# EMBEDDED SYSTEM FOR CONDITION MONITORING OF MARINE PUMPS

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## Aims

- Build a functioning embedded system which monitors the condition of a marine pump
- Collect data and perform on board processing
- Use data to provide basic diagnostics of the pump
- Evaluate sensors from different price points

## Why?

- Time and money is wasted repairing pumps on a fixed schedule or only once they have failed [1]
- Providing cheap monitoring systems would allow Condition-Based Maintenance of these pumps
- Current solutions are not viable due to their high cost

## Condition-Based Maintenance (CBM)

- CBM describes measuring data during operation to accurately estimate the health of a machine or individual component [1]
- Shown to successfully reduce maintenance costs across a range of industries and minimise shutdown time [2]
- Machines are worked closer to their predicted lifetime and repairs can be targeted towards specific faults [3]
- Indirect damage as a result of failure during operation is avoided
- Essential for efficiently operating autonomous ships in the future

## Condition Monitoring Methods

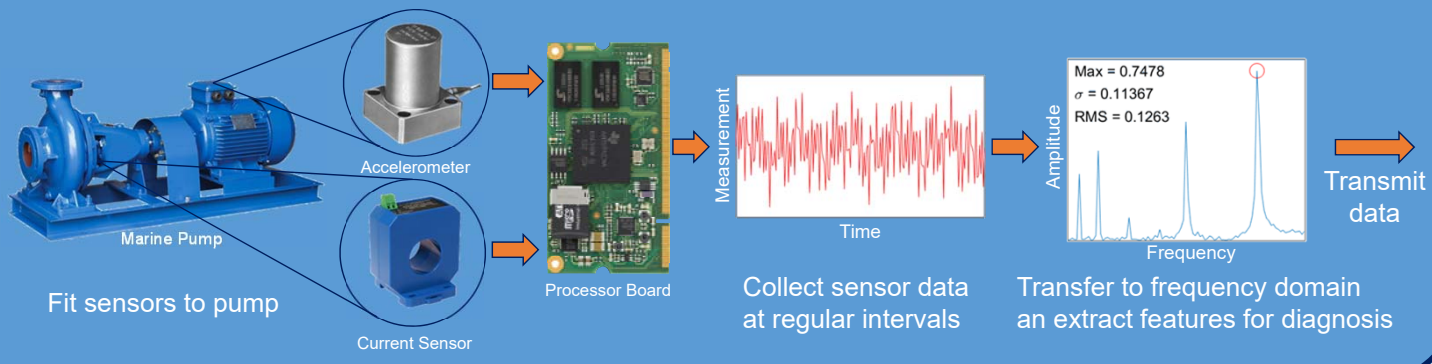
### Vibration analysis

- Most prevalent method [2]
- Measure with accelerometer or velocity transducer
- Detects mechanical faults
- Requires measuring high frequencies ~10 kHz [3]
- Sensor placement is important

### Motor Current Signature Analysis (MCSA)

- Detects both electrical faults and mechanical faults
- Measure stator current using Hall Effect Current Transducer
- Lower frequency range ~5kHz [4]
- Very noisy measurements [3]

## Embedded System Diagram



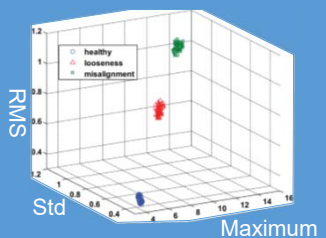

Fit sensors to pump

Collect sensor data at regular intervals

Transfer to frequency domain an extract features for diagnosis

## Measurements and Diagnostics

- Currently, many pumps on board ships operate without any record of their condition or performance
- This system will transmit the runtime and operating speed of pumps, along with simple statistical features
- Such data is immediately useful to workers who maintain pumps, and provides the basis for data-driven learning, predicting remaining lifetime and environmental effects
- Even small numbers of features such as maximum, root mean square and standard deviation of the frequency spectrum can detect and diagnose faults [2]
- Healthy and faulty conditions will be diagnosed on-board




