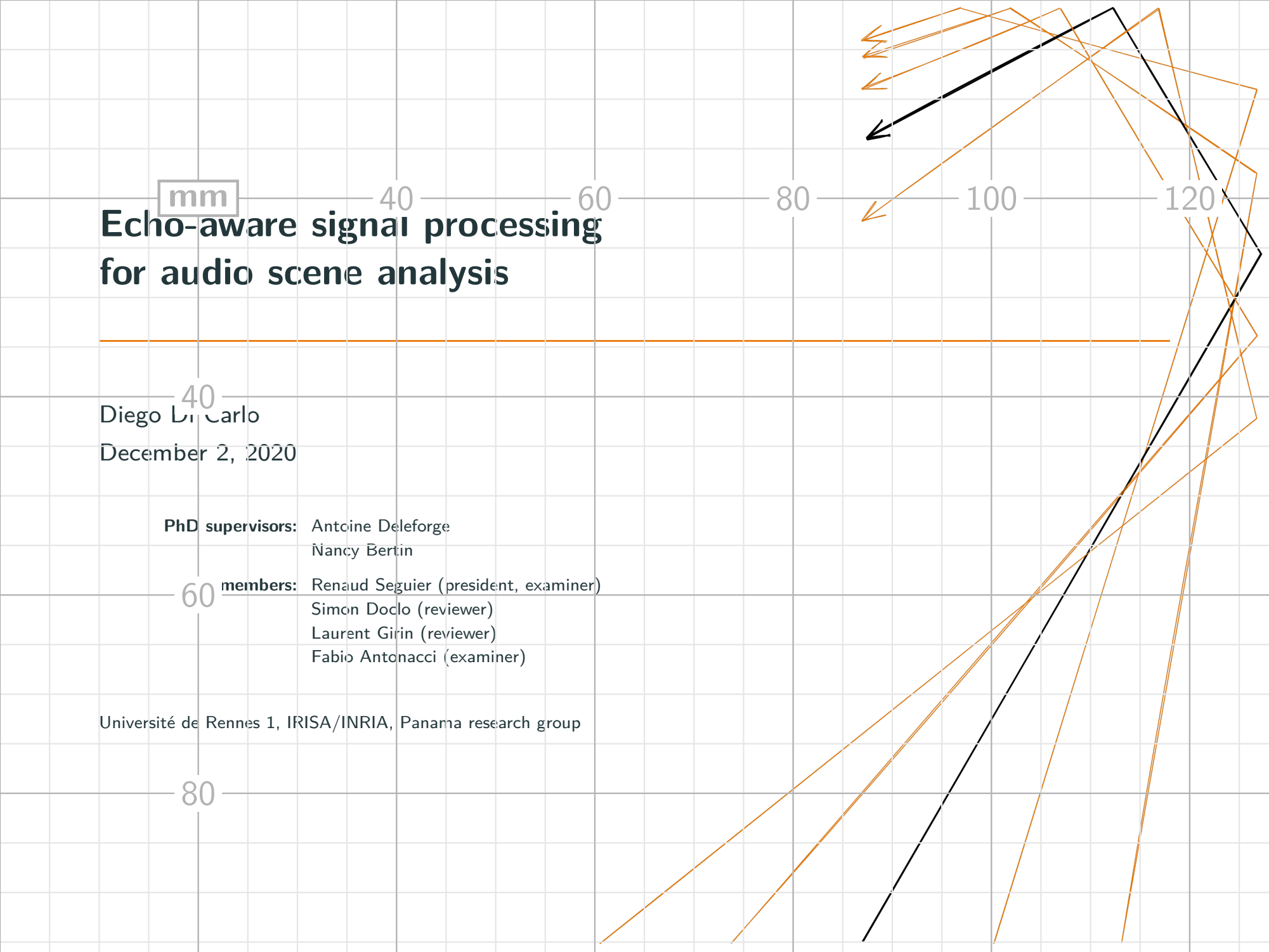


Echo-aware signal processing for audio scene analysis

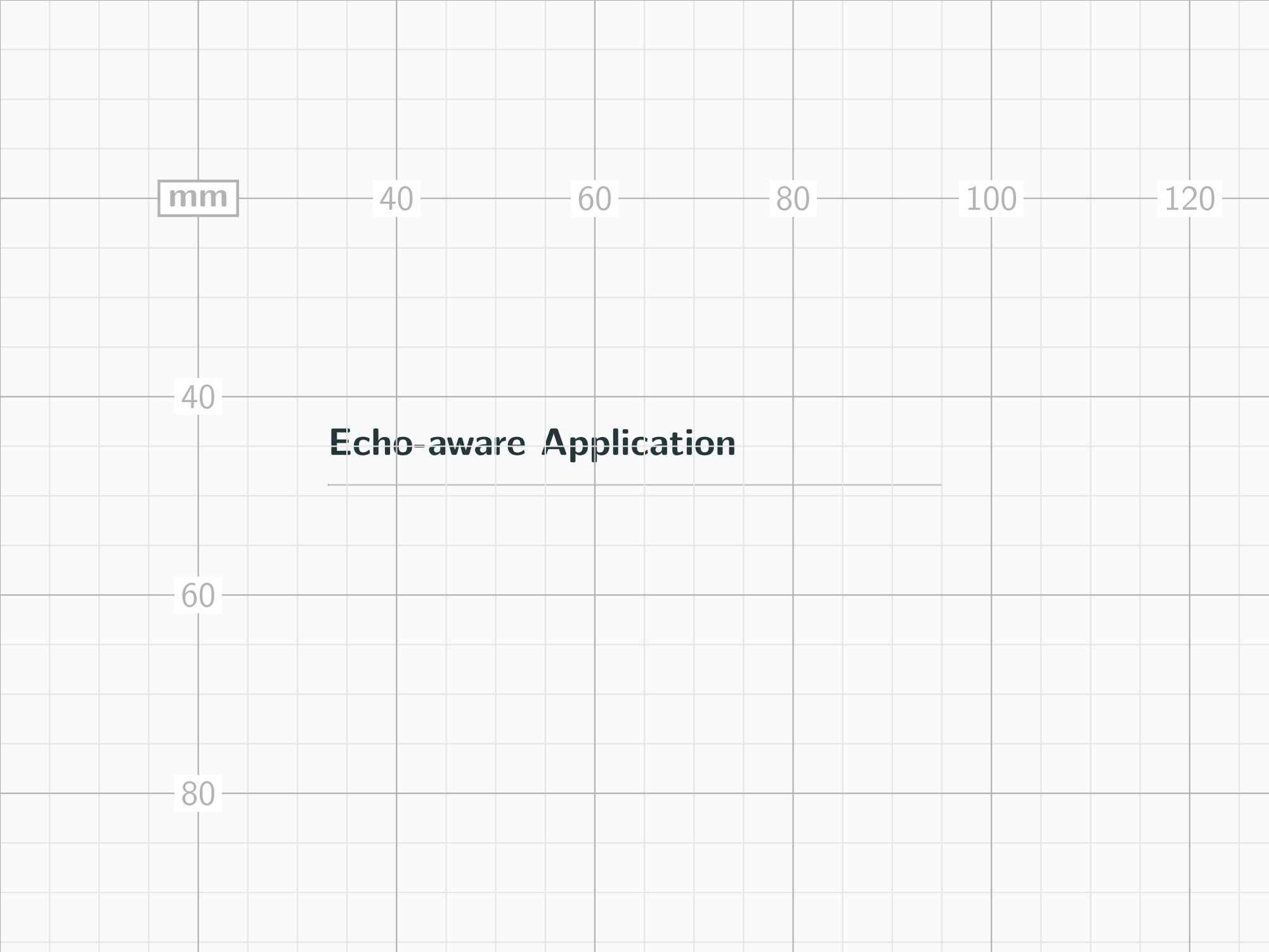
Diego Di Carlo

December 2, 2020

PhD supervisors: Antoine Deleforge
Nancy Bertin

members: Renaud Seguier (president, examiner)
Simon Doclo (reviewer)
Laurent Girin (reviewer)
Fabio Antonacci (examiner)

