Smart Ships – Paradigm Shift with Data Analytics

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MARENER 2017
International Conference on Maritime Energy Management
World Maritime University, Malmo, 23-25 January 2017

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.

Building Blocks

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

Granularity and Database Size ?

Engineering Data

- **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

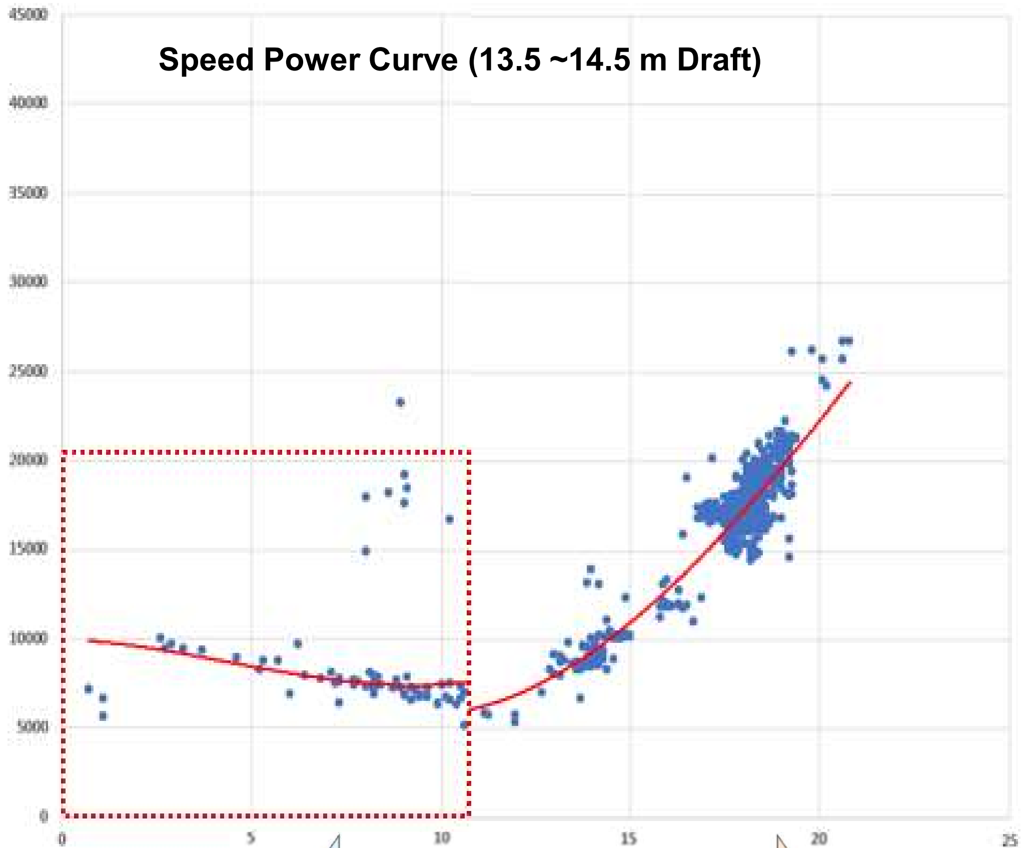
Technical Solution
- Match data intervals
- No switching off action
- Alarm function

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

Data Holes

									couver	Grand Total	Priority	Remark
									0	0	16	
									27	55763	10	Background filling
									43	58641	9	
									48	58648	8	
									47	11660	11	
									47	58686	7	
									45	11643	13	
									52	11660	11	
									43	11659	12	
Ground Speed	1135	6862	3575	146	189	95	435	210	174	12821	15	Background filling
Position	1135	6864	3585	103	190	97	1564	210	128	13876	14	
Water Depth	55306	13751	3594	32936	41760	59244	52290	6778	51985	317644	1	human action
Water Speed	2063	6872	16236	104	190	1308	61364	211	114	88462	6	Background program
Wind Direction(abs)	1182	6872	33360	149	212	108	230	53186	59056	154355	4	
Wind Direction(rel)	1136	6850	3583	1000	191	99	61364	53185	51257	178665	2	Background program
Wind Speed(abs)	1182	6872	33360	657	212	108	653	53186	59057	155287	3	
Wind Speed(rel)	1136	6850	3583	1001	191	99	1432	53185	51258	118735	5	Background program
Grand Total	64462	77118	103590	36171	43292	63370	413653	243168	273381			

