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<th><strong>Title</strong></th>
<th>Underwater searching system on unmanned surface vehicle</th>
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<td><strong>Author(s)</strong></td>
<td>Liu, Jiaqi</td>
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RobotX is an international competition organized by Singapore and US, aiming to gather students with strong passion on surface robots. This year, the 1st competition is hosted by Singapore at Marina Bay Floating Area. One of the tasks is to build a search system to locate an underwater pinger (generating acoustic signal).

According to the rules, there are 4 balloons on the water surface, and one of the balloons will be tied with an unknown pinger randomly. The pinger will generate acoustic signal with the following features:

- Signal frequency: 20kHz - 40kHz, lasting for 5ms each time.
- Time span between each signal: 0.5s to 2s.
- Depth of the pinger: 0m to 6m.

100 marks will be given for reporting the correct GPS location of the pinger, and 500 marks for the depth of the pinger. Reporting of frequency and time span are not compulsory.

**Methodology**

- **Hardware Platform Building**: Hydrophone (TC4013 by TELEDYNE RESON) detects 1Hz-170kHz signal. The output voltage is within 10mV. It shall be amplified before sampling.
- **Analog to Digital Converting**: By Nyquist Sampling Theory $f_s > 2 \times f_n$, sampling frequency must be greater than 80kHz. Using ADS805EG4, the signal is sampled at 200kHz.
- **Signal Processing (Noise Removal & Fast Fourier Transform)**: STM32F407 DISCOVERY board is the processing unit, because its SPI running at 48MHz is fast enough for data transmission, and the build-in Fourier Transform function is fast as 1ms. The Fourier transform requires 512 samples to give accurate result, so we take 3ms ($200 \times 3 > 512$) as a time span to process the data. Noise is removed by F.I.R. Filter before Fourier transform is carried out. Lastly, DISCOVERY board will send frequency spectrum to host PC.
- **Depth Calculation**: An easy approach to get the depth is to measure the strength of signal at different locations. The pingers are tied under the floating balloons, so we slowly approach the balloons and use two hydrophones to take signal samples at different distance and depth. The appearance of peak values are taken note of and the depth can be calculated by linear interpolation.

During the competition, the detection system successfully reported the location of the pinger. However, due to the unknown noise from sea water and vehicle engine, the error of depth is about 1m.