NeuSOS: Neural Enhanced Underwater SOS Detection

Qiang Yang\textsuperscript{12}, Yuanqing Zheng\textsuperscript{1}

\textsuperscript{1}The Hong Kong Polytechnic University, Hong Kong SAR
\textsuperscript{2}University of Cambridge, UK
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.

2 young brothers drown in pool in Roseville, police say

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
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

AquaHelper: SOS Transmission with Wearable Devices

One-button SOS transmission

SOS Transmission and Detection: Acoustic Chirps

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

**Received chirp**

**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

*Received chirp*

*Clear chirp*

*Bursting noise*
NeuSOS: SOS Detection with Deep Learning

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

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

**Underwater noise**

**Bursting noise**
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 denoiser and enhancer

SOS
(a) SOS input
(b) Layer 1
(c) Layer 2
(d) Layer 3
(e) Layer 4
(f) Layer 5

Noise
(g) Noise input
(h) Layer 1
(i) Layer 2
(j) Layer 3
(k) Layer 4
(l) Layer 5
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

Qiang Yang
The Hong Kong Polytechnic University
University of Cambridge
qiang.yang@cl.cam.ac.uk