Data Density Cluster Process



- Water speed=<11kn
- Shaft power>5000
- RPM>5
- -1=<Trim=<1
- Wind speed=<10.5

Reintegration—low water speed range

Filtered—high water speed range

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

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

sampletime	POSITION	WATER SPEE	ME FO CONSUMPTIO	ME SHAFT POW	SHAFT SPEED	SHAFT TORQUE	GROUND SPEE	WATER DEP	COUR	HEADI	WIND DIRECTION (AB	WIND DIRECTION (RE	WIND SPEED (AB
2013-10-02 06:35:00.000 +00:00	2122.7130N11414.3740E	17.8	66.96	16570	59.6	2626	17.6	58.2	193.8	193.5	NULL	238.9	NULL
2013-10-02 06:40:00.000 +00:00	2121.2130N11413.9600E	17.9	66.24	16570	59.7	2638	17.7	60.9	194.9	194	NULL	252.1	NULL
2013-10-02 06:45:00.000 +00:00	2119.7200N11413.5520E	17.9	65.52	16450	59.6	2614	17.6	61.4	194.4	194	NULL	274.6	NULL
2013-10-02 06:50:00.000 +00:00	2118.2220N11413.1390E	17.9	65.52	16330	59.5	2584	17.7	60.7	194.8	194.5	NULL	265.2	NULL
2013-10-02 06:55:00.000 +00:00	2117.1140N11412.8560E	17.7	69.83	16570	59.7	2632	17.7	60.7	192.7	192.2	NULL	268.4	NULL
2013-10-02 07:00:00.000 +00:00	2115.6000N11412.4960E	17.9	66.23	16330	59.5	2596	17.9	63.2	192.7	192.1	NULL	263.4	NULL
2013-10-02 07:05:00.000 +00:00	2114.0700N11412.1280E	17.9	68.39	16210	59.7	2566	17.8	63.9	192.5	191.9	NULL	281.3	NULL
2013-10-02 07:10:00.000 +00:00	2112.5490N11411.7560E	17.9	66.95	16510	59.6	2620	17.9	64.3	193	192.2	NULL	251.6	NULL
2013-10-02 07:15:00.000 +00:00	2110.9290N11411.4070E	18	65.5	16450	59.6	2614	18	63.2	191	189.4	NULL	246.7	NULL
2013-10-02 07:20:00.000 +00:00	2109.3780N11411.1030E	18.1	67.65	16630	59.6	2638	18	63.3	190.3	189.5	NULL	238.4	NULL
2013-10-02 07:25:00.000 +00:00	2107.8390N11410.8220E	17.8	71.94	16570	59.8	2620	17.7	62.9	194.3	192.8	NULL	269.2	NULL
2013-10-02 07:30:00.000 +00:00	2106.7270N11410.5350E	18	67.62	15910	59.6	2518	17.9	65	192.8	192.3	NULL	291.3	NULL

