general motors

An ontology-based text mining and semantic similarity system for knowledge discovery in the automotive domain

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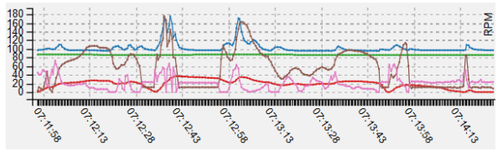
Different stages of vehicle life cycle and data collection

DFMEA / Requirements	Station to Station End of line	Pre-launch Verbatim Telemetry	Verbatim Telemetry	Verbatim Telemetry



"Ignition On/Ignition Off"

Diagnostic Trouble Codes (DTCs)
P0300 | **B**0001 | **U**1040 | **C**0550

Telemetry

~ Hundred of thousands/year

Design	Manufacturing	Pre-launch	Launch	Warranty

Key challenges associated with the text data

- Heterogenous data sources
  - Technical, non-technical, and survey
- Lean language
  - ‘Engine Control Module’ vs ‘Powertrain Control Module’
- Surface representation consists of limited/no overlap
  - ‘Vehicle Loss of Power’ vs ‘PCM P0300’
- High volume data (hundred of millions)
  - Curse of dimensionality
- Different types of noises
  - Misspelling, run-on-word, additional whitespaces, abbreviations, etc.

Data cleaning pipeline is developed to pre-process the data

Pre-warranty

Warranty

External (e.g., National Highway Traffic Safety Administration)

