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► To cite this version:

Rémi Cousson, Marie-Agnès Pallas, Quentin Leclère, Michel Bérengier. Identification of acoustic moving sources in the context of a road vehicle at pass-by: A numerical comparison. Forum Acusticum, Jun 2017, BOSTON, United States. Acoustical Society of America, Forum Acusticum, 5 (141), pp.3883, 2017, 10.1121/1.4988696 . hal-01627750

HAL Id: hal-01627750

<https://hal.science/hal-01627750>

Submitted on 13 Nov 2017

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Identification of acoustic moving sources in the context of a road vehicle at pass-by: a numerical and experimental comparison

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Abstract n°2713429

METHOD DESCRIPTION: MOVING SOURCE ADAPTED - PSF

Assumptions:

- Uncorrelated sources
- Monopoles linearly moving at constant speed U
- $UT \ll D$
- Ergodic random sources
- Differences in dopplerized frequencies $< \Delta f (= \frac{1}{T})$

$$\tilde{H}(\omega_p) s(\omega_p) = b(\omega_p)$$

$$\tilde{H}_{i,j}(\omega_p) = \sum_{m=1}^{N_M} \tilde{G}_{i,m}^{(k)*} \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \tilde{G}_{j,m}^{(k)} \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right)$$

Snapshot k ($k=1..N_k$):

$$\text{Beamforming at frequency } f_{dopp}^{(k)} = \frac{f}{1 - M \cos \theta_k}$$

PSF calculated at $f_{dopp}^{(k)}$

- Averaged BF output over N_k
- Averaged PSF over N_k
- Deconvolution

$$b_i(\omega_p) \approx \sum_{m=1}^{N_M} \tilde{G}_{i,m}^{(k)*} \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \Gamma_{i,m,n}^{(k)}(\omega_p) \tilde{G}_{i,n}^{(k)} \left(\frac{\omega_p}{1 - M_{i,n}^{(k)}} \right)$$

$$\Gamma_{i,m,n}^{(k)}(\omega_p) = \tilde{p}_m^{(k)} \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \tilde{p}_n^{(k)*} \left(\frac{\omega_p}{1 - M_{i,n}^{(k)}} \right)$$

NUMERICAL SIMULATIONS: PERFORMANCE ASSESSMENT

1. LOCALIZATION

2. QUANTIFICATION

3. SEPARATION POWER

SIMULATION PARAMETERS

$F_s = 8000$ Hz
 $N_M = 32$ sensors
 $d = [0.05 - 0.29]$ m
 $L_{array} = 4$ m
 $D = 4$ m
 $T_{signal} = 2$ s
 $U = [30 - 90]$ km/h

$X_{source} = 0$ m
 $X_{sep} = [-0.05 ; +0.05]$ m
 $f_{range} = [500 - 3000]$ Hz
 $T = 0.02$ s
 $N_k = 29$
 $Overlap = 60\%$
 $N_{simus} = 60$

MSA-PSF: Moving Source Adapted - Point Spread Function

CBF: Conventional Beamforming
 (Sweeping focus time domain BF + Deconvolution with static PSF)

- Better localization of sources: more robust and less dispersive
- Better quantification: error < 1dB until 2.5kHz vs error > 1dB in whole frequency range for CBF
- Better separation of close sources

ACADEMIC EXPERIMENT

Moving sources:
 Smartphone with two independent loudspeakers

30 Microphones linear array microphones

T
O
N
E
S
O
U
R
C
E
S

$F_s = 51200$ Hz
 $P = 30$ sensors
 $d = 0.02$ m
 $D = 0.5$ m
 $T_{signal} = 2$ s
 $U = 3.5$ m/s

$X_{sources} = [-0.06 ; +0.06]$ m
 $f_{s1} = 8$ kHz
 $f_{s2} = 6$ kHz
 $T = 0.02$ s
 $N_k = 21$
 $Overlap = 60\%$

R
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REFERENCES

- [1] V. Fleury, J. Bulté, *Extension of deconvolution algorithms for the mapping of moving acoustic sources*, J. Acoust. Soc. Am., Vol. 129, 1417-1428 (2011)
- [2] B. Oudompheng, *Array processing for the localization and the contribution of acoustic sources of passing-by ship using a short antenna*, Univ. Grenoble Alpes (2015)
- [3] P.M. Morse, K.I. Ingard, *Theoretical Acoustics*, Princeton University Press, 717-726 (1992)

PERSPECTIVES

Real pass-by condition measurements