Université de Rennes 1, IRISA/INRIA, Panama research group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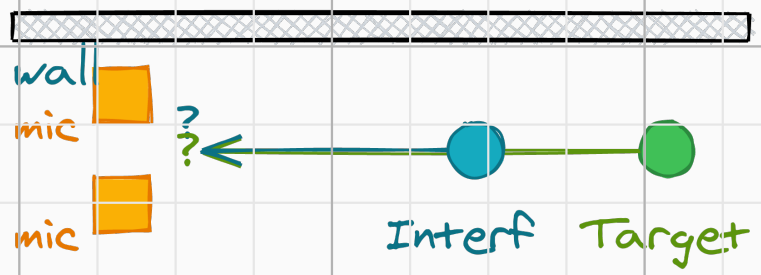
Echo-aware Application

Echo-aware Application

Echo mm **me conten** 40 **ifferent time** 60 **rection** 80 100 120

Image Source Model
⇔
Image Microphone Model

40



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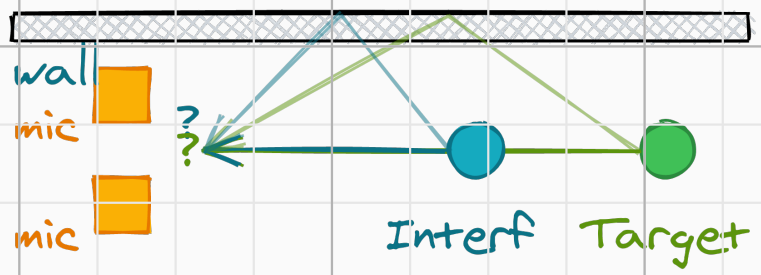