~ Pre-launch verbatim

Warranty Repair Verbatim

Technician Assistance Verbatim

Customer Assistance Verbatim

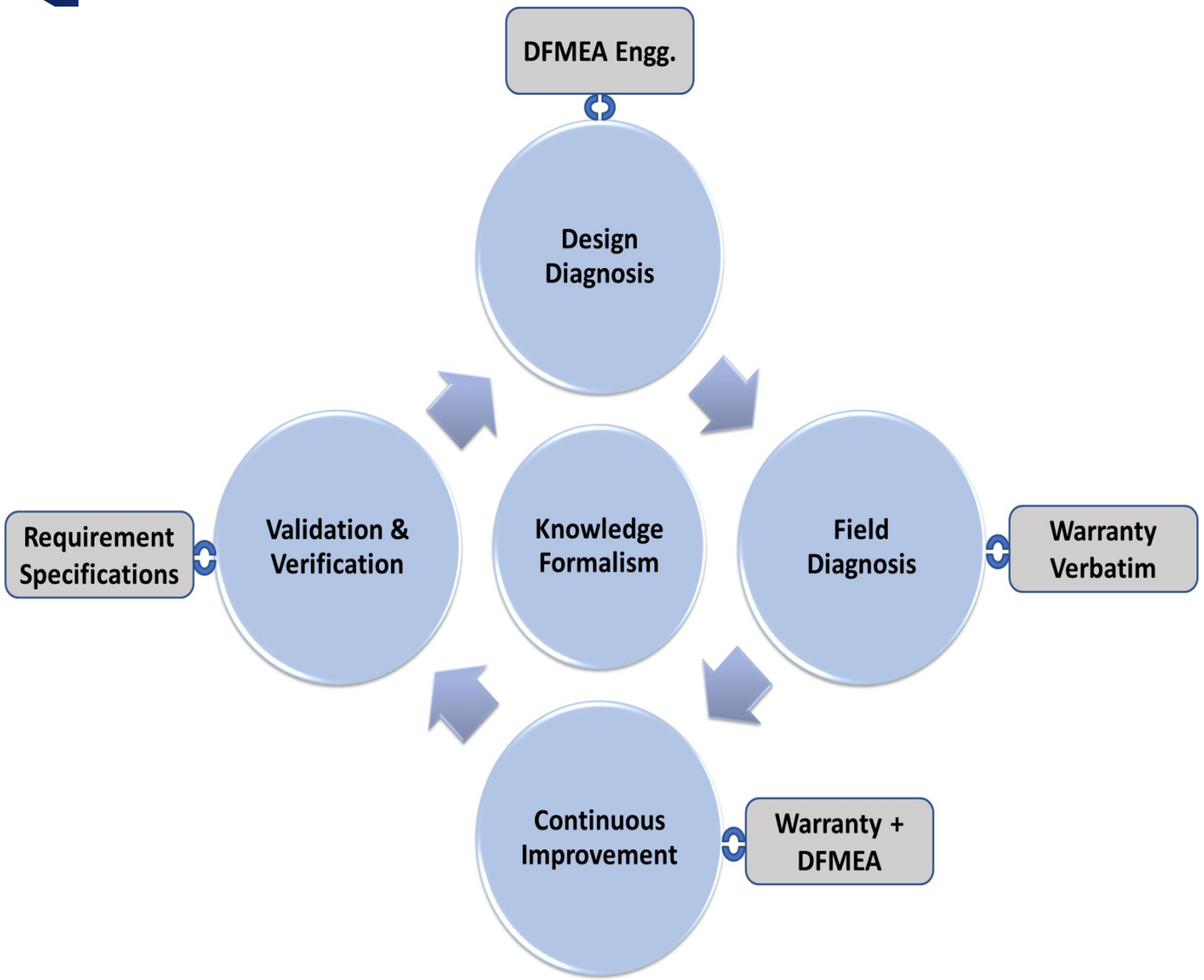
Vehicle Owners Questionnaire NHTSA

Misspelling Correction → Extra White Spaces → Word2Vec

Run On Word Correction → Abbreviation Disambiguation

Cleaned Unstructured Data

Business problems



- **Knowledge formalism**
  - Automatic ontology learning from warranty data
- **Validation & Verification**
  - Automatic linking of requirements using semantic similarity
- **Diagnosis & Prognosis**
  - Automatic development of fault dependency matrix
  - Text mining for knowledge discovery from the warranty data
- **Continuous Improvement**
  - Augmentation of DFMEAs considering new symptoms and failure modes discovered from the warranty data

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"CS Vehicle with loss of power. Detected leaks in cooler line, it was loose, repaired"

Warranty Data

~ Hundred of thousands/year

SCAN TOOLS

Service/Quality

- Frequent Failures → Best Practice Repairs
- Legacy Issues
- Dealer Training Need

