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SEISMIC DETECTION OF ELEPHANT FOOTSTEPS

Daniel Goderik, Albin Westlund, **Gustav Zetterqvist**,
Fredrik Gustafsson & Gustaf Hendeby

LINKÖPING UNIVERSITY

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BACKGROUND

- Human-Elephant conficts are a global problem

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- Harm to both people, property and crops

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- Harm to both people, property and crops
- Hundreds of casualties in India each year

BACKGROUND

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- Last year, proof of concept
- Now, focus on detection

SIGNAL MODEL

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$z_i^n(t)$: nth event for geophone i

$e_i(t)$: ambient noise

EVENT DETECTION

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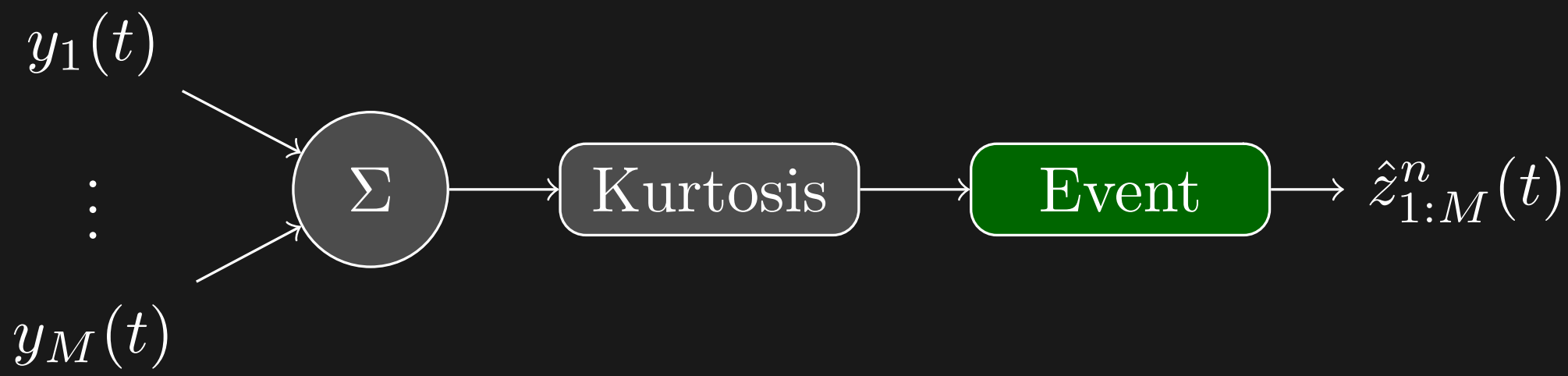
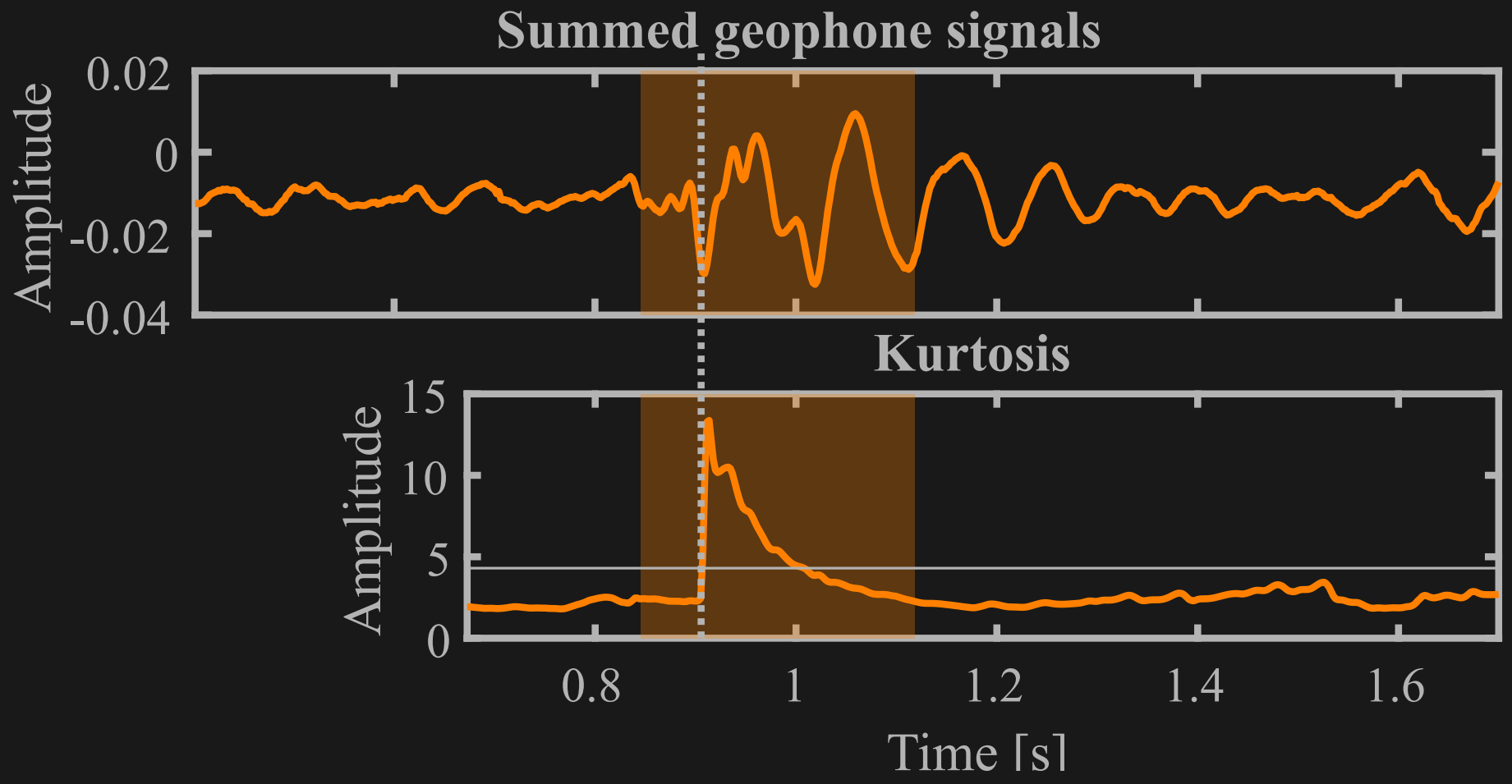
- $$Q[k] = \frac{\frac{\sum_{l=k-N+1}^{k} (\bar{y}[l] - \mu[k])^4}{N}}{\left(\frac{\sum_{l=k-N+1}^{k} (\bar{y}[l] - \mu[k])^2}{N} \right)^2}$$