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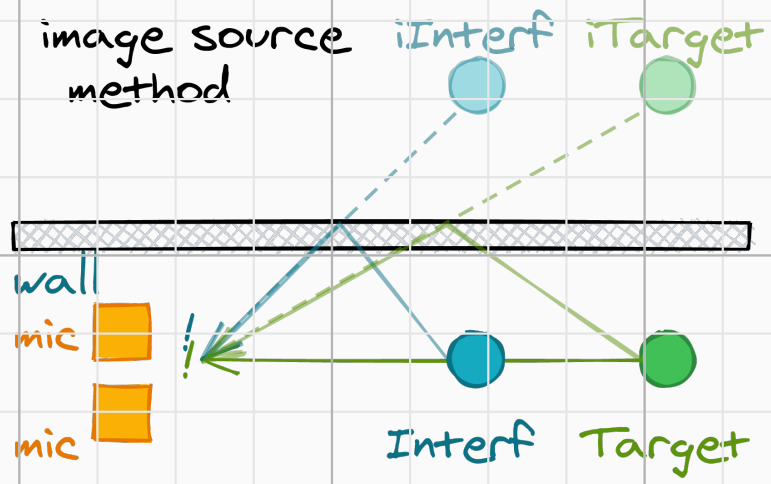

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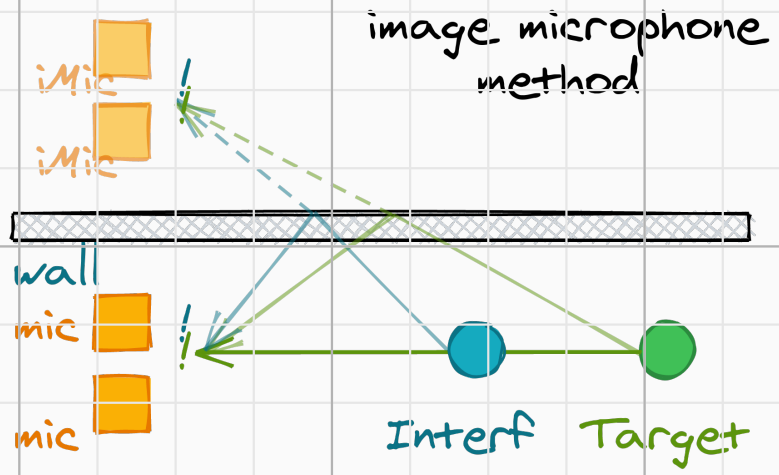

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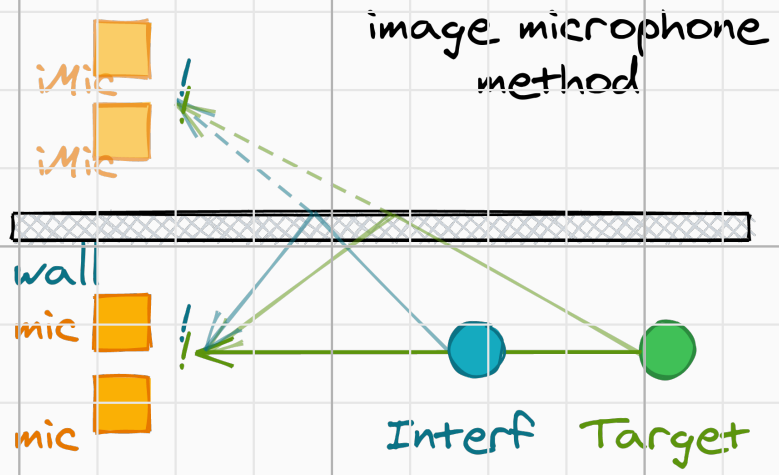

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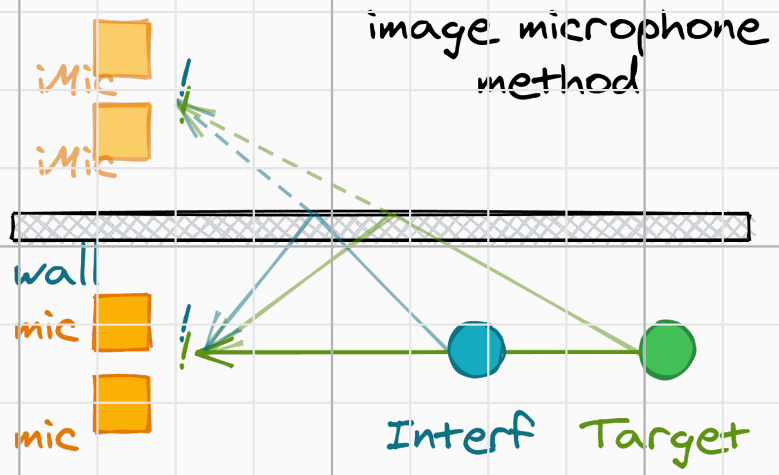