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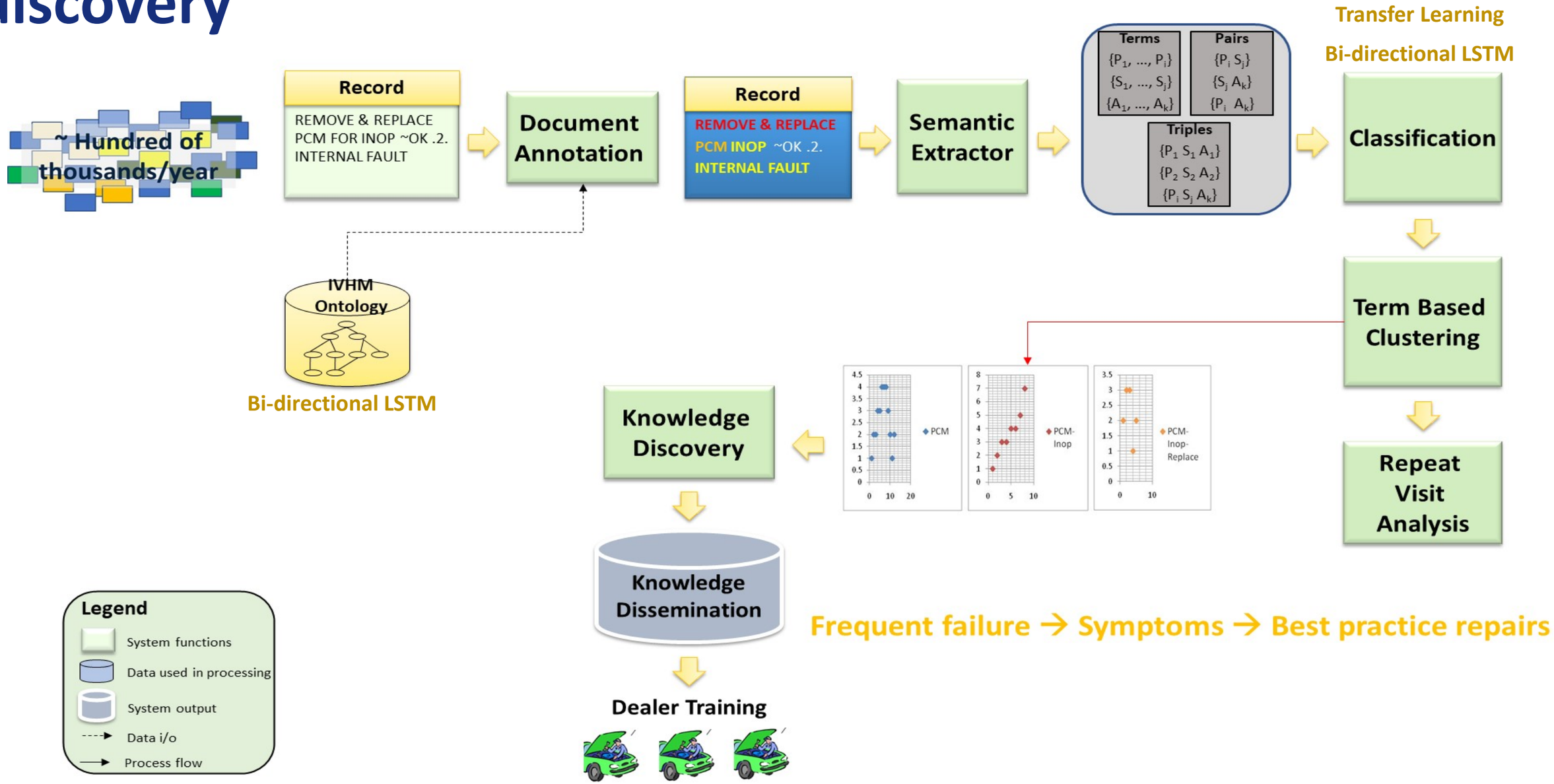
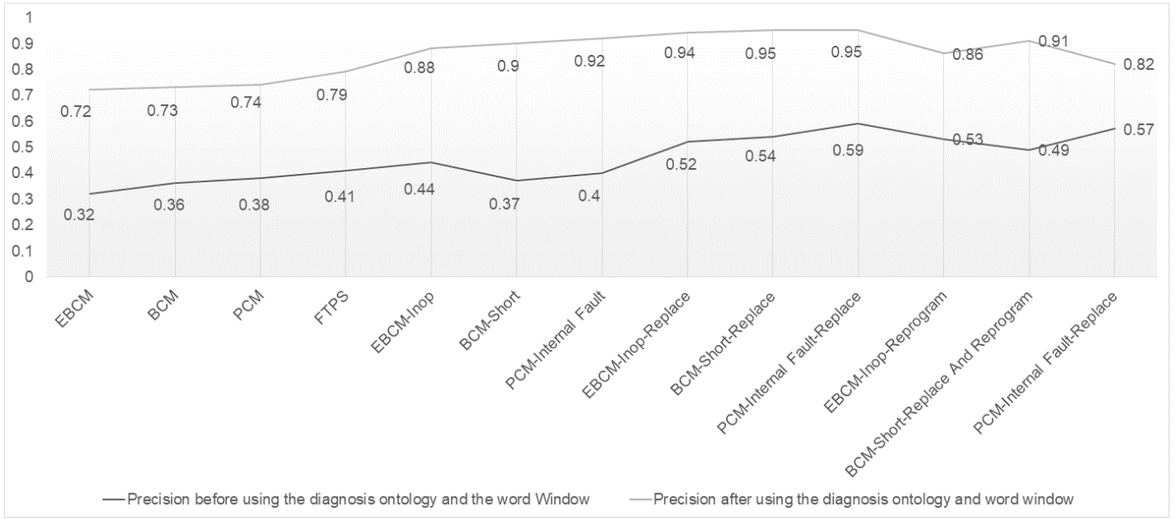


