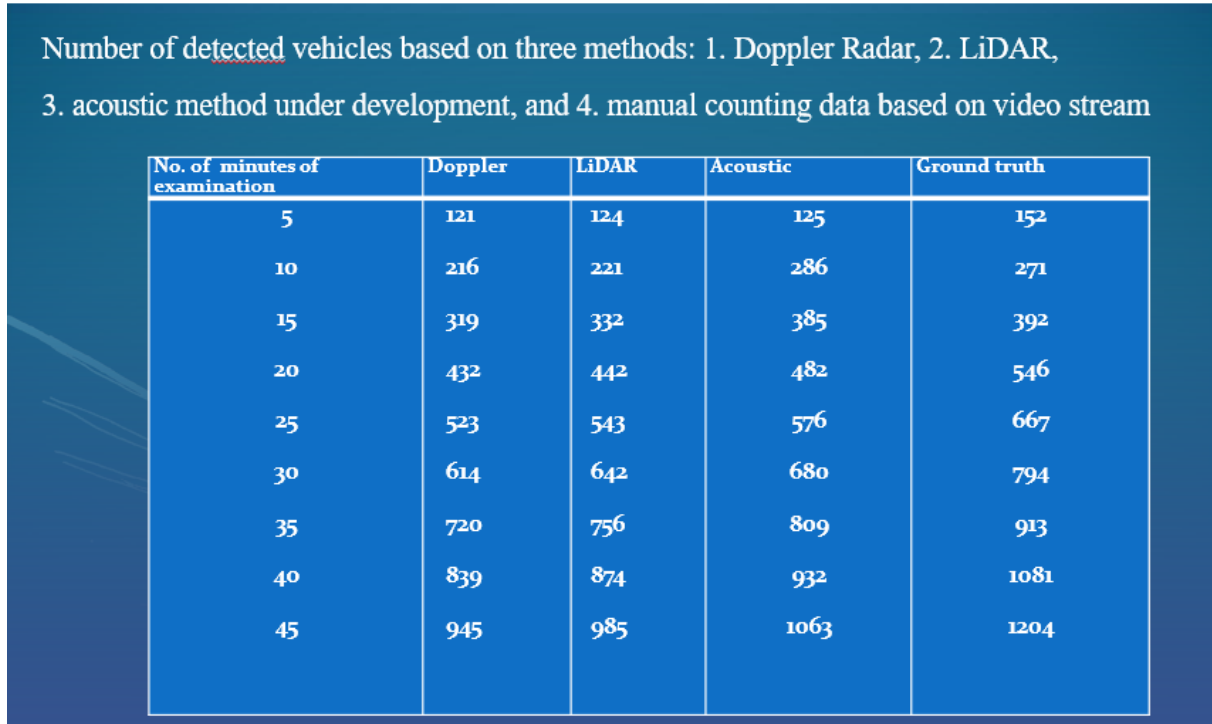


Figure 5 Comparative results of traffic analysis employing various approaches

### Acknowledgements

The Polish National Centre for Research and Development (NCBR) subsidizes project No. POIR.04.01.04/2019 is entitled: infoLIGHT - "Cloud-based lighting system for smart cities" from the budget of the European Regional Development Fund.

### REFERENCES

- [1] Czyżewski, J. Kotus, G. Szwoch, Estimating traffic intensity employing passive acoustic radar and enhanced microwave Doppler radar sensor, *Remote Sensing*, 2019, **1**, 110-110, <https://doi.10.3390/rs12010110>
- [2] Czyżewski A., Sroczyński A., Śmiałkowski T., Hoffmann P., Development of Intelligent Road Signs with V2X Interface for Adaptive Traffic Controlling, *MT-ITS2019 6th International Conference on Models and Technologies for Intelligent Transportation Systems*, 5-7.06.2019, Cracow. <https://doi.10.1109/MTITS.2019.8883369>
- [3] Czyżewski A et al., Comparative study on the effectiveness of various types of road traffic intensity detectors, *MT-ITS2019 6th International Conference on Models and Technologies for Intelligent Transportation Systems*, 5-7.06.2019 Cracow. <https://doi.10.1109/MTITS.2019.8883354>
- [4] Cygert S., Czyżewski A., Vehicle Detection with Self-Training for Adaptive Video Processing Embedded Platform, *Applied Sciences*, **10**(17):5763, Aug. 2020. <https://doi.org/10.3390/app10175763>
- [5] Cygert S., Czyżewski A., Style Transfer for Detecting Vehicles with Thermal Camera, *23rd International Conference, SPA 2019*, 18-20.09.2019, Poznań. <https://doi.10.23919/SPA.2019.8936707>

- [6] Prashant Borkar, Latesh G. Malik, Review on vehicular speed, density estimation and classification using acoustic signal. *International Journal for Traffic and Transport Engineering*. vol. **3**, pp. 331-343, 2913, [http://dx.doi.org/10.7708/ijtte.2013.3\(3\).08](http://dx.doi.org/10.7708/ijtte.2013.3(3).08)
- [7] Gonzalez X. V., Alías F., Automatic classification of road vehicles considering their pass-by acoustic signature, *Proc. Meet. Acoust.*, vol. **19**, 2013. *The Journal of the Acoustical Society of America* 133(5):3322. <https://asa.scitation.org/doi/10.1121/1.4805552>
- [8] Kurowski A., Marciniuk K., Kostek B., Separability Assessment of Selected Types of Vehicle-Associated Noise, part of the *Advances in Intelligent Systems and Computing* book series (AISC, vol. **506**), pp. 113–121. 2016. [https://doi.org/10.1007/978-3-319-43982-2\\_10](https://doi.org/10.1007/978-3-319-43982-2_10)
- [9] Kotus J., Czyżewski A., Counting and tracking vehicles using acoustic vector sensors, 176th Meeting of the Acoustical Society of America and 2018 Acoustics Week in Canada, Victoria, Canada, 05-09.11.2018. *The Journal of the Acoustical Society of America* **144**, 1830 (2018); <https://doi.org/10.1121/1.5068061>
- [10] Czyżewski, A. (2019). Diagnosing wind turbine condition employing a neural network to the analysis of vibroacoustic signals. *Journal of the Acoustical Society of America*, 146, 2952-2952. <https://doi.org/10.1121/1.5137251>  
Protected industrial design (Polish Patent Office, Application No. Wp.28574)