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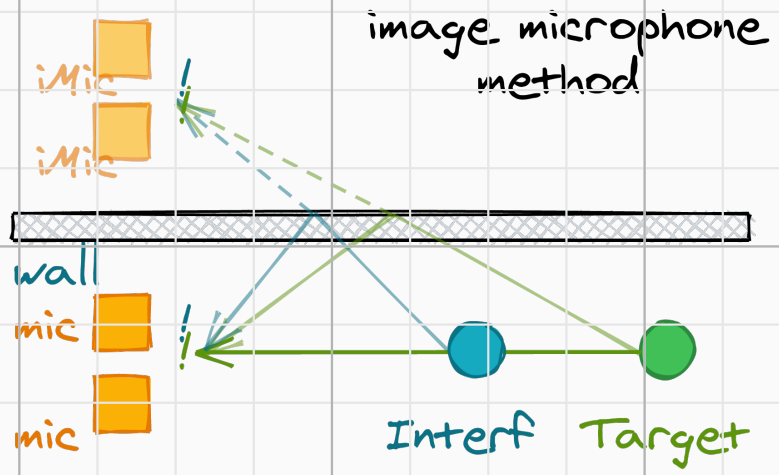

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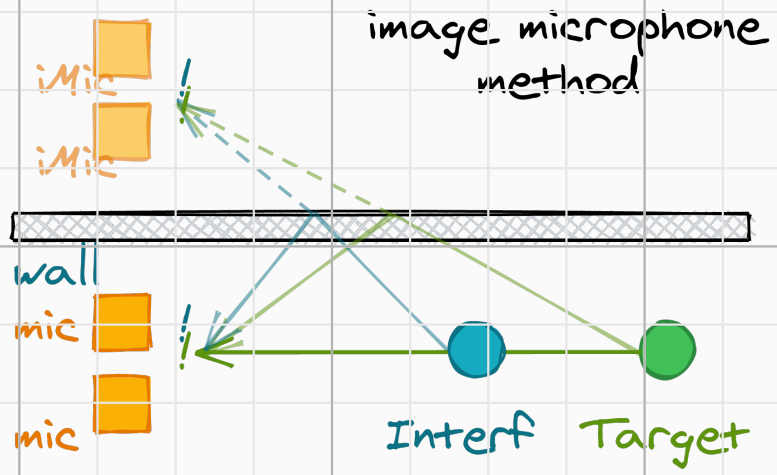

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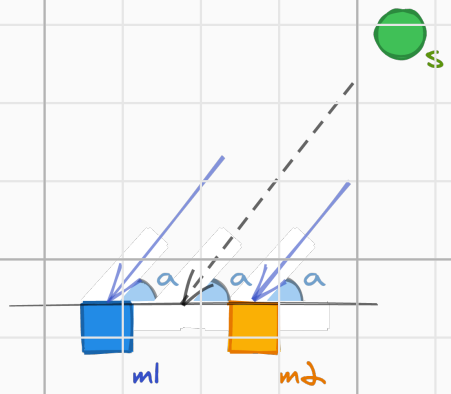
Sound Source Localization (SSL)

(common knowledge)

We consider here distance estimation.

SSL with 2 microphones

- Only one angle of arrival (AOA)
- can be approximated from TDOA using e.g. GCC-PHAT[1]
  (known limitation, but good in practice)



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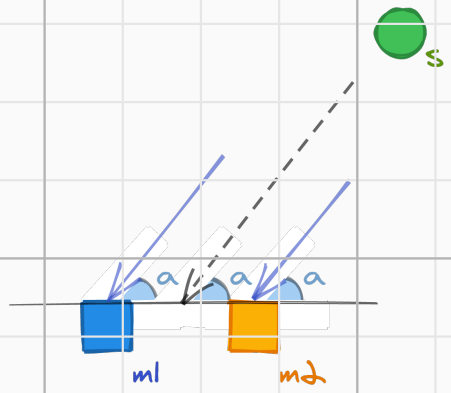
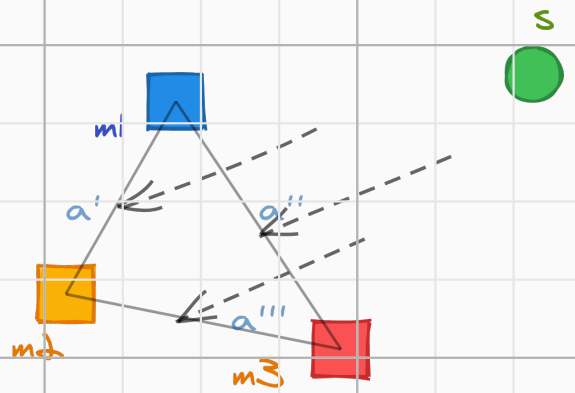