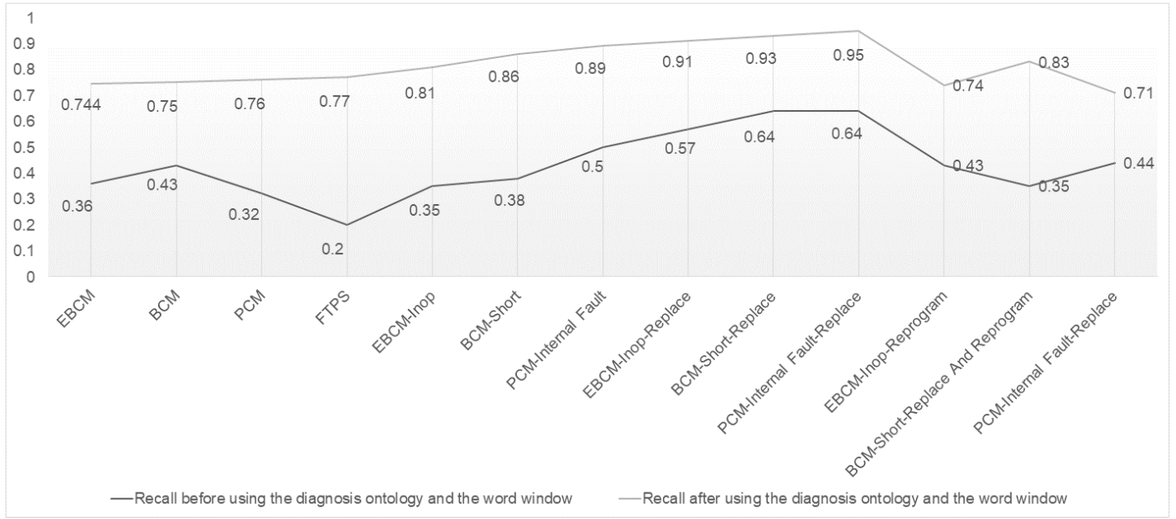
Frequent failure → Symptoms → Best practice repairs

Results

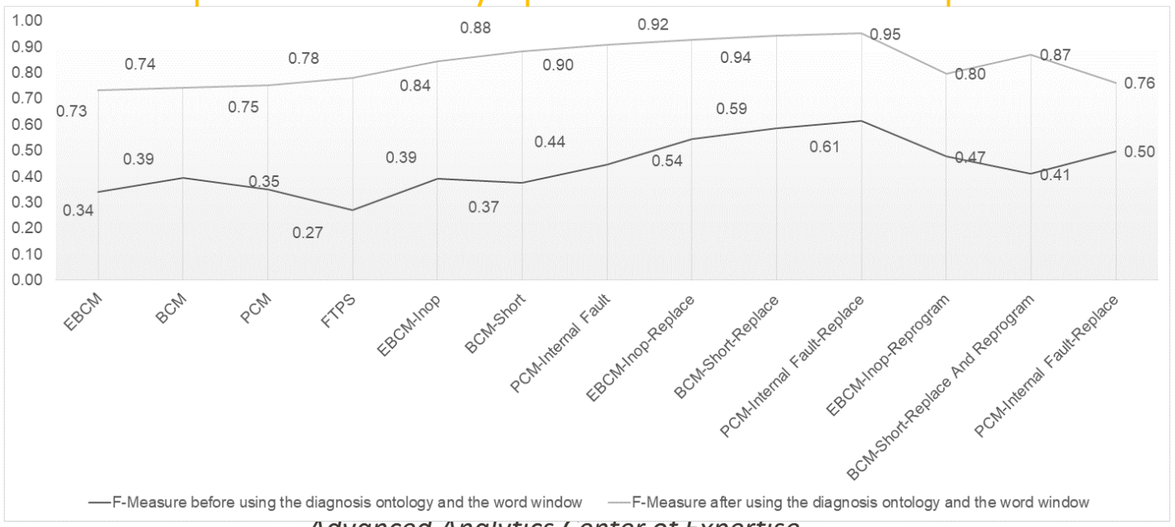
Precision: Frequent Failure → Symptoms → Best Practice Repairs



