

# An Ontology-based Comprehensive D-matrix Construction for Accurate FDD

Madhuri Mahesh Varma<sup>1</sup>, Jyoti Nandimath<sup>2</sup>

<sup>1</sup>Pune University, Smt. Kashibai Navale college of Engineering, Pune, Maharashtra, India

<sup>2</sup>Professor, Pune University, Smt. Kashibai Navale college of Engineering, Pune, Maharashtra, India

**Abstract:** *There is need to gather information regarding servable symptoms and failure modes to modify the fault dependency matrix which can be helpful to build Accurate and efficient fault diagnosis. Dependency matrix is an organized diagnostic model to pinch the graded system-level fault diagnostic information. Organizing this information is typically based on the previously known knowledge and research. It's not enough to collect the information like symptoms, related diagnostic mechanism only once since technology is improving day by day. It is a challenging task to regularly update the D-matrix to have best result. To represent unstructured knowledge, ontology based data mining technology can be helpful which deals with grouping of unstructured data considering similarities and differences between them. Ontology is constructed which will describe the commonly observed correlation in fault diagnostic domains. By using different text mining algorithm, necessary artifacts like symptoms, failure mode and their relation with unstructured data can be discovered. In this paper, various ways are mentioned to create D-matrix with the help of available data like engineering design, data source and also by using text mining techniques like document annotation, term extraction, and phrase merging. The association in faults and their causes are mapped into D-matrix by using engineering knowledge. Engineering knowledge like engine control, mode of failure, data analysis, effects after failure etc. scene development of diagnostic matrix, takes much of efforts and time as compared to text mining techniques.*

**Keywords:** Ontology, D-Matrix, Data mining, Unstructured data, Diagnostic

## 1. Introduction

Normally, developed system works in its pre recognized working conditions and done with its given task as stated. There is nothing to worry about the system until it is working correctly and gives acceptable outcomes. If the result of the system is not as per the expectations, fault is introduced in system. Identification of faults and its correction is a subfield of control engineering which relate with supervising a system, identifying when a fault has occurred, what are the reasons behind it and find out the type of fault and its location [3]. It is necessary to find out the root cause of a fault because there may be possibility that other interconnected subsystems may also give fault indications that may possibly hide the root cause.

Systems like On-board diagnostics (OBD) referring to a vehicle's self-diagnostic and reporting capability. OBD system has microcontroller based processing system which is used in automatically controlled devices such as automobile engine control systems, medical devices [5]. This system is able to diagnose faults, notify user of any abnormal condition and also indicate the cause of faults. After resolving the various problems it is necessary to note down its causes, effect of the cause on the system in structured manner so that this information can be used later while developing the system so as to make it perfect.

The purpose of Text Mining is to process unstructured data, fetch out meaningful indices from the textual data using mining algorithms. In order to develop an ontology system for the fault diagnosis of automobile systems, it is necessary to analyse numerous concepts and relationships exhibited. D-matrix is constructed using an ontology based text mining

method for accurate and efficient fault diagnosis in automobile systems.

## 2. Literature Review

Literature on D-Matrix from unstructured data using Ontology & Text Mining is classified into Text mining, Fault diagnosis and Ontology.

### A. Text Mining

“Text mining” is used to describe the application of data mining techniques for automated discovery of useful or interesting knowledge from unstructured text [7]. Several techniques have been proposed for text mining that contains decision trees, association rule mining, conceptual structure, rule induction methods and episode rule mining. The task of information extraction (IE) is pinpointing specific items in natural-language documents to transform text into more structured data which is then mined for interesting relationships [2].

Text mining also searches for patterns in unstructured text. In addition, Information Retrieval (IR) techniques are widely used for tasks such as matching document and grouping [8]. In [9], Prof. Felke had implemented an application using D-matrix technology to find out dependencies between symptoms, failure modes and repairs by analyzing the structured service manual data. But the model that is too general will not provide the required accuracy.

### B. Fault diagnosis

Fault detection and diagnosis is a main part of many operations which manage automation systems. Fault

diagnosis include fault detection, fault isolation & fault identification. Fault detection: Indicating if there is a fault. Fault isolation: Determining where the fault is. In Fault isolation, when an unexpected outcome is found, the negative outcomes are limited. By limiting the scope of problems minimize the degree for damage and makes systems easier to maintain [10]. Detection + Isolation = Diagnosis. Fault identification: include Determining the size of the fault & Determining the time of onset of the fault.

In [11], a FDI approach used which is based on analytical redundancy to achieve maximum robustness by decoupling the effects of faults and errors. But analytical redundancy-FDI method is applied on non-linear discrete time systems only.

Prof. Singh had implemented a paper on Dynamic multiple fault diagnosis used for performing diagnostic inference for multiple failure modes used in aircraft and automobiles require multi-state component models with multiple test outcomes to reduce complexity in detecting multiple failures and also need to improve convergence[12].

### C. Ontology

Ontology is the study of nature of being, becoming, reality, what is existing as well as the basic categories of being and

their relationship. Ontology deals with questions concerning what entities exist or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences. Ontological engineering have become an efficient methodology for knowledge representation and management in many domains and tasks. Design, methodologies and approaches of ontology are very important factors to build ontologies for specific task. The ontological engineering methodology is widely used in many aspects of cooperative information systems, information retrieval and extraction, knowledge representation, DBMS, computer and information science [6]. Ontology defines “a set of representational primitives with which to model a domain of knowledge or discourse”. Prof. Noy and McGuiness [4] consider that an ontology is composed of classes (called concepts), properties of each concept (slots) and restrictions on slots (facets).

Prof. Wang has done research on fault diagnosis for power transformer using ontology which involves integration of methods using ontology for monitoring and diagnose power transformer faults. But the ontology based method lack in efficiency and veracity of fault diagnosis for power transformer [13].

Name of Author	Paper	Advantages	Disadvantages
P.M. Frank	Fault diagnosis in Dynamic Systems using analytical and Knowledge –based redundancy	Achieve maximum robustness by decoupling the effects of faults and errors.	Analytical redundancy-FDI method applied only on dynamic systems
O.Benedittini	State-of-the-art in integrated vehicle health management	Provision of a proactive decision support capability, Benefits from reduced occurrences of faults.	Hw/sw req for adopting IVHM are very costly. Fails to operate and maintain on complex assets.
D.Wang	Ontology-based fault diagnosis for power transformers.	Minimize the risk of failures by integrating transformer diagnostic method using ontology.	Lack of efficiency and veracity of fault diagnosis.
T.Felke	Application of model-based diagnostic technology on the Boeing 777 airplane.”	Identifies the dependencies among failure modes, symptoms and repairs with appropriate level of resolution	Lack of accuracy
S. Singh	Dynamic multiple fault Diagnosis	It is used to perform fault diagnostics for multiple failure modes	Lack of convergence, high complexity, multiple times fails to detect all failure modes.

## 3. Proposed System

### A. Fault Diagnosis Ontology

Ontology is a mechanism that