SSL with more microphones

- To get Direction of Arrival (DoA): azimuth (↔) and elevation (↕)

1. AOA for each pair can be "fused" together (e.g. angular spectra in SRP-PHAT[2])
   (known limitation, but good in practice)



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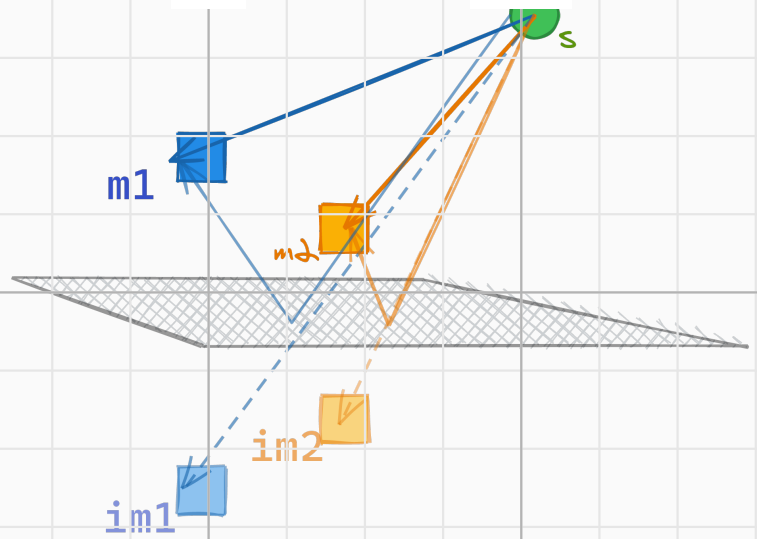
Sound Source Localization with Echoes

The Picnic Scenario:

- One source
- Two microphones

→ passive scenario

→ generalizable to any array geometry



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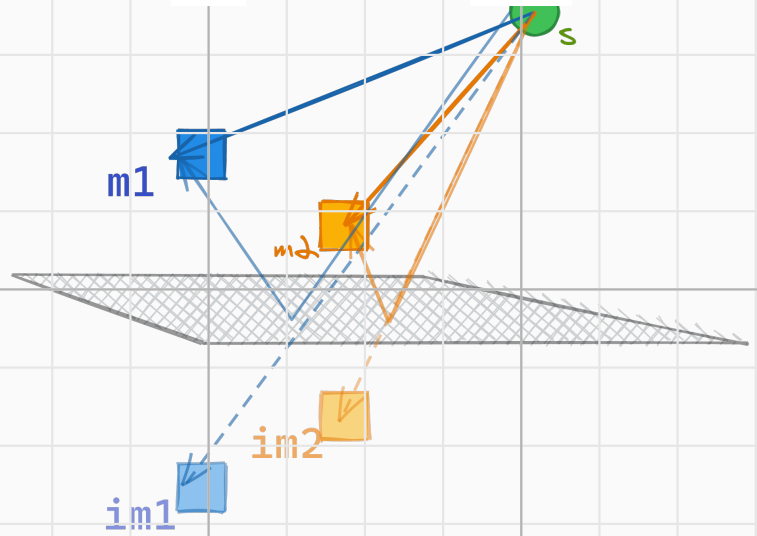