Filtering & Clustering of Larger Data Sets

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

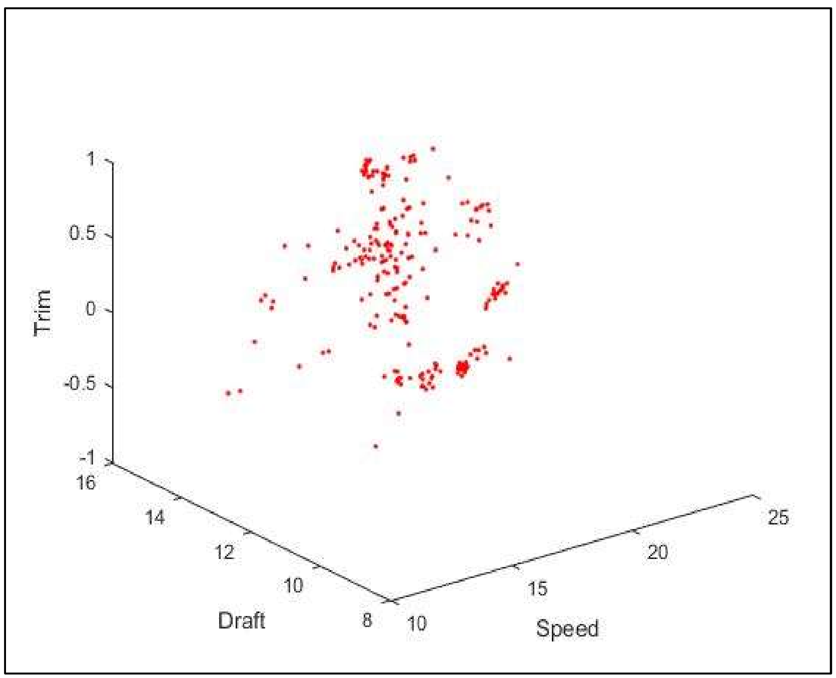
$$|\text{Draft} - \text{Moving Average}| >= 0.15m$$

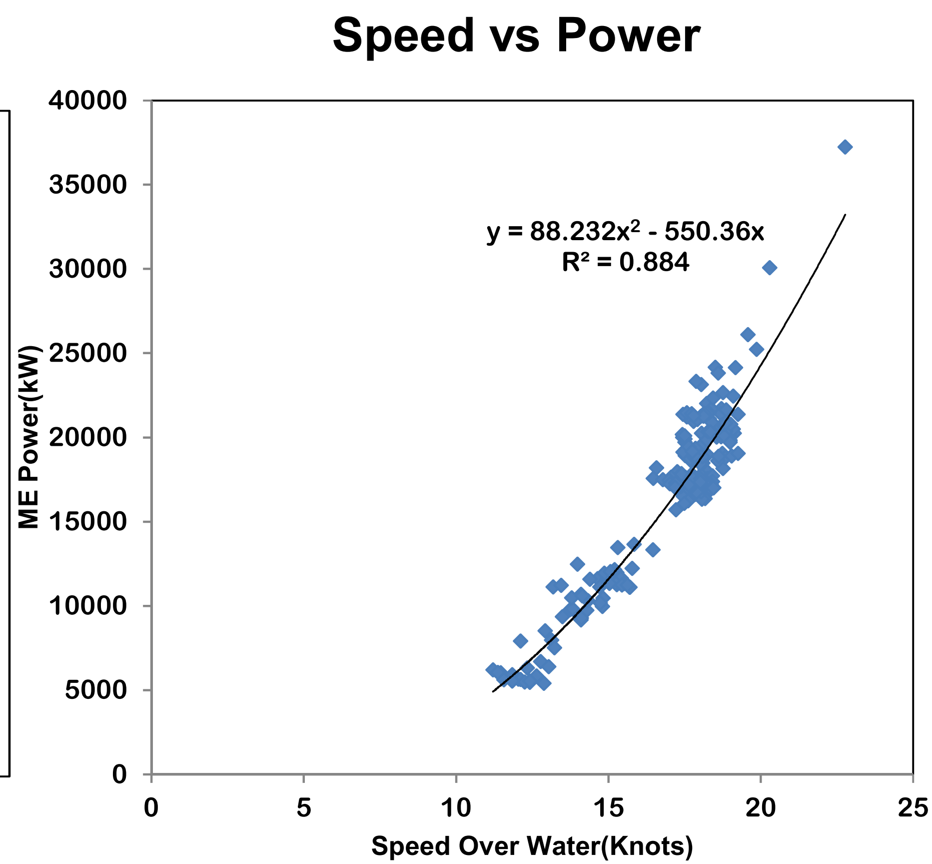
- Data Set Size : 17,915

Filtering & Clustering of Larger Data Sets

Step 4: Cluster the Data Set based on a specialized Clustering Algorithm

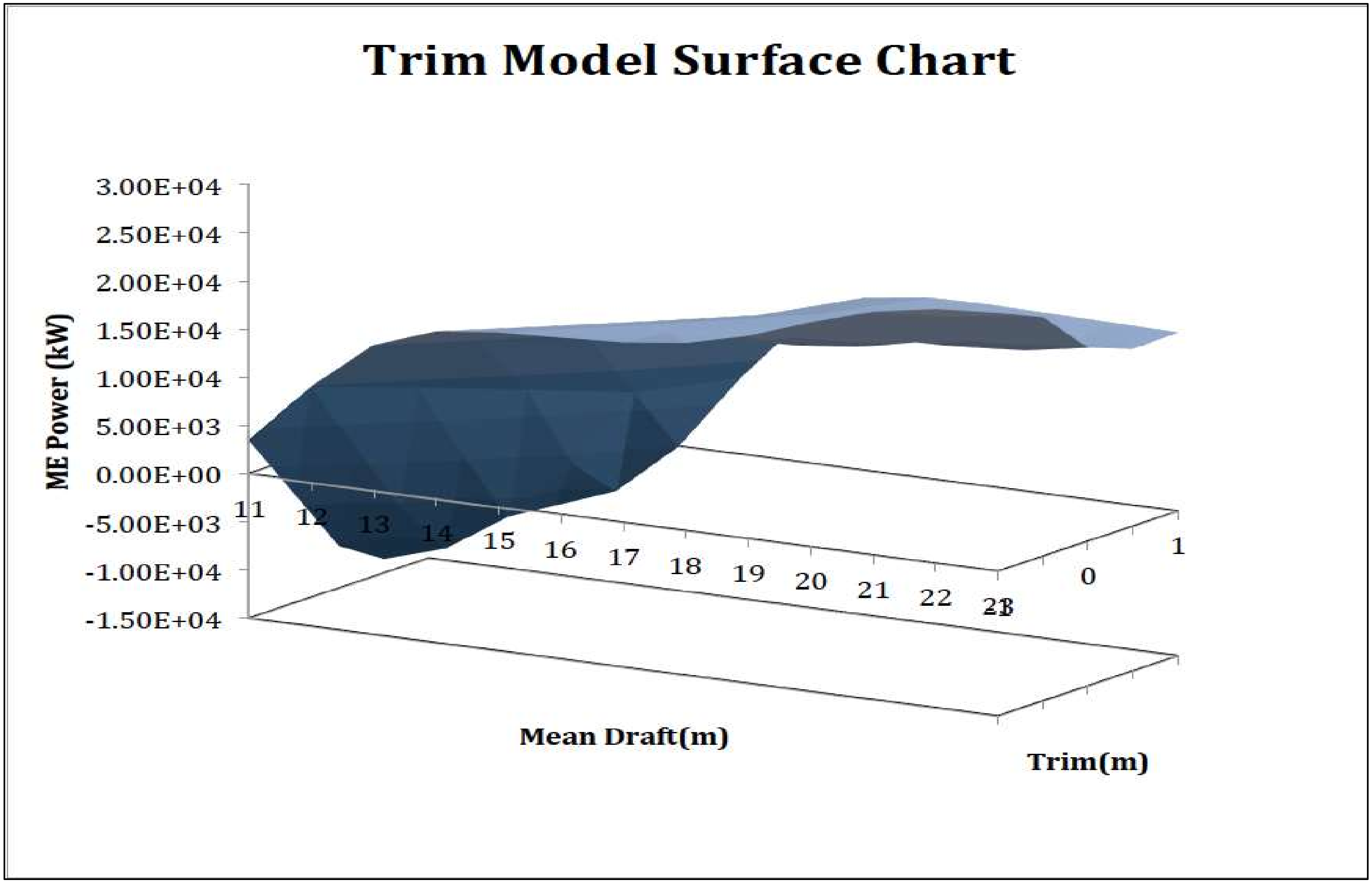
- Data Size: 233





Filtering & Clustering of Larger Data Sets

<u>Step 5</u>: 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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