- $$Q[k] > T \rightarrow \text{Event}$$

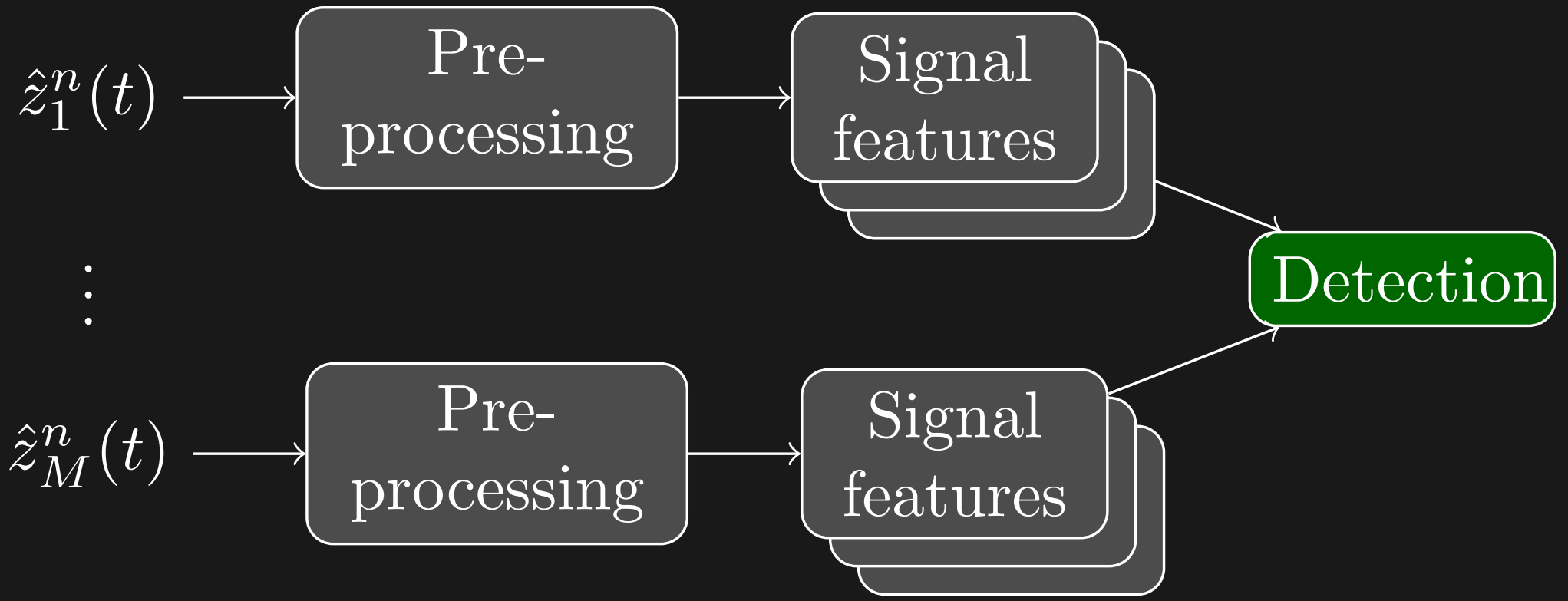
EVENT DETECTION



EVENT DETECTION



ELEPHANT FOOTSTEP DETECTION



PRE-PROCESSING

- Bandpass filter between 4 and 45 Hz
- Normalization

SIGNAL FEATURES

- Standard deviation
- Frequency peak
- Spectral centroid
- Frequency distribution

DIRECTION OF ARRIVAL ESTIMATION

$$\text{Signal model}: z_i[k] = s\left[k - \tau_i\left(\phi[k]\right)\right] + e_i[k]$$

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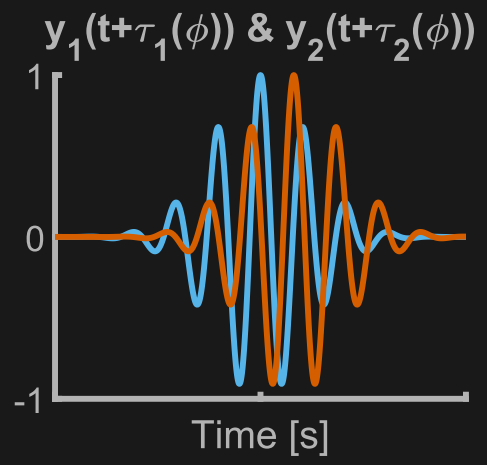
Delay-and-Sum Beamformer:

$$\hat{\phi}[k] = \arg\max_{\phi} \sum_{k=1}^{N} \left| \frac{1}{M} \sum_{i=1}^{M} z_i[k + \tau_i(\phi)] \right|^2$$