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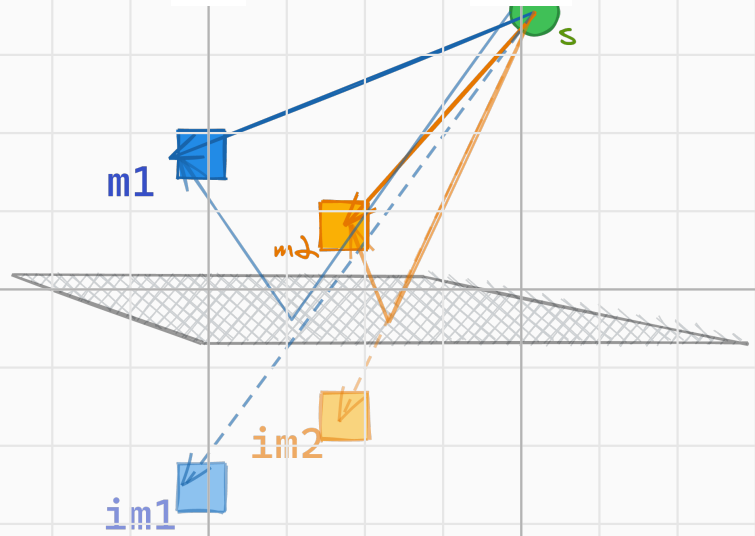
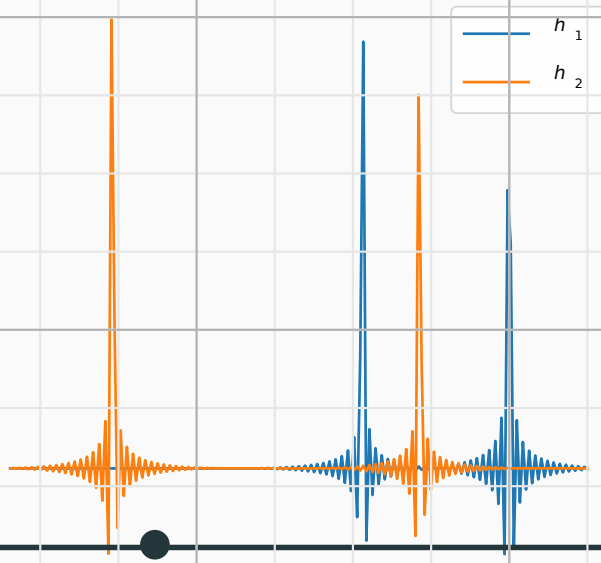


Each [illegible] is augmented with echoes

Mirage Array

(Microphone Array Augmetation with Echoes)

How t[illegible]ccess the *image* microphones?



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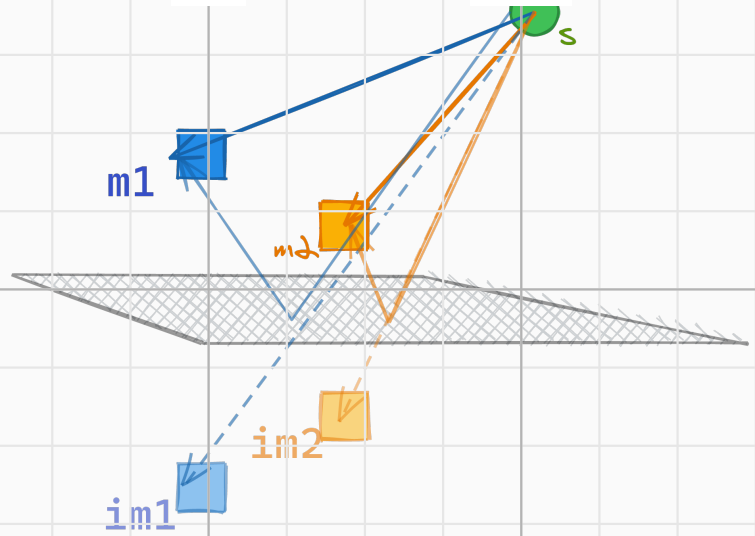

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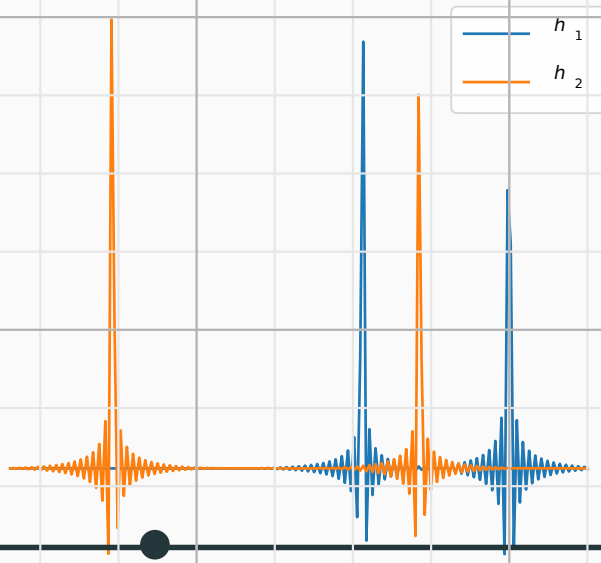