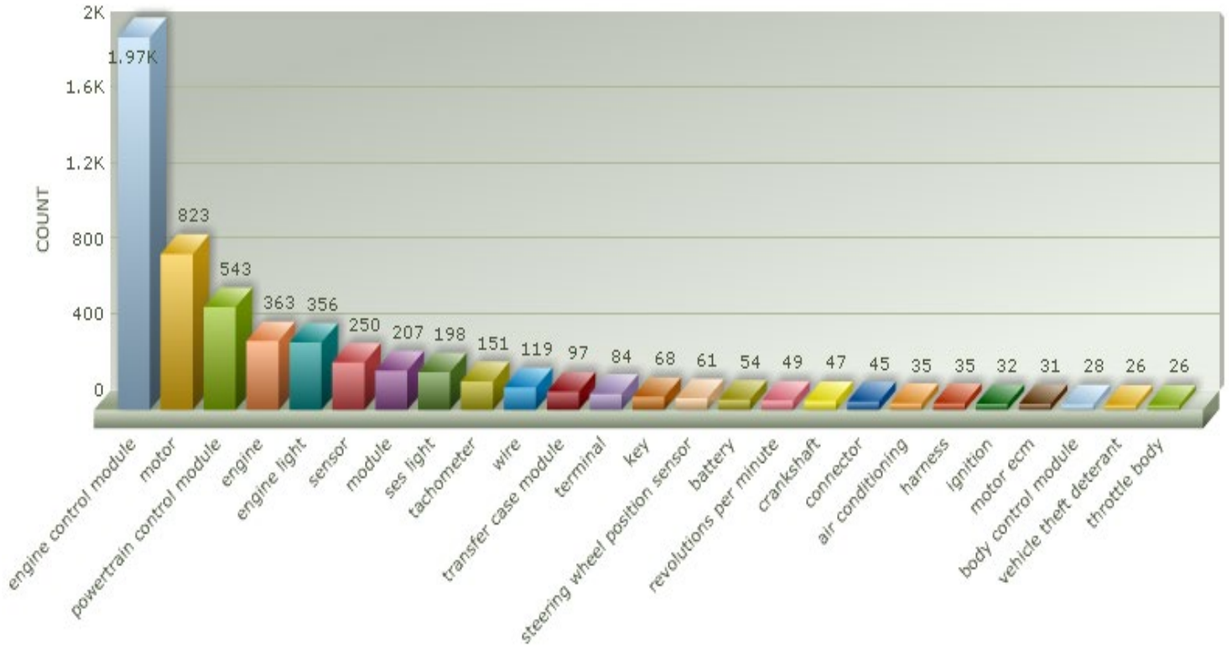
Recall: Frequent Failure → Symptoms → Best Practice Repairs