DIRECTION OF ARRIVAL ESTIMATION



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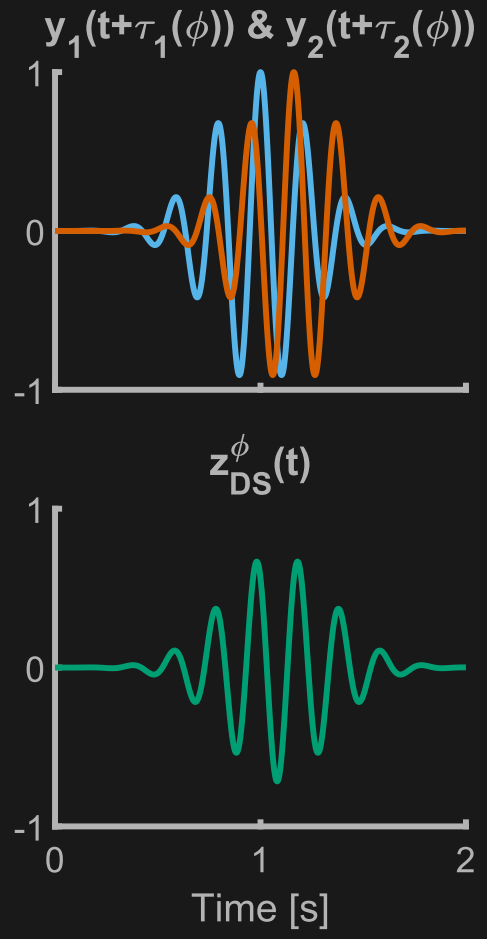