Diagnosis of system from basic statistical features [2]

## Testing and development

- Computation will be tested by sending data to the embedded system over a communication channel and comparing the output with an offline implementation
- Sensor data will then be verified by comparison with sensors on the Remote Access Laboratory (RAL)
- RAL is an existing setup with motor, shaft, multiple bearings and accurate condition monitoring equipment
- Direct comparison of system performance
- Multiple fault types can be induced, including damaged bearings and shaft bending
- Long term tests to simulate live environment


Remote Access Laboratory available in Tribology department at UoS

## References

[1] Z. Hameed, S. Ahn and Y. Cho, "Practical aspects of a condition monitoring system for a wind turbine with emphasis on its design, system architecture, testing and installation", Renewable Energy, vol. 35, no. 5, pp. 879-894, 2010
[2] A. Moosavian et al., "Fault diagnosis and classification of water pump using adaptive neuro-fuzzy inference system based on vibration signals", Structural Health Monitoring: An International Journal, vol. 14, no. 5, pp. 402-410, 2015
[3] R. Randall, Vibration-based condition monitoring, Hoboken, N.J.: Wiley, 2013
[4] F. Bonnardot, R. Randall and J. Antoni, "Enhanced Unsupervised Noise Cancellation using Angular Resampling for Planetary Bearing Fault Diagnosis", The International Journal of Acoustics and Vibration, vol. 9, no. 2, 2004

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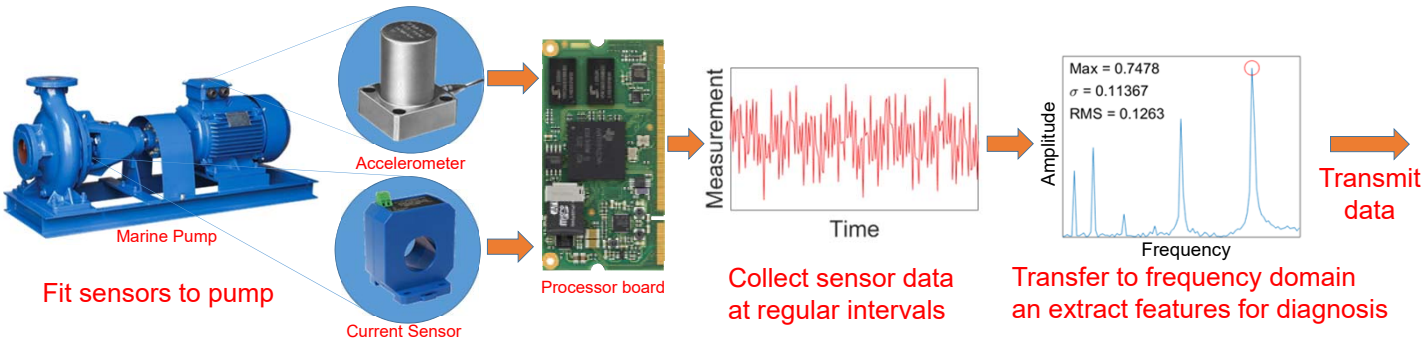
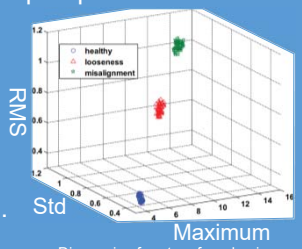



## Measurements and Diagnostics

- Currently, many pumps on board ships operate without any record of their condition or performance.
- This system will transmit the runtime and operating speed of pumps, along with simple statistical features.
- Such data provides the basis for data-driven learning, performed on powerful computers, and is immediately useful to workers who maintain pumps.
- Even small numbers of features such as maximum, root mean square and standard deviation of the frequency spectrum can detect and diagnose faults [2].




Diagnosis of system from basic statistical features [2]