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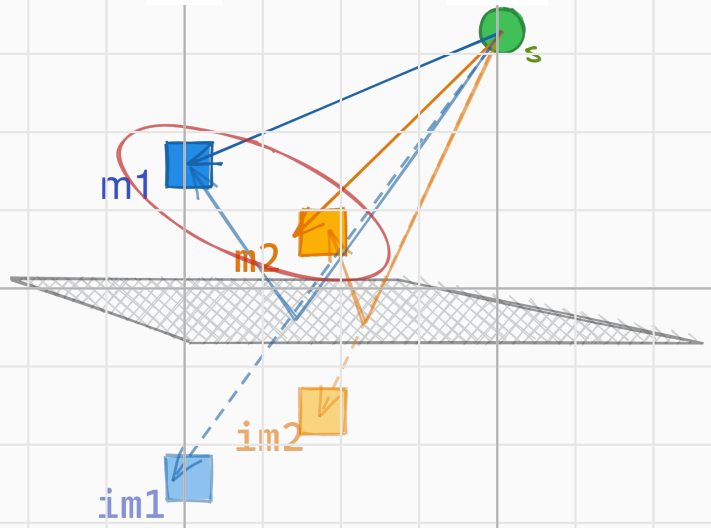

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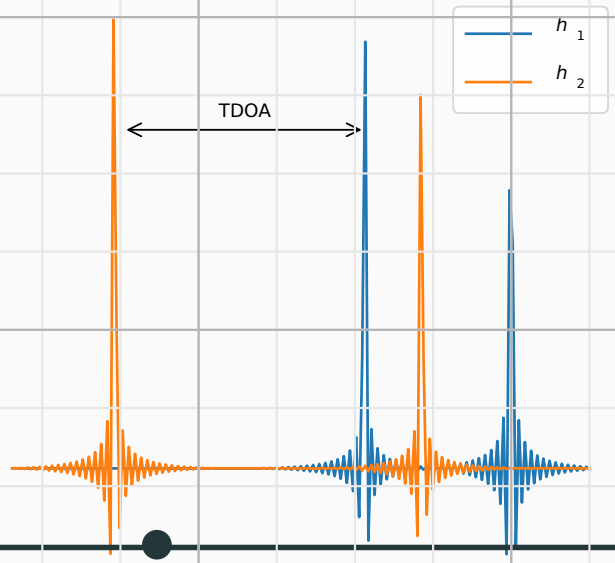

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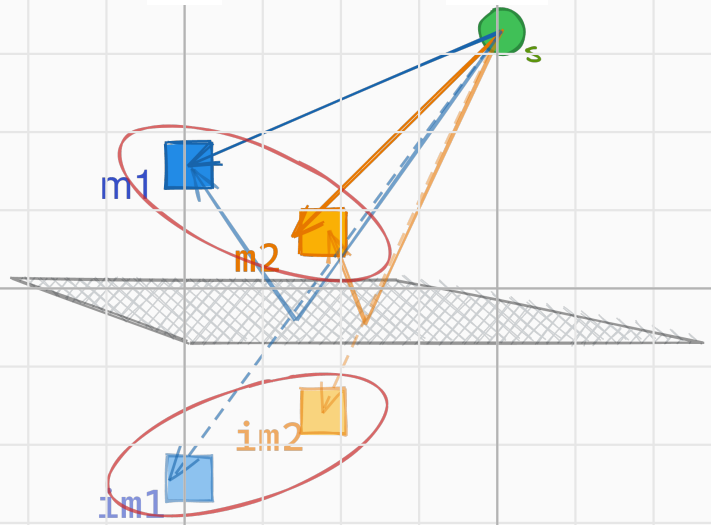

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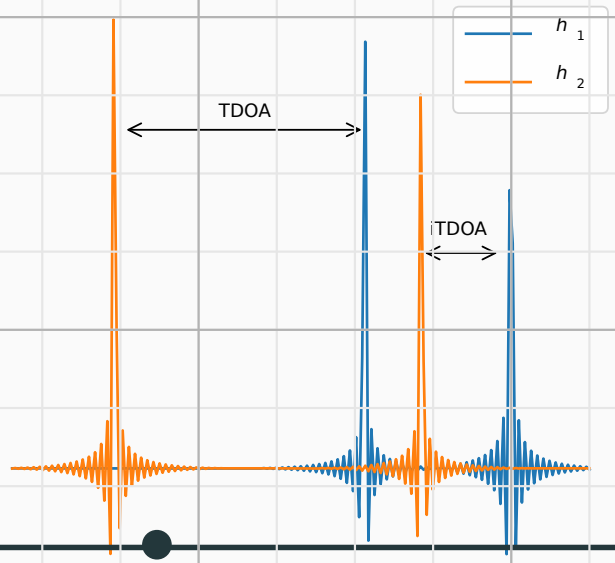