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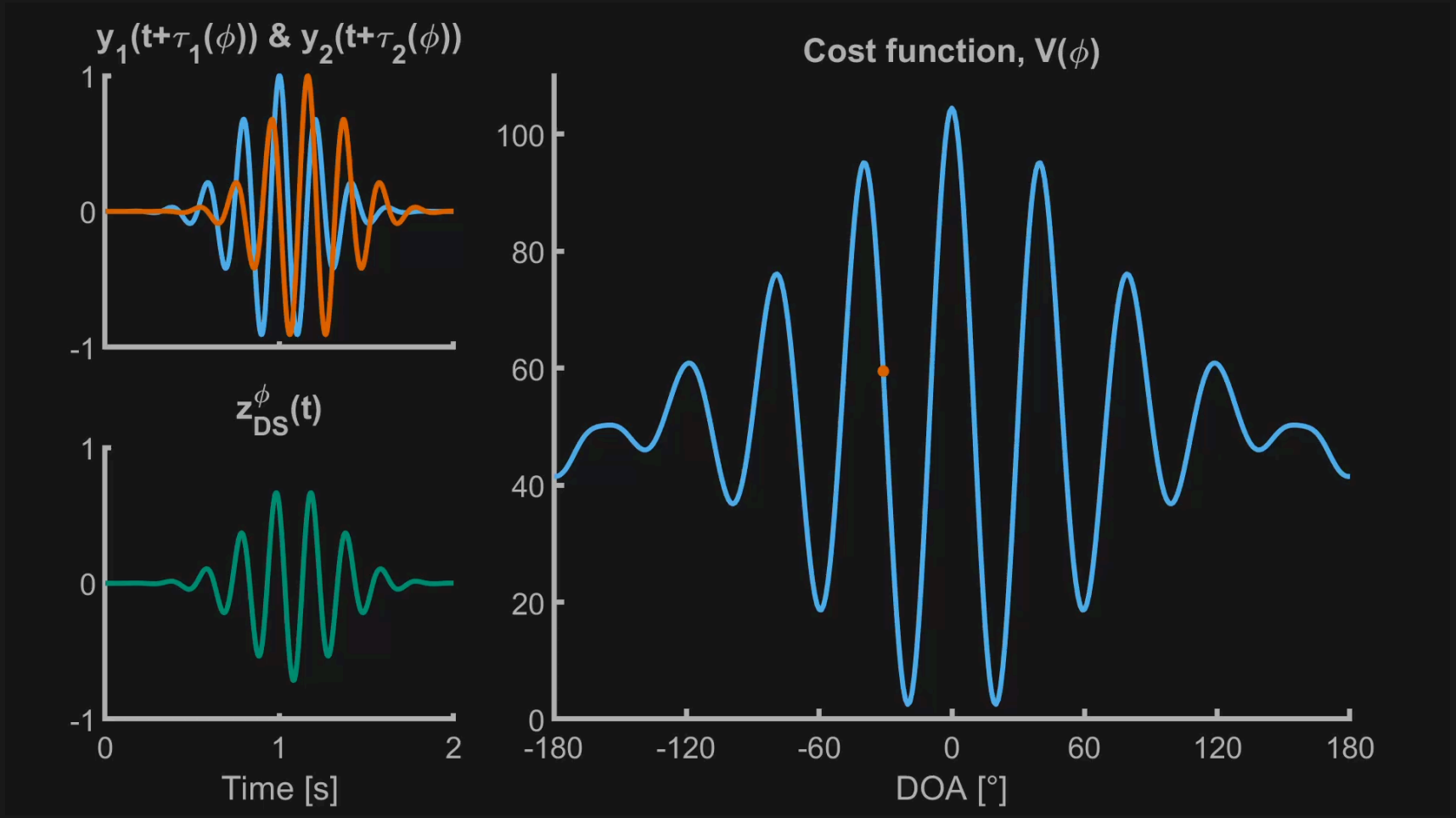
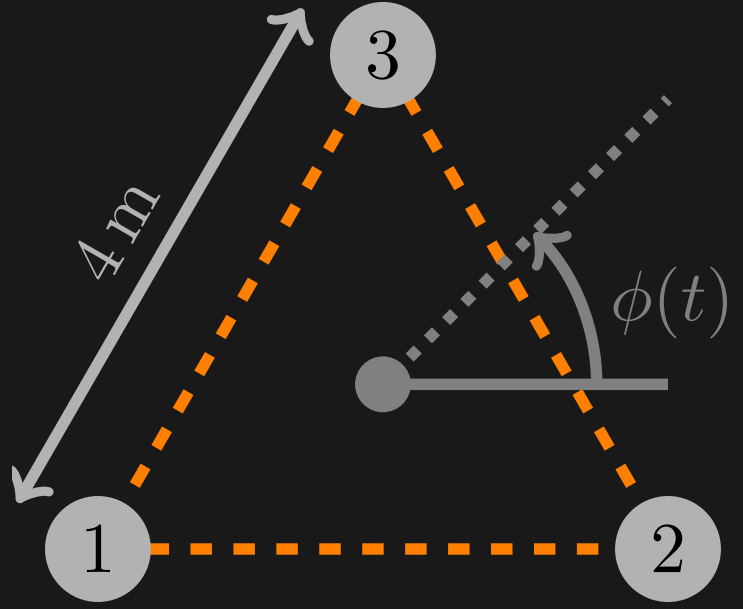