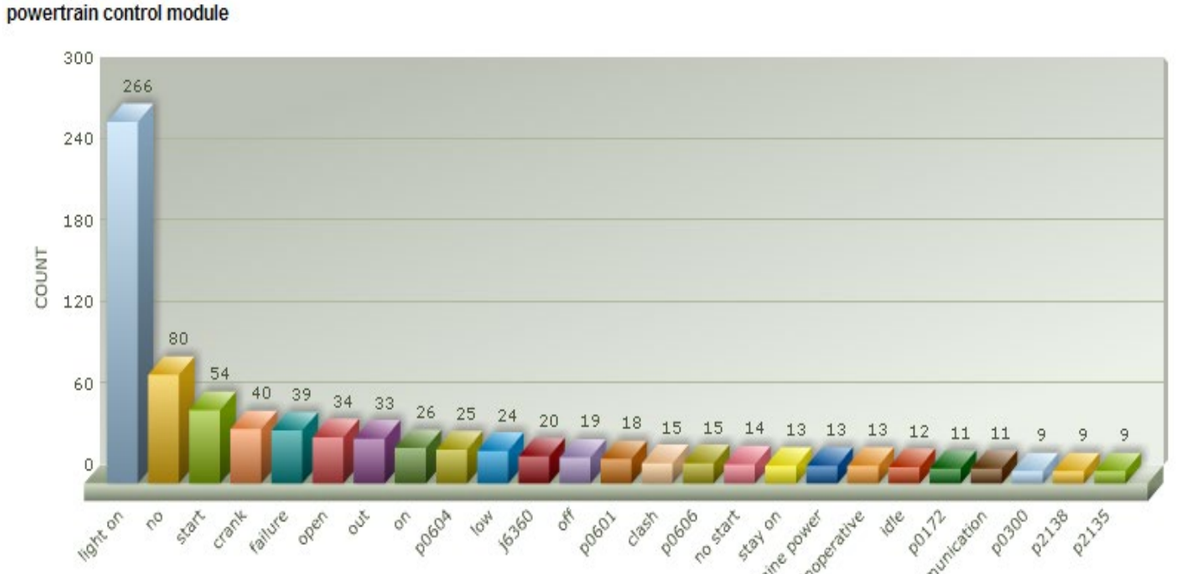


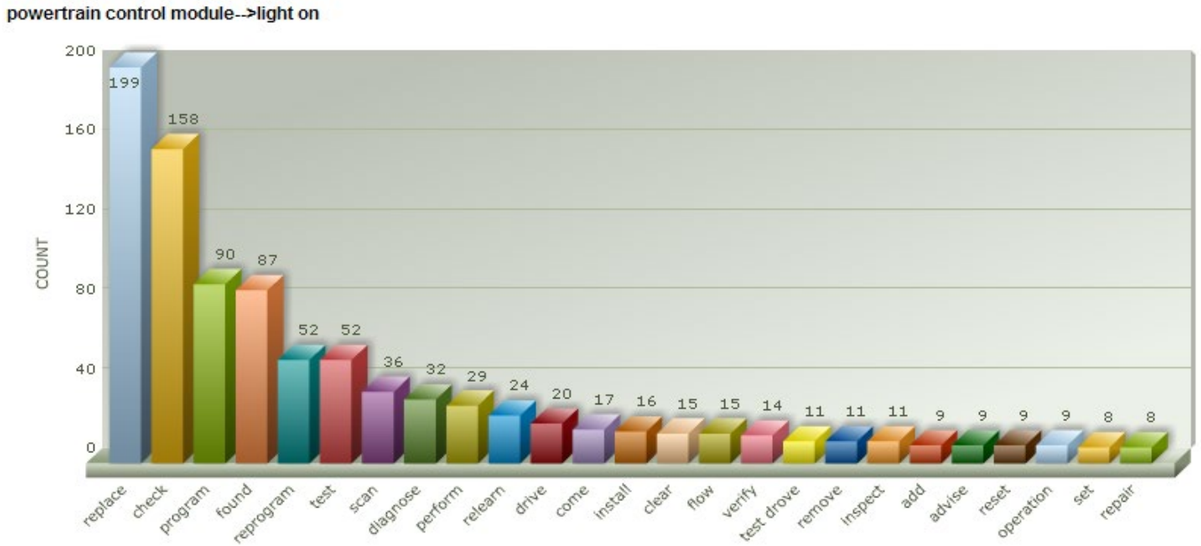
F1: Frequent Failure → Symptoms → Best Practice Repairs