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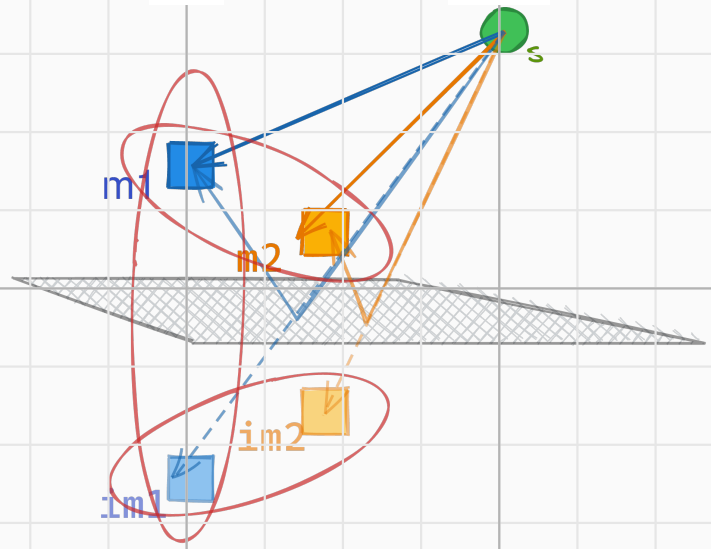

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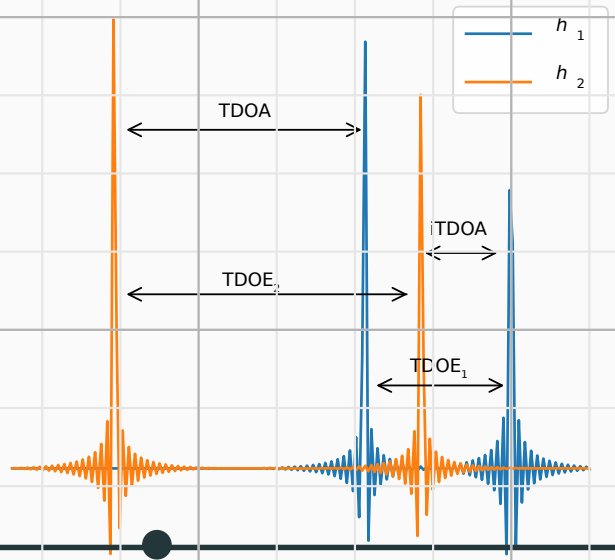
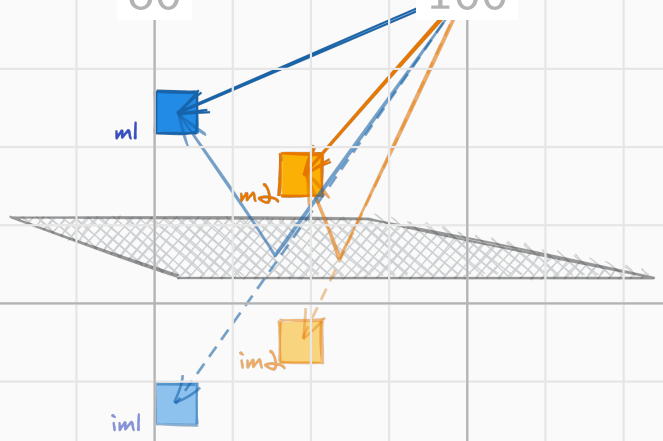


Sound Source Localization with Echoes

Idea: DoA estimate on the MIRAGE array.
Recall: these TDOAs are the same of the DNN-based method



Proposed Approach:

1. use proposed learning-based approach (`MLP`) for TDOAs estimation for each pair
2. fuse together the estimation ...
   - 2.1 use the error on a validation set as measure of uncertainty.
   - 2.2 DDDDDDOOOODOO DDOO BETTER HERE for each pair of the `Mirage` array (similar to SRP-PHAT[1]),
   - 2.3 knowing the position of the microphones,

Basel `GCC PHAT` on true microphones[2]

[2] [DiBiase et al., 2001]
[1] [Knapp and Carter, 1976]

Experimental results

Proposed: MLP with Mirage

Baseline: GCC PHAT[1]

Data: 200 synthetic stereophonic recordings for close-surface scenario

Metric: accuracy in % ($<10°$, $<20°$) (↩ also error in the manuscript)

AO	Input	ACCURACY $\alpha < 10°$	ACCURACY $\alpha < 20°$
Mirage	wn	77	97
GCC PHAT	wn	**81**	**97**

Observation

✓ comparable to baseline when white noise source in noiseless case

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Mirage	sp+n	17	12	38	43

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- ✗ not generalize to noisy and speech data
- ✓ Takled "impossible" localization

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- ✗ not generalize to noisy and speech data
- ✓ Takled "impossible" localization
- ⚠ Performance depending on echo estimation methods (work in progress)

References i

mm o, M., Truc 40 A., and Del 60 , A. (2017). 80 100 120
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