EXPERIMENTAL SETUP

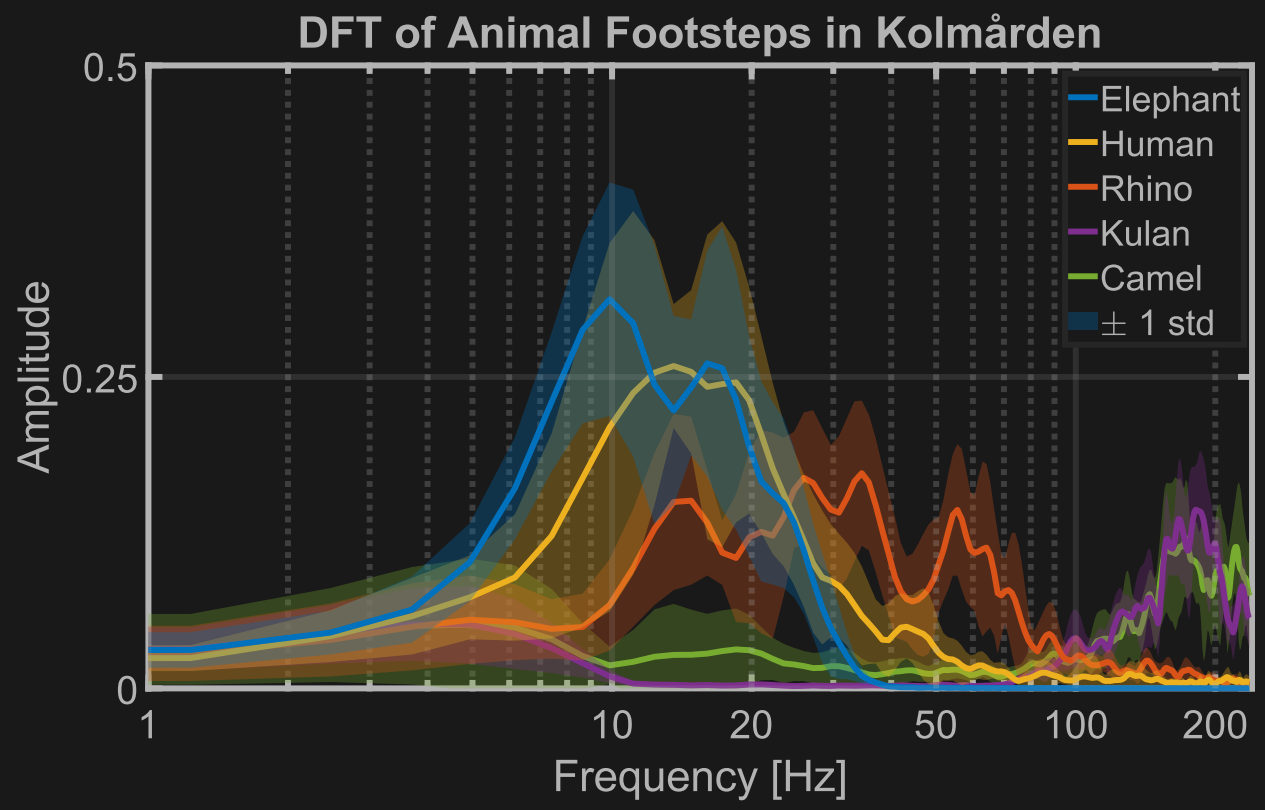


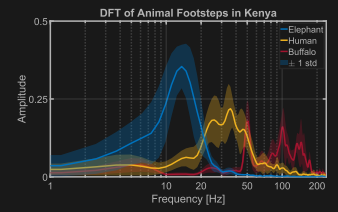
EXPERIMENTAL SETUP

DATA COLLECTION

Animal	Kolmården	Kenya
Elephant	Asian	African
Human	✓	✓
Rihno	✓	-
Kulan	✓	-
Camel	✓	-
Buffalo	-	✓

SIGNAL FREQUENCY





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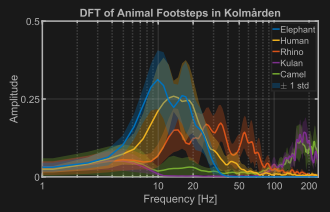

