Smart Ships – Paradigm Shift with Data Analytics

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Presentation Outline

• Data Analytics – Maritime Paradigm

• Data Analytics Implementation

• Data Integrity & Data Density Clustering Process

• Algorithms
  – Prediction of operational fuel curves from noon reports
  – Large data sets filtering and clustering – speed vs. power curves
  – Trim optimisation

• Conclusions
Maritime Paradigm (Data Analytics)

- Information highway – fiber optics / cabling / information or
digital technology (ICT) / computing power = maturity
- Diagnostic response → remote monitoring

Immediate Aspiration – Support Commercial / Marine Operation and
Ship Management

Intermediate layer: Pragmatic Step.
Data Reliability – Monitoring / Verification and / or Calibration for
Execution
Supports / Test bedding / Feedback to Autonomous Ships
Programme.

Vision: Technical Aspiration
Autonomous Vehicles / Ships
Maritime Paradigm (Data Analytics)

- A journey less travelled (Paradigm / Fear – Knowledge Gap)
- Change is slow (Marine Industry / Behaviour)
- Information Gap (Ships’ digital divide and cost of communication)

Disruptors in the Digital Worldwide Web / World

- Cloud computing
- Big Data / mobile apps / whatsapp / machine learning
- Wearable devices / mobile technology
- Internet of things
- Drones / Robotics

Autonomous Vehicles / Ships
Data Analytics Implementation

- Maritime Paradigm Shift (Regulatory Change)
- Started with Voyage Data Recorder (VDR) – Estonia in 1994
- Next Move (EU MRV) – Monitoring, Reporting and Verification

**Dataset : What data etc?**

Regulatory Changes bring about small changes but each change, causes disruption with physical activity.

Re-conceptualise the change process.

Why incremental data inclusion, Why not all possible data with data exclusion. Change = software upgrading.

Hence, the journey with a Data Acquisition Server (Integrator)
Data Integrity

- **Data Quantity Management**
  - Data stream: vertical — horizontal
  - Identify data frequency and period for analysis (5mins intervals, 10 months)
  - Create category / grouping / classes

- **Data Quality Management**
  - Data holes
    ✓ Different sensor intervals
    ✓ Manual human interference
    ✓ Sensor breakdown
  - Data Verification Process

**Granularity and Database Size**

**Engineering Data**

- **Technical Solution**
  - Match data intervals
  - No switching off action
  - Alarm function

- **Statistical Solution**
  - Filtering out
  - Filling in—ECDIS / average / adjacent data water depth
  - Wave height and direction info
  - Assumption—water depth holes processing

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**Data Holes**

<table>
<thead>
<tr>
<th>Source</th>
<th>Grand Total</th>
<th>Priority</th>
<th>Remark</th>
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<tbody>
<tr>
<td>Ground</td>
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<td>6862</td>
<td>1075</td>
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<td>Position</td>
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<td>Water Depth</td>
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<td>6872</td>
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<tr>
<td>Wind Speed</td>
<td>1136</td>
<td>6872</td>
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<tr>
<td>Grand Total</td>
<td>64462</td>
<td>77118</td>
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</table>
Data Density Cluster Process

- Water speed $\leq 11$ kn
- Shaft power $> 5000$
- RPM $> 5$
- $-1 = \text{Trim} = 1$
- Wind speed $\leq 10.5$

Reintegration — low water speed range

Filtered — high water speed range

- Water speed $> 11$ kn
- Shaft power $> 5000$
- RPM $< 5$
- $-1 = \text{Trim} = 1$
- Wind speed $< 10.5$
- Water depth $> 70$ m

Speed Power Curve (13.5 ~14.5 m Draft)
Algorithms

• Prediction of operational fuel curves from noon reports

• Large data sets filtering and clustering – speed vs. power curves

• Trim optimisation
Large Data Sets Filtering & Clustering

• *Artificial Neural Network Implementation*
  – The training algorithm is based on the fastest and safest method of supervised learning through a back propagation algorithm
    • Input parameters: trim, speed, and draft
    • Output parameter: shaft power
  – The network performs the task of adjusting the weights on the connections between neurons, so that after repeatedly providing the input and output parameters, it is able to recognize this connection.
Filtering & Clustering of Larger Data Sets

**Step 1: Acquire Database**

- An SQL Algorithm was used to extract real time data from the a ship.
- Data Set Size: 119,467
Step 2: Carry out “Coarse” Filtering

- RPM > 5
- ME Power > 5000 kW
  - -1 <= Trim <= 1
- Water Depth > 55m
- Water Speed > 11 knots
- Wind Speed <= 10.5 Knots
- Data Set Size: 18,618
Filtering & Clustering of Larger Data Sets

**Step 3: Carry out Fine Filtering**

- Fine Filtering Criteria was Based on: The data point corresponding to the mean draft was eliminated if

\[ |\text{Draft} - \text{Moving Average} | \geq 0.15m \]

- Data Set Size: 17,915
Step 4: Cluster the Data Set based on a specialized Clustering Algorithm

- Data Size: 233
Filtering & Clustering of Larger Data Sets

Step 5: Feed into 2-Layer Neural Network
Conclusions

• An overview on the use of data analytics for the maritime industry has been presented, highlighting the approach adopted and the limitations and challenges present

• Algorithms for the prediction of operational fuel consumption curves have been presented

• Current work focuses on improving the robustness of the algorithms and enhancing their potential with naval architecture domain knowledge
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