Identifying a Drilling State Machine

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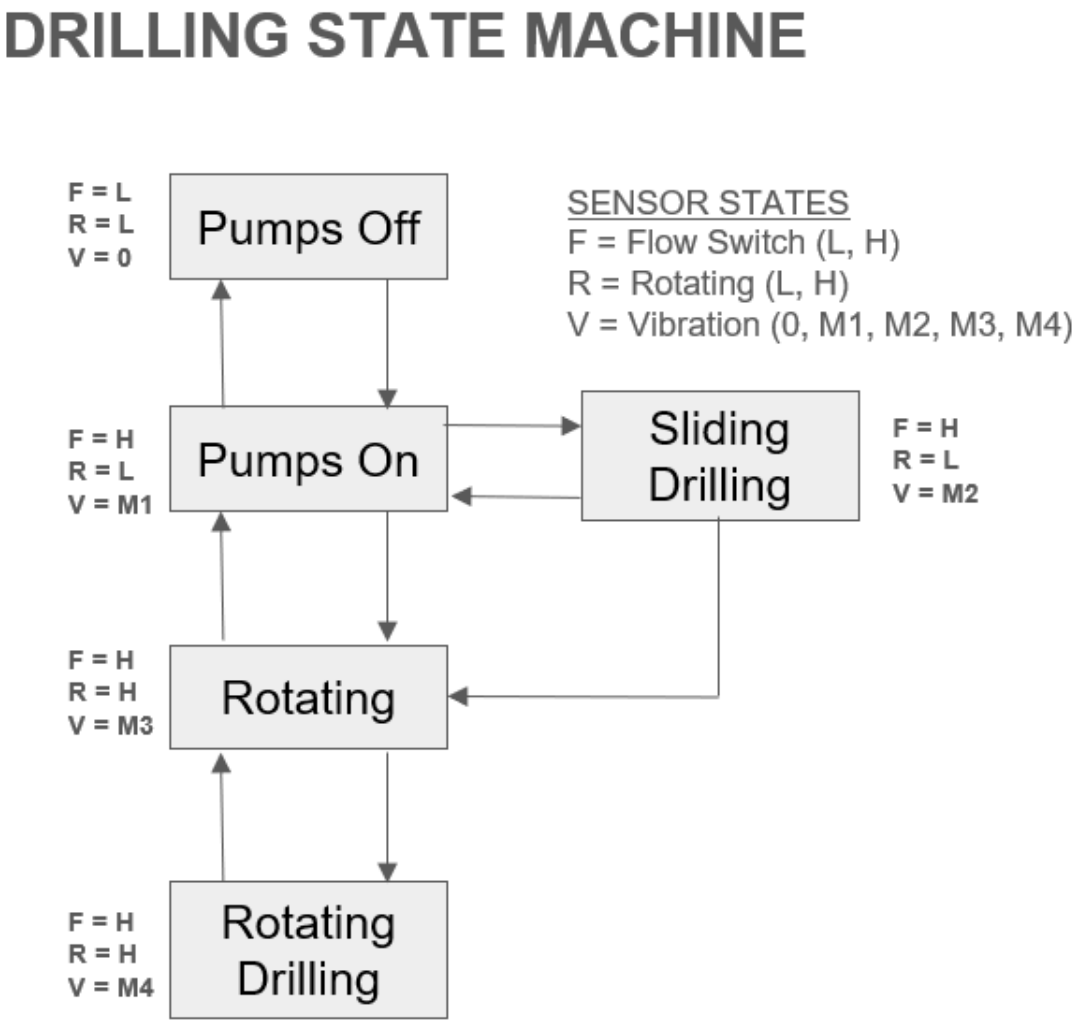
The Problem

- Software on drilling tools can be optimized by knowing what state the tool is in
- Deere Development Company (DDC) has outlined the Drilling State Machine seen here to fulfill their software needs
- Indicating Drilling Parameters
  - Flow
  - Rotation
  - Vibration
  - Weight on Bit (WOB)



Well	Run	Date In	Date Out	MD In	MD Out
Flybar 1 WB	Run 7	12/2/2024	12/4/2024	10582	13222
	Run 8	12/4/2024	12/8/2024	13222	17880
Flybar 1 WC	Run 6	12/9/2024	12/10/2024	10175	10287
	Run 7	12/10/2024	12/11/2024	10287	10713
	Run 8	12/11/2024	12/12/2024	10713	12088
Flybar 2 WC	Run 5	11/23/2024	11/28/2024	10960	16782

The Data

- Provided by DDC from real runs on oil rigs
- Includes the following items:
  - Time
  - Depth
  - Gallons per Minute (GPM) (Flow)
  - RPM
  - Axial and Lateral Vibration (at Motor and Pulser)
  - Weight on Bit (WOB)

Related Previous Work: Supervised

Method	Random Forest (RF)
Industries	• Oil & Gas
Applications	• Geological Formation Prediction
Data	• Sensor Data

Related Previous Work: Unsupervised

Method	Hidden Markov Model (HMM)	Gaussian Mixture Model (GMM)	Hierarchical Density-Based Spatial Clustering for Applications with Noise (HDBSCAN)
Industries	• Oil & Gas	• Oil & Gas • Statistical Research	• Manufacturing • Natural Language Processing
Applications	• Pump Jack Performance Analysis	• Pump Jack Performance Analysis • Oil Spill Image Classification	• Robotic Welding Monitoring • Record Classification
Data	• Large dataset • Time-series • Sensor Data	• Large dataset • Time-series • Sensor Data	• Real Time • Sensor Data

Proposed Work

- Hidden Markov Model Training and Testing
- Gaussian Mixture Model Training
- HDBSCAN Training
- Clustering Methods Evaluation
- Random Forest Training and Testing

Progress

Preprocessing	• Forward Filled • Only included necessary parameters • Segmented rigs into runs
Warehousing	• CSVs for each Rig and Run

Challenges/Lessons Learned

- Initially planning to use data labels
  - Found they were unreliable
- Pivoted to unsupervised methods for creating labels followed by supervised method for faster implementation
- Also decided to include HMM, not a traditional clustering algorithm for testing, due to direct application of method

Evaluation

Train on Flybar 1WB and 1WC

5 Runs in Total

Test on Flybar 2WC

1 Run

Statistical Analysis

Domain Knowledge

Inter/Intra Cluster Similarity Indices

Next Steps

Modeling

- HMM
- GMM
- HDBSCAN

Evaluation

- HMM testing
- Clustering evaluation
- RF implementation

Conclusion

- Project to be completed by end of June
- Methods of building and testing prioritized:
  - HMM
  - GMM
  - HDBSCAN
  - RF
- Evaluated for heuristic sense and inter/intra cluster similarity
- Completion will allow for better implementation of MWD software
  - Leading to more cost effective, safe, and time efficient drilling techniques