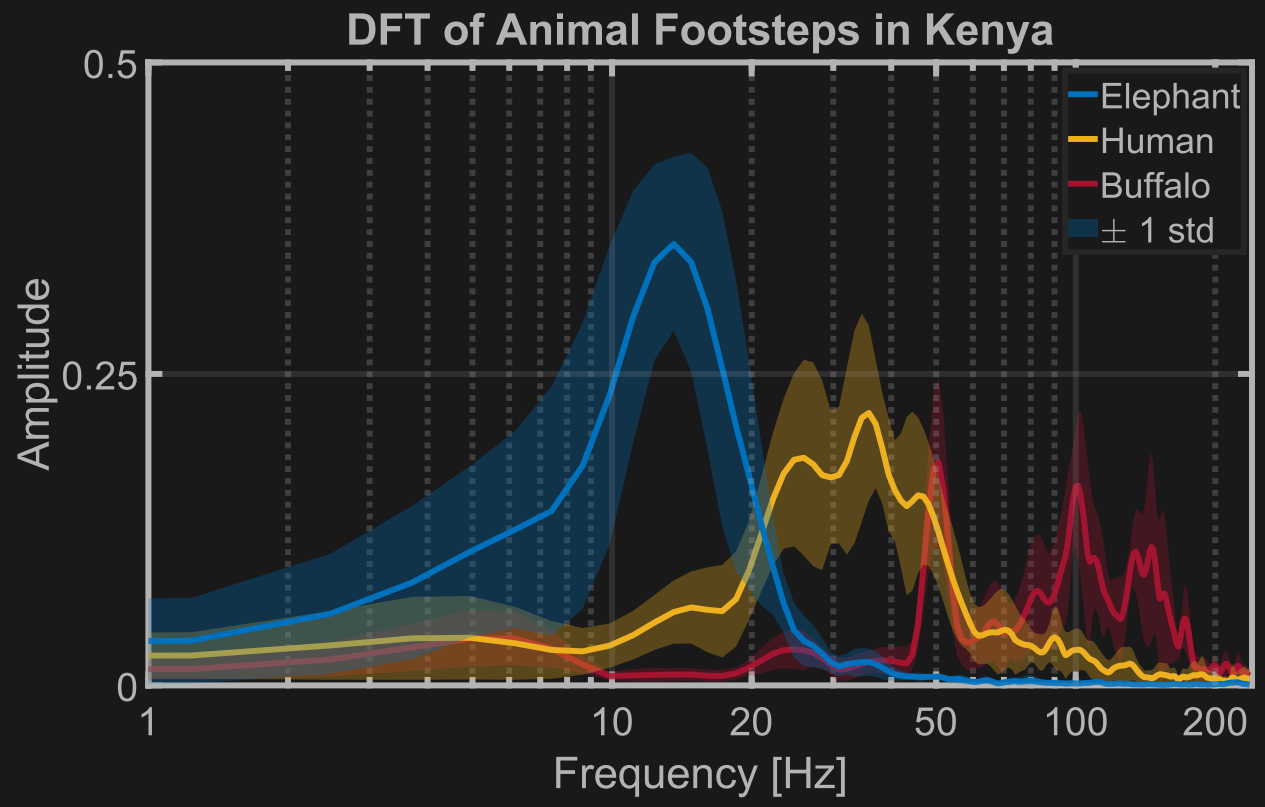

SIGNAL FEATURES

	Kolmården	
Feature	**Mean**	**σ**
Standard Deviation	0.08821	6.5e-4
Frequency peak	13.2	3.72
Spectral Centroid	19.1	3.62
Frequency Ratio	603.1	478.9

SIGNAL FEATURES

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Feature	**Mean**	**σ**	**Mean**	**σ**
Standard Deviation	0.08821	6.5e-4	0.08812	9.3e-4
Frequency peak	13.2	3.72	12.9	3.15
Spectral Centroid	19.1	3.62	18.3	3.53
Frequency Ratio	603.1	478.9	48.1	27.4

DETECTION RESULTS

- **Accuracy**: Proportion of correct predictions

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- **F1 score**: Harmonic mean of precision and recall

DETECTION RESULTS

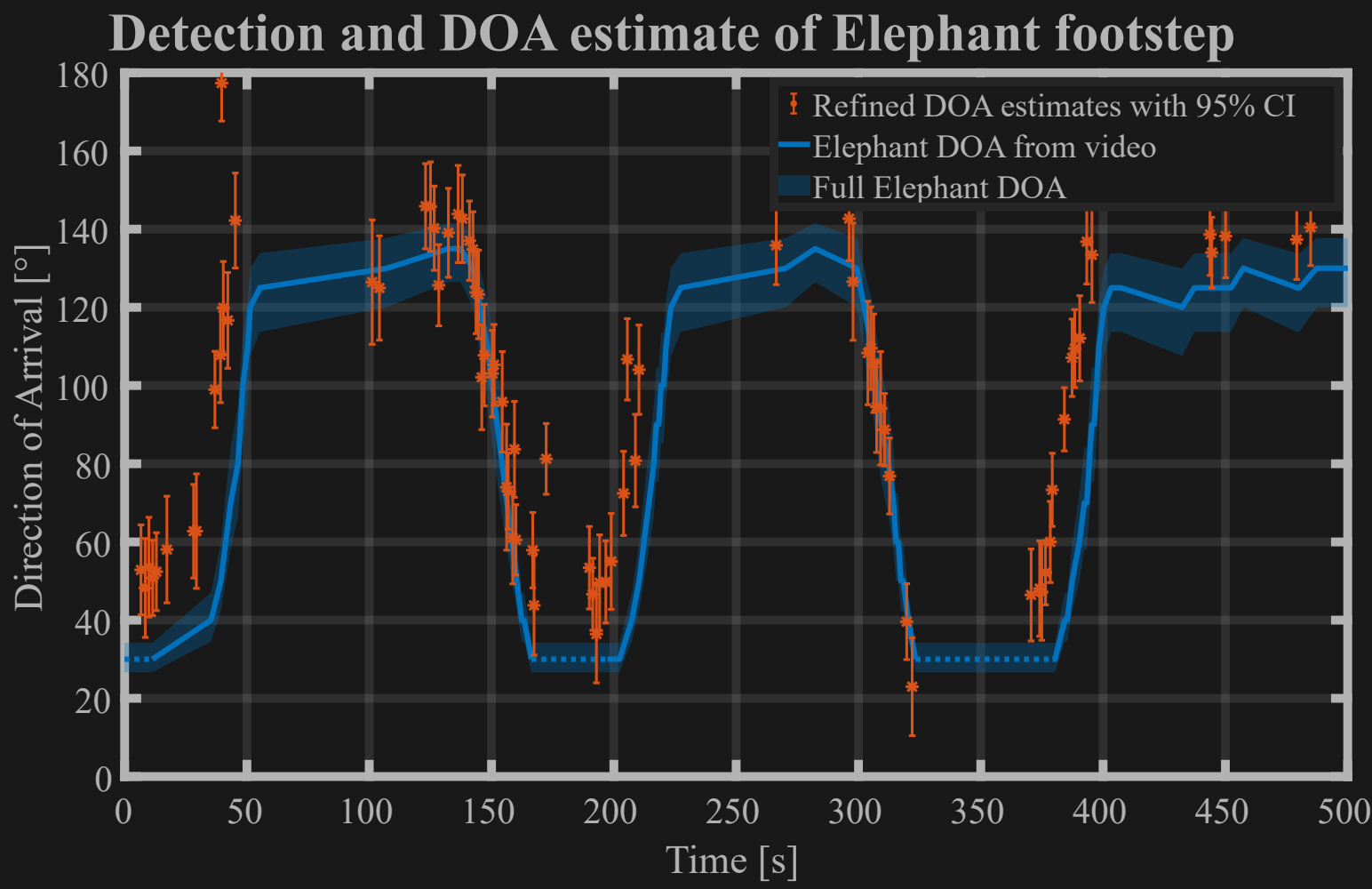
Evaluation scores from Kolmården Wildlife Park.

±σ(s)	Accuracy	Recall	Precision	F1 score
1	0.86	0.30	**1**	0.46
1.5	**0.89**	0.54	0.89	0.67
2	**0.89**	**0.61**	0.81	**0.7**

COMPARISON

	Proposed algorithm				Last year			
Animal	**TP**	**TN**	**FP**	**FN**	**TP**	**TN**	**FP**	**FN**
Elephant	8	0	1	2	10	0	8	0
Human	0	10	0	0	0	9	1	0
Rhino	0	10	0	0	0	9	1	0
Camel	0	10	0	0	0	10	0	0
Kulan	0	10	0	0	0	10	0	0
Total	8	**40**	**1**	2	**10**	38	10	**0**

DOA RESULTS


Detection and DOA estimate of Elephant footstep
Refined DOA estimates with 95% CI
Elephant DOA from video
Full Elephant DOA
Direction of Arrival [°]
Time [s]
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
400
450
500

CONCLUSIONS

- Proposed algorithm reduces false alarms

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- High accuracy for elephant detection

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- Proposed algorithm reduces false alarms
- High accuracy for elephant detection
- Direction of arrival estimation is accurate

QUESTIONS?

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