Drill down analysis for knowledge discovery







- ❑ Suppliers
- ❑ Manufacturing plants
- ❑ Platform level analysis

Automatic development of fault dependency matrix

1. DFMEA/ Engineering Data

Components, Symptoms, Failure modes

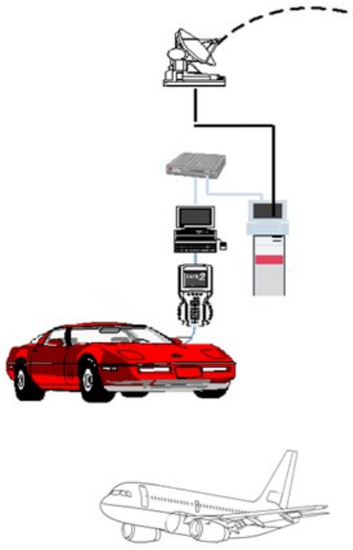
OEM's Database

Components, Symptoms, Failure modes

Context Vector, Syntactic Vector, Semantic Vector

Semantic Similarity Model

5. Enhance DFME/Engineering data with newly discovered knowledge



3. Data is collected via diagnostic tools

2. Field Diagnosis is performed

4. Develop text-based Fault D-Matrix

Filaure Source: 9, Test: 9	P0451	P0446	P0452	P0454	Loss Of Power	Engine Stalled	Engine Will Not Start	Unusual Guage Reading	Engine Runs Rough
FTP Sensor_Circuit Short And Pulling Down	1	0	0	0	1	0	0	0	0
FTP Sensor_Circuit Short To Ground	1	1	1	1	1	1	1	0	0
FTP Sensor_Faulty	1	1	0	0	1	1	1	1	0
FTP Sensor_Out Of Range	1	0	0	0	0	0	0	0	0
FTP Sensor_Open Circuit	1	1	0	0	0	0	0	0	0
FTP Sensor_Short Circuit in 5V Ref	0	0	0	0	1	0	0	0	0
FTP Sensor_Crack	1	0	0	0	0	0	0	0	0
FTP Sensor_Moisture	1	0	0	0	0	0	0	0	1
FTP Sensor_Stuck	1	0	0	0	0	0	0	0	0

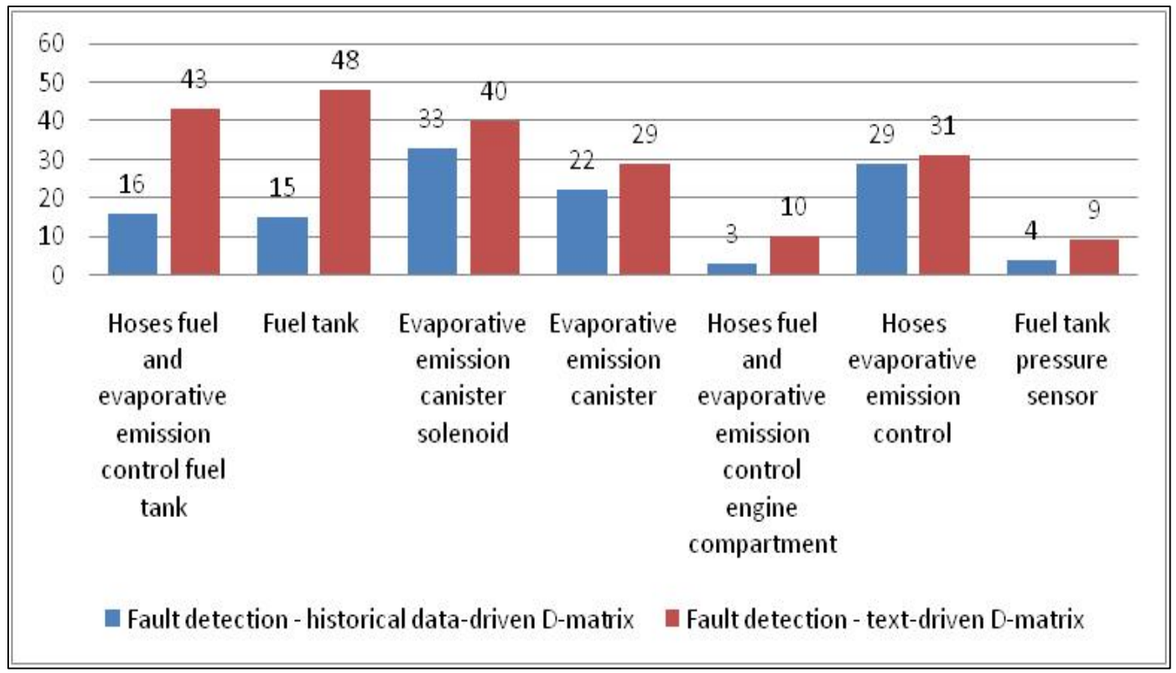
Results

$$P_D = \frac{[\sum_{i=1}^{m} D_i]}{m}$$

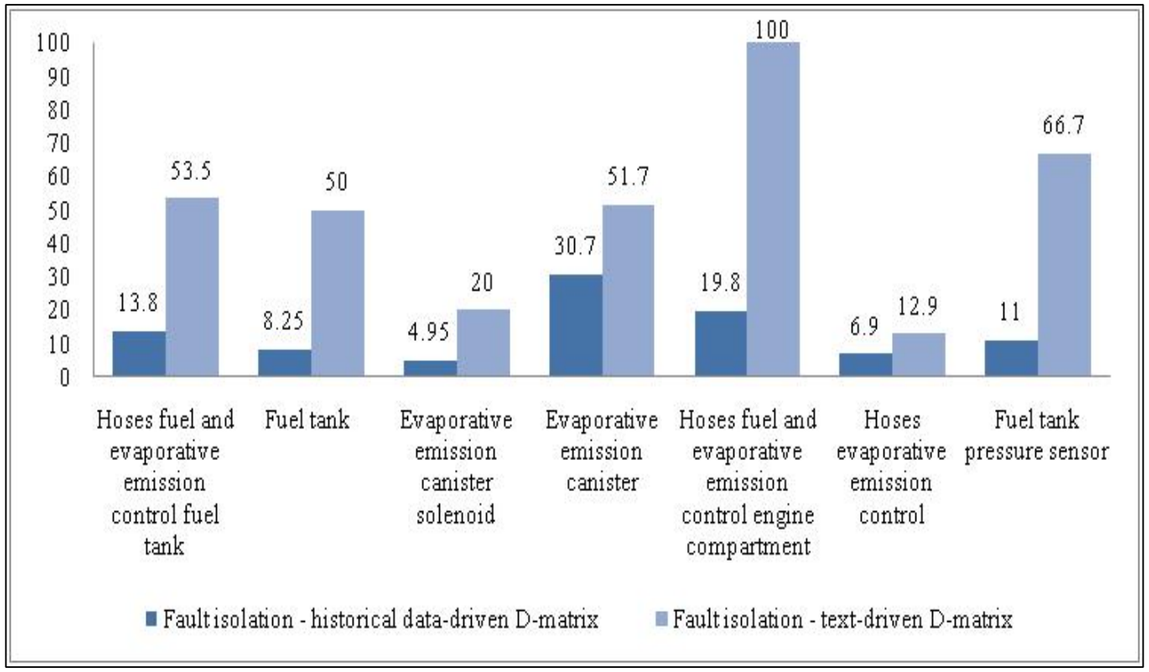
The ***fault detection*** (P_D) is defined as the percent of faults detected by the symptoms by observing the failure modes associated with a system.

$$F_I = \frac{[\sum_{i=1}^{m} ISO_i]}{m}$$

The ***fault isolation*** (F_I) is the probability that the symptoms uniquely isolate the faults of a system for the failure modes associated with a system.

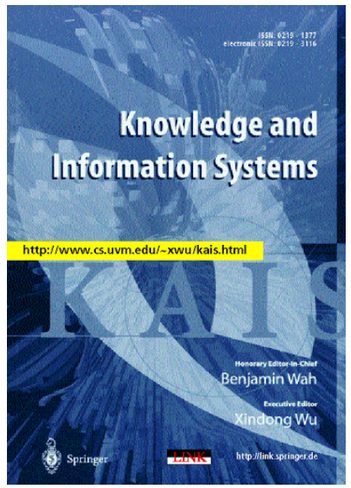


Comparison of fault detection between historical Data-driven D-matrix vs. Text-driven D-matrix



Comparison of % fault isolation between historical Data-driven D-matrix vs. Text-driven D-matrix

Publications



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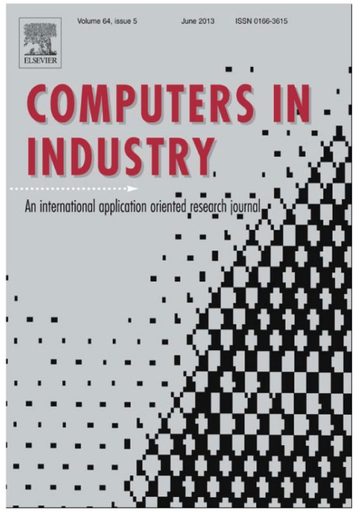

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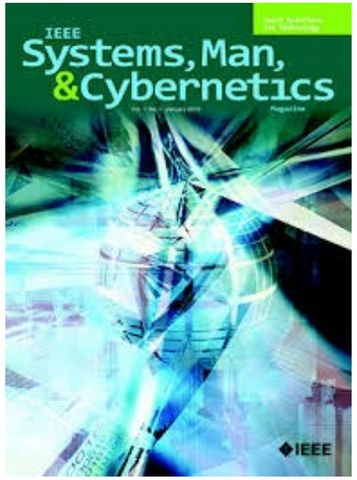
Publications



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Thank you