NeuSOS: Neural Enhanced Underwater SOS Detection

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Drowning Incidents are a Pressing Public Safety Concern

Boy, 8, drowns in public pool in China despite other swimmers metres away

He struggled for around a minute before sinking to the bottom of the pool.

Ashley Tan | Aug

LOCAL NEWS ›

2 young brothers drown in pool in Roseville, police say

BY RICHARD RAMOS
OCTOBER 9, 2023 / 4:33

Hong Kong / Law and Crime

Hong Kong police investigate after girl drowns in swimming pool of upmarket Harbourside residential building

- Staff call police after two girls, both aged under 10, found unconscious while swimming in clubhouse
- In separate incident, woman in her 40s certified dead at scene after body found floating in reservoir

Christy Leung + FOLLOW
Published: 8:24pm, 28 May, 2022

Why you can trust SCMP

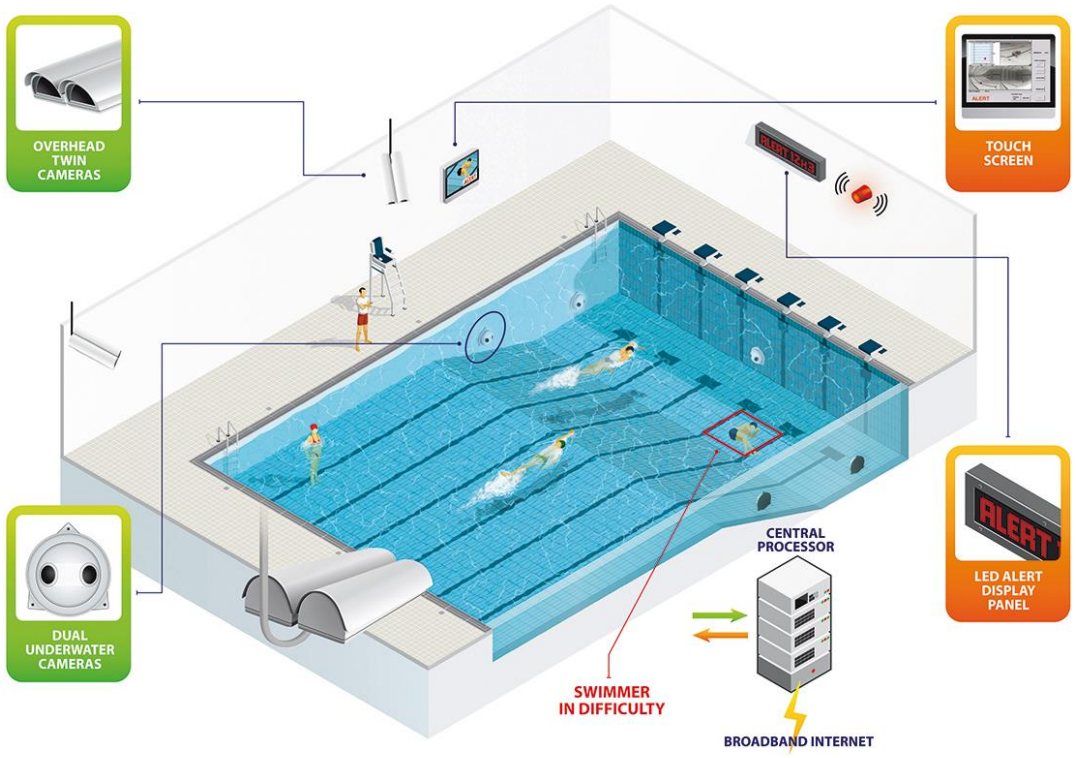
What We Imagine about Drowning

The swimmer will splash and yell for help

In Reality…

Drowning is silent and fast

Existing Vision-based Drowning Monitoring Systems



- Already suffocate
- Cannot call for help actively

Triggering an alert when the swimmer keeps motionless at the bottom for 10 seconds

Poseidon - Drowning detection system for swimming pools. https://poseidon-tech.com/en-GB/technology-2/.

AquaHelper: SOS Transmission with Wearable Devices

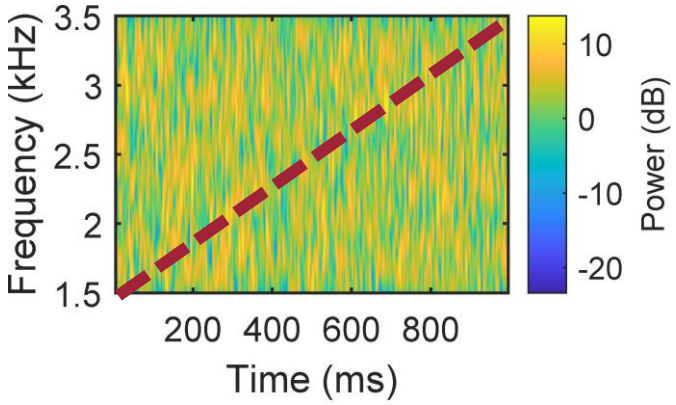
One-button SOS transmission

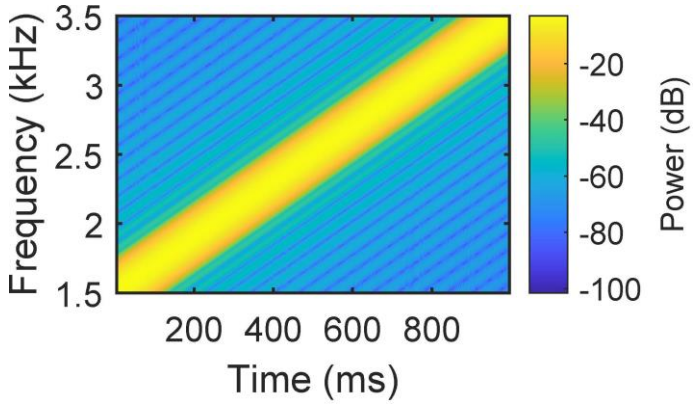
[**SenSys'23**] Yang, Qiang, and Yuanqing Zheng. "***AquaHelper: Underwater sos transmission and detection in swimming pools***." Proceedings of the 21st ACM Conference on Embedded Networked Sensor Systems. 2023.

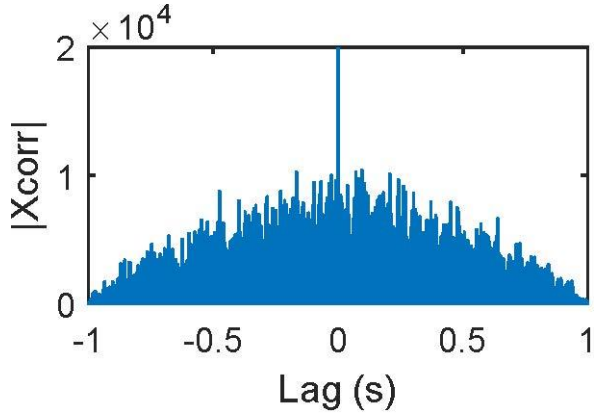
SOS Transmission and Detection: Acoustic Chirps

- Frequency band: 1.5~3.5 kHz, duration: 1s

Received chirp

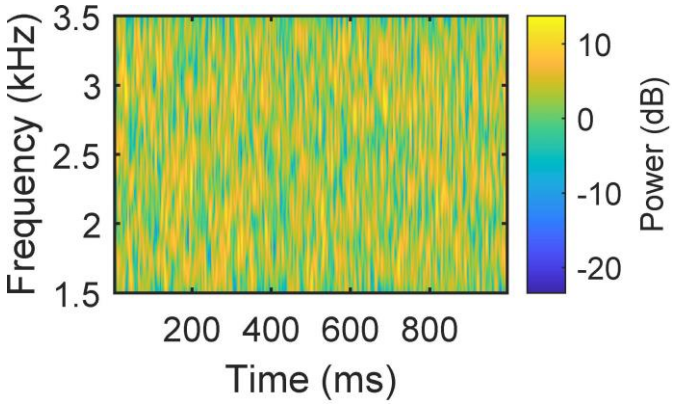


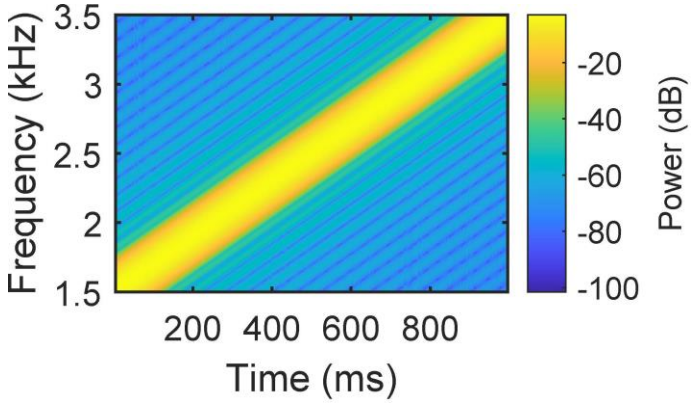


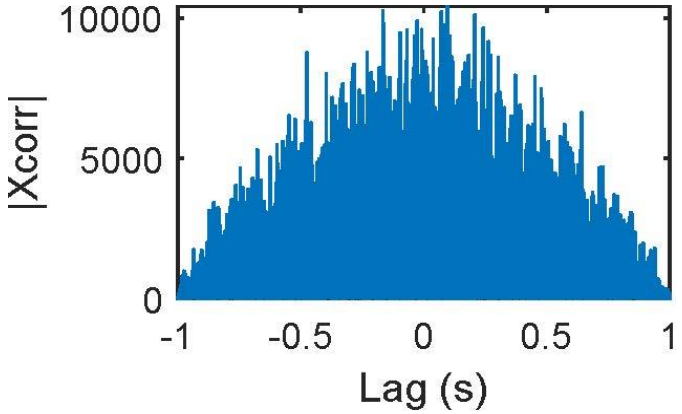


xcorr

Clear chirp



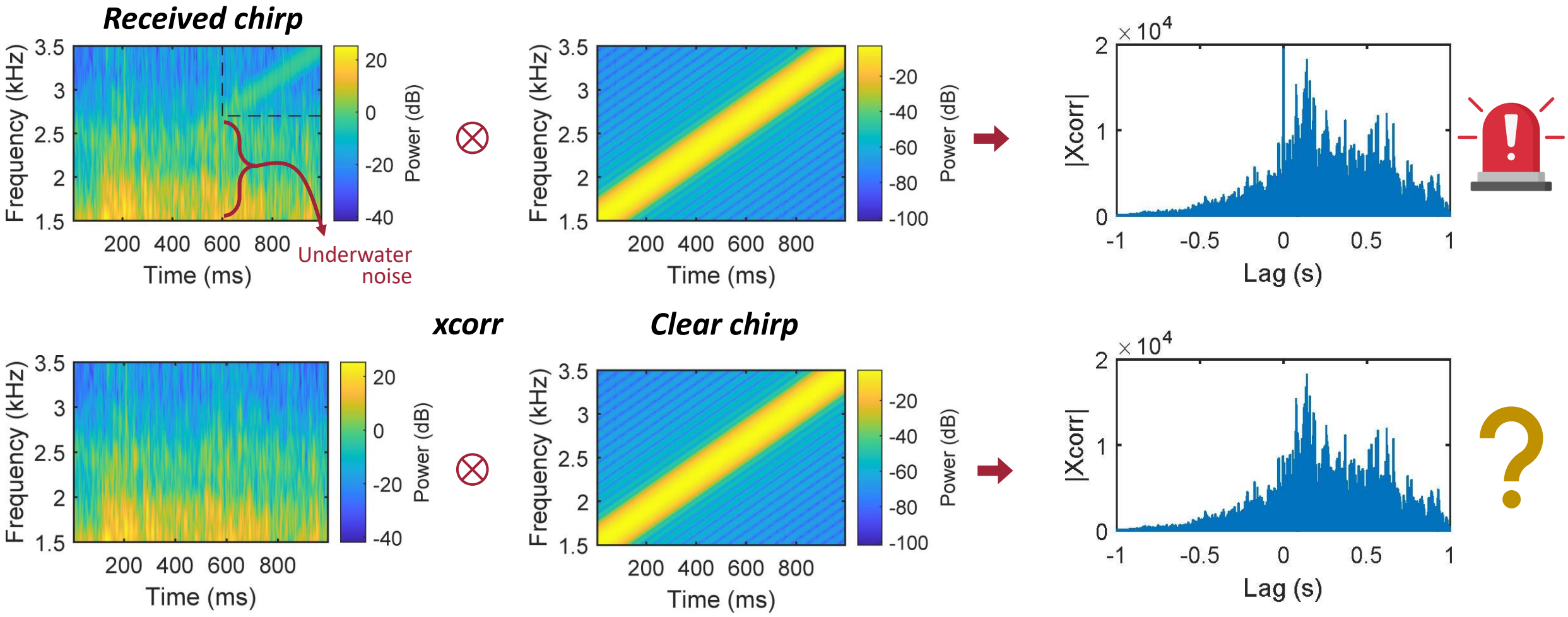




Gaussian noise

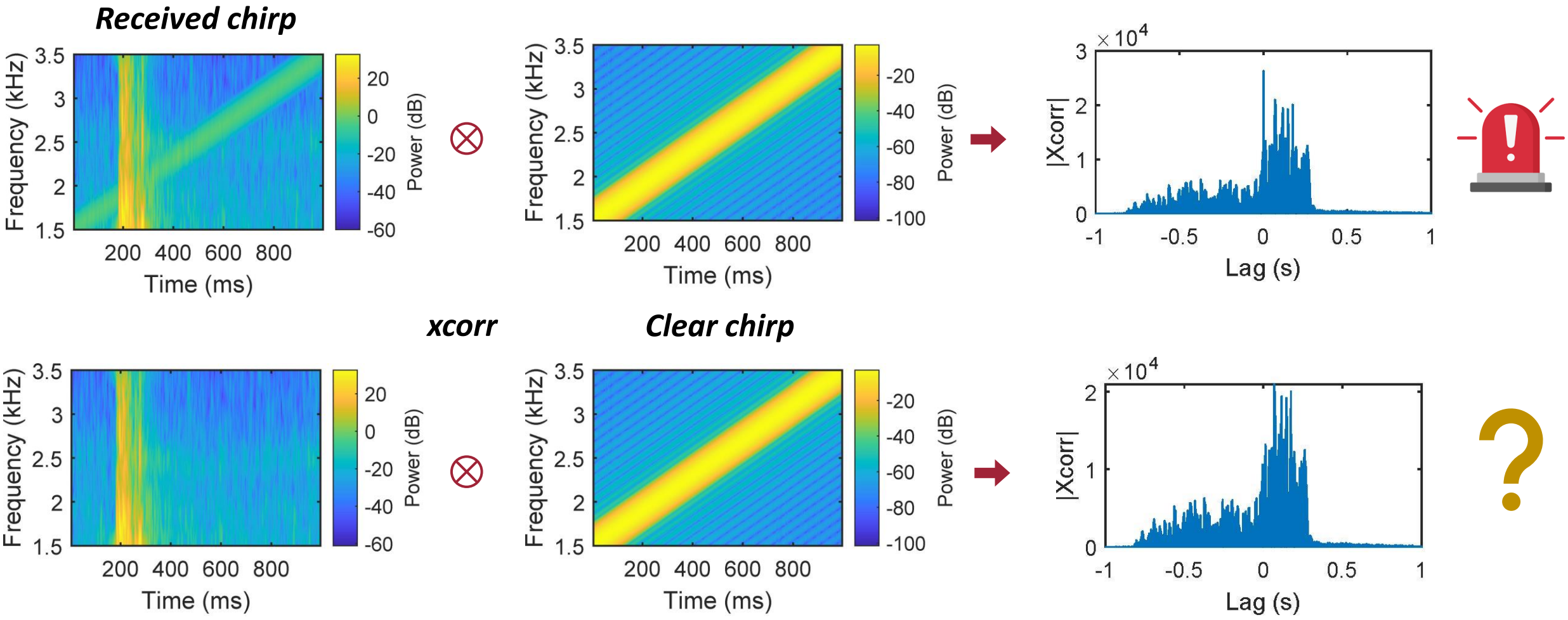
Challenge: Unbalanced Noise Distribution

- Most underwater noise is below 2.5 kHz



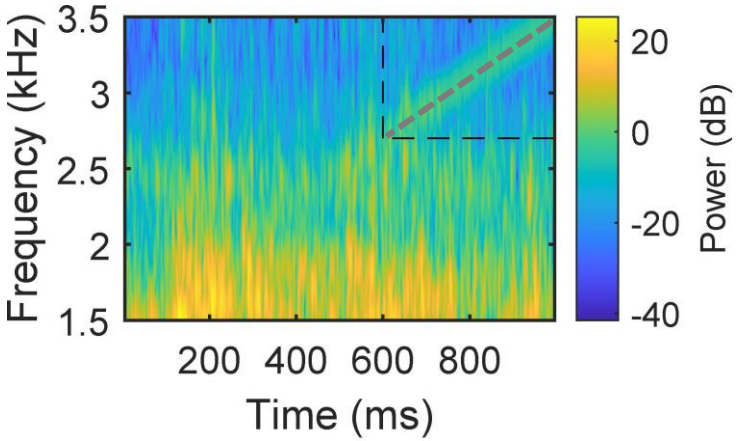
Challenge: Bursting Noise

- Powerful noise from water pumps and splashing

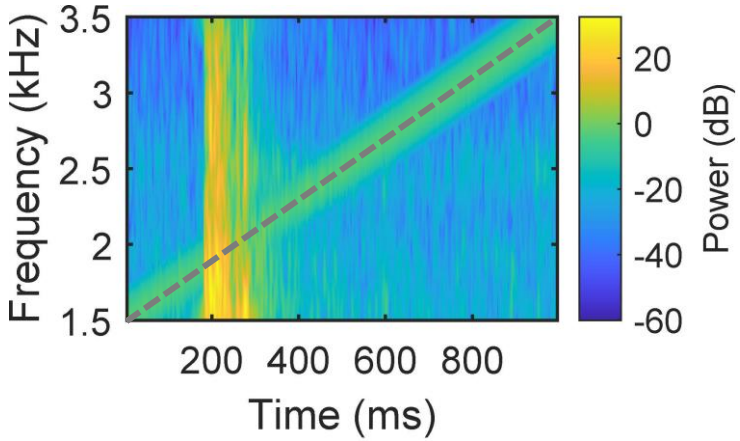


NeuSOS: SOS Detection with Deep Learning

- Opportunity: the (partial) chirp signal can be observed in the spectrogram!



Underwater noise

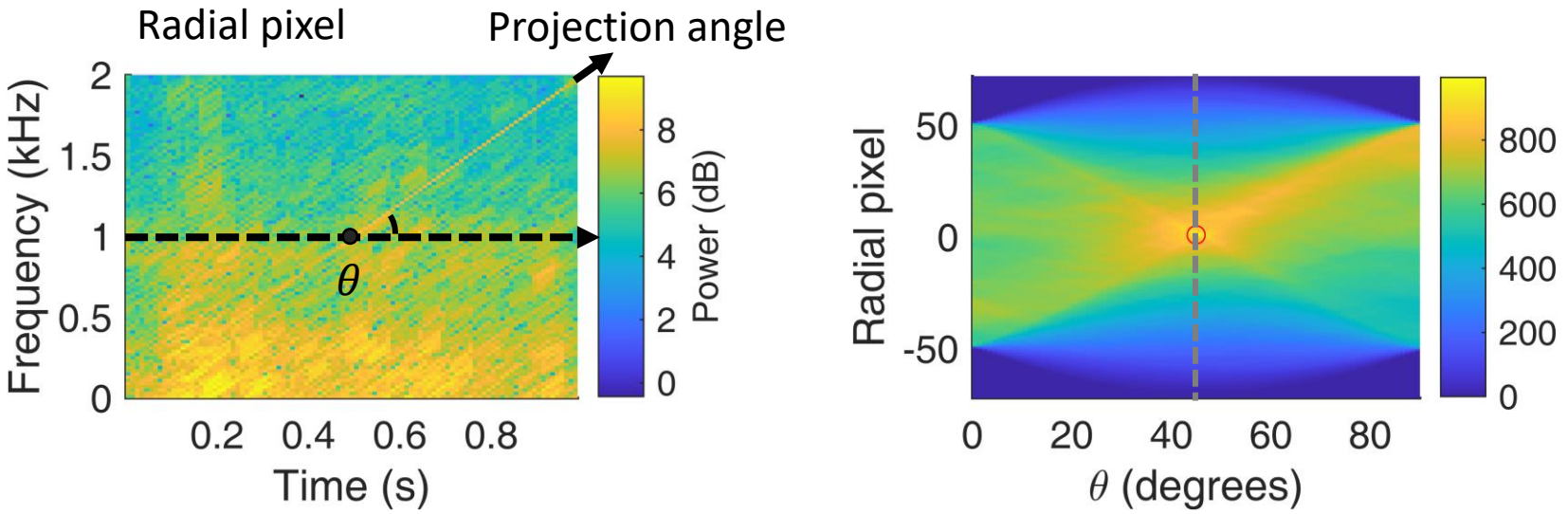


Bursting noise

Using deep learning to examine the unique chirp track in the image

Physics-informed Deep Learning

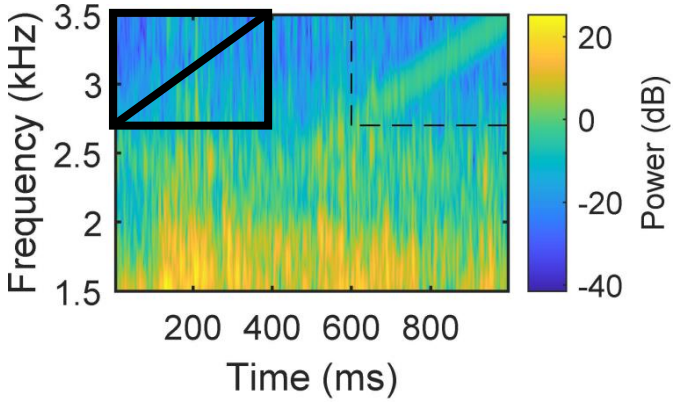
- Explicitly enhancing and detecting the chirp pattern



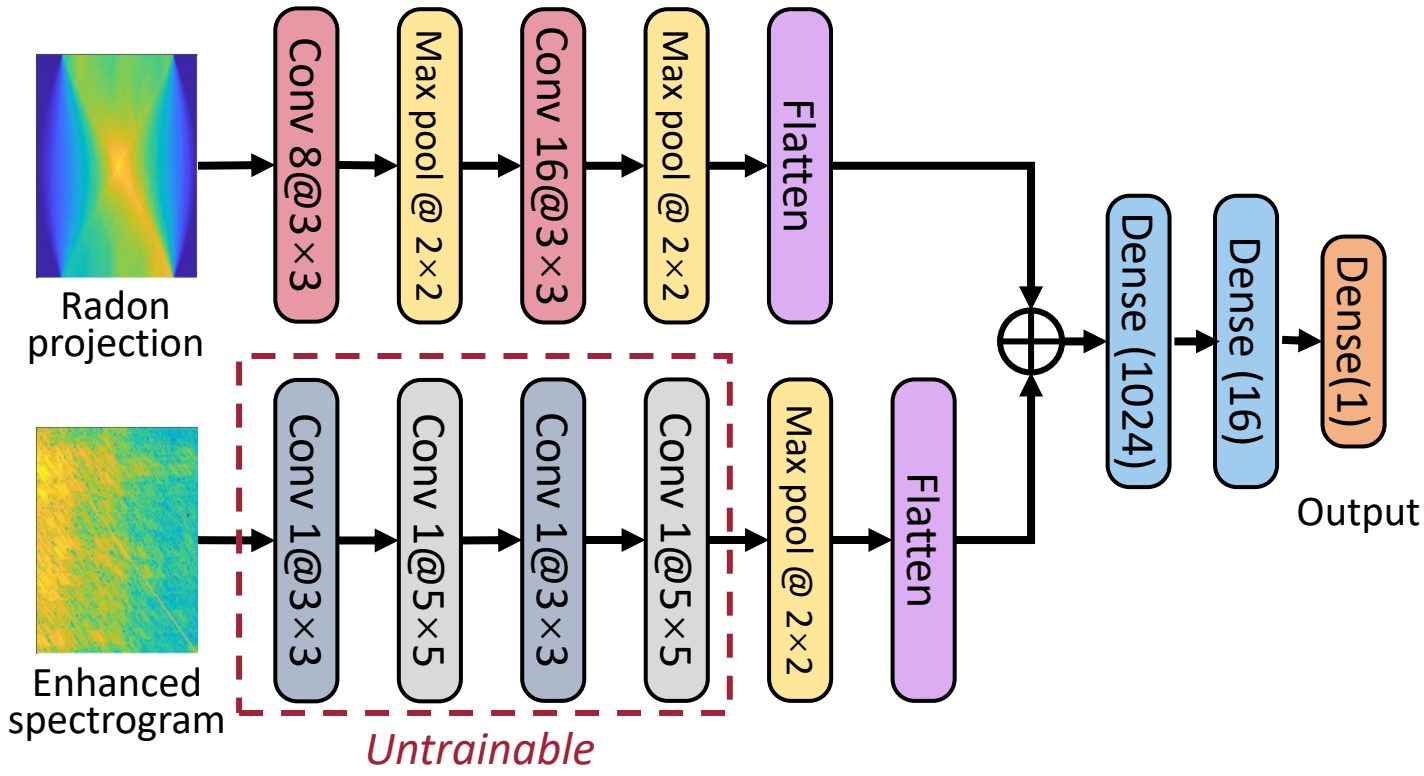
Radon transform: projecting the spectrogram to a specific angle

Physics-informed Deep Learning

- Deep learning as a signal denoiser and enhancer



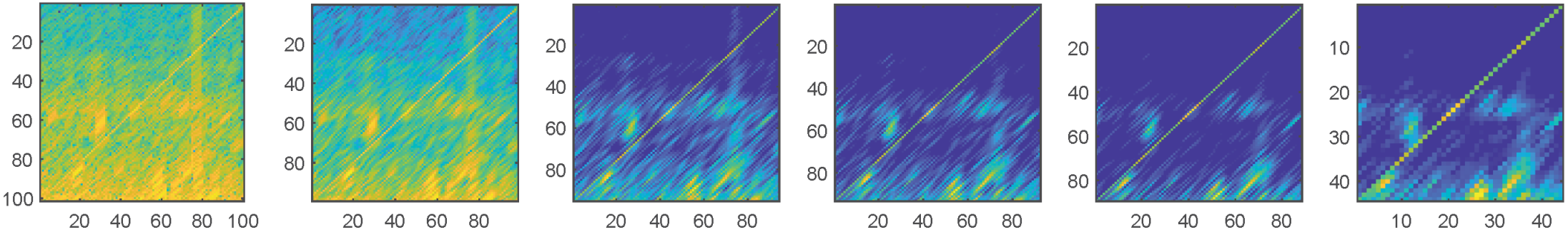
Signal-aware kernel design



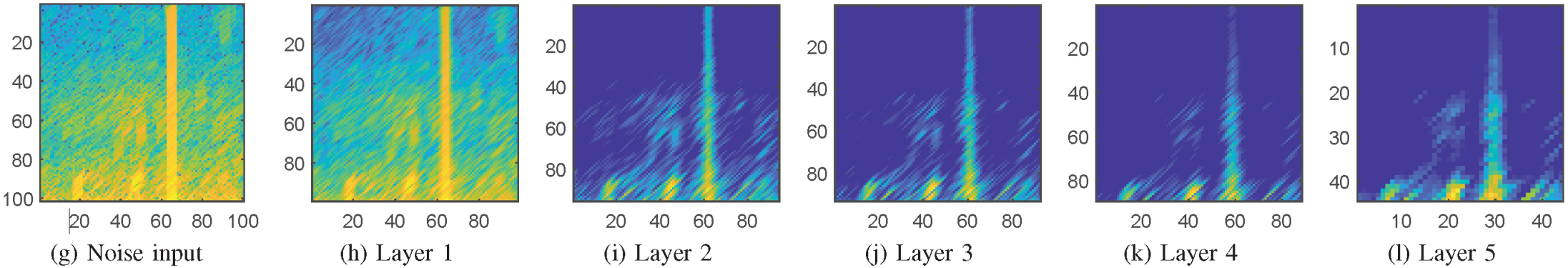
Physics-informed Deep Learning

- Deep learning as a signal signal denoiser and enhancer

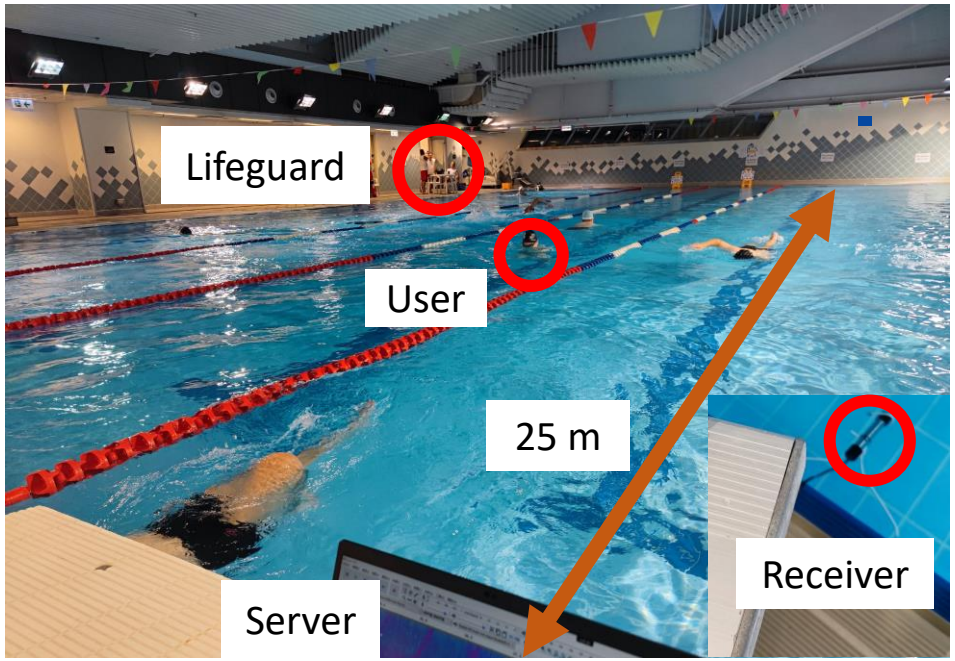
SOS

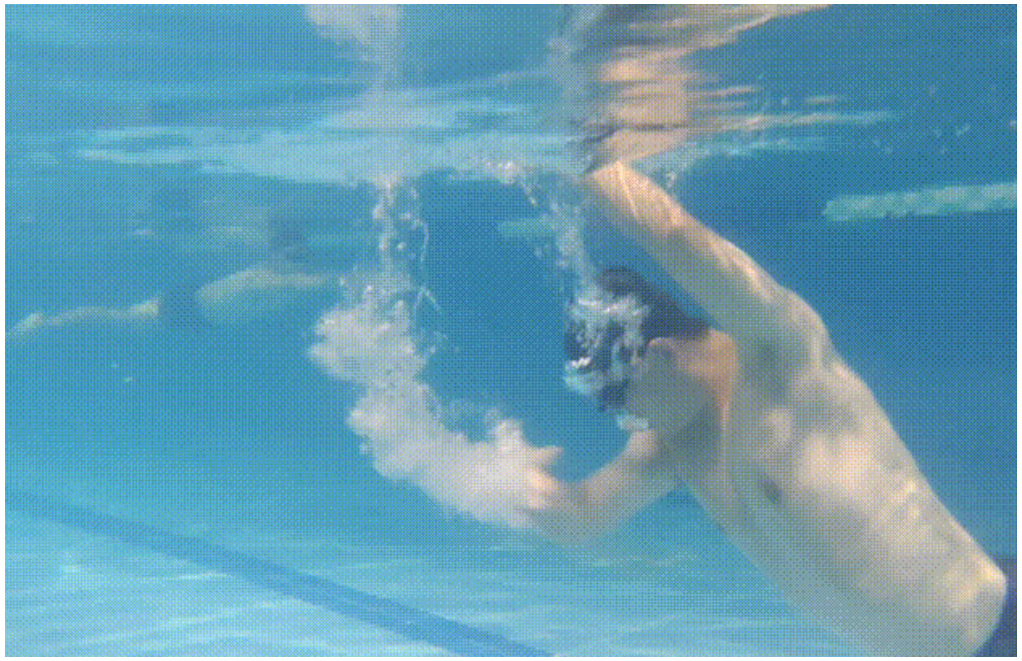


Noise



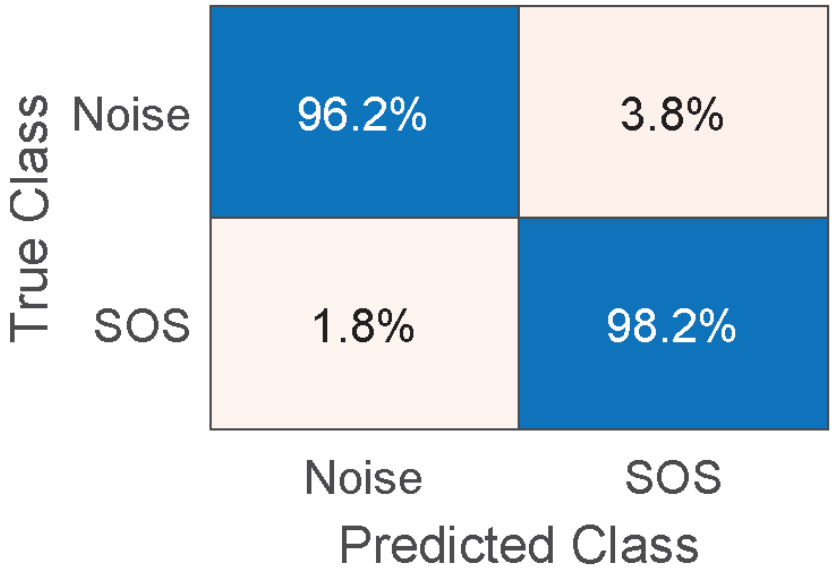
Experiment

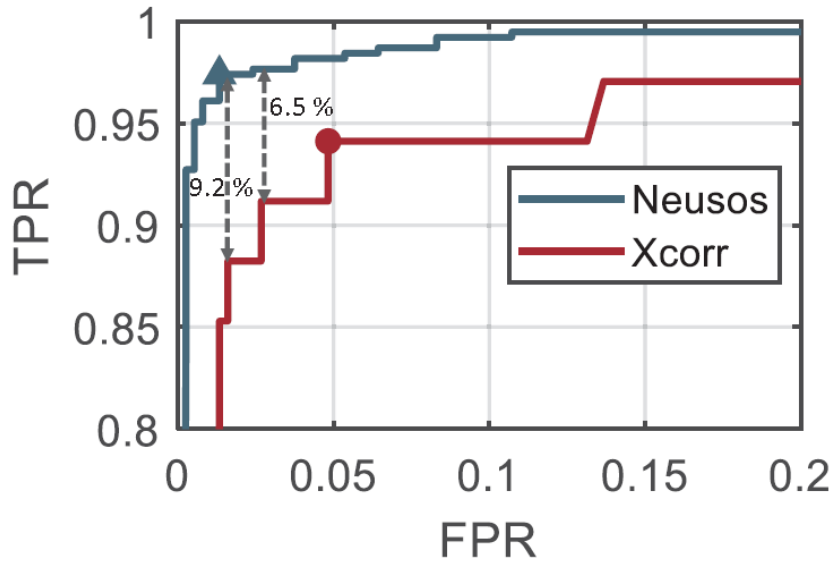




Swimming pool in operation hours

Evaluation





- Overall accuracy: 97.2%
- NeuSOS outperforms cross-correlation by 9.2% with the same FPR of 1%.

Conclusion and Takeaway

- Drowning incidents can happen even with the professional lifeguards present.
- We propose NeuSOS, a robust underwater SOS system that can detect SOS signal in dynamic underwater noise and bursting interference.
- We develop an explicit signal-aware deep learning model to effectively capture the SOS chirp signals, outperforming the traditional xcorr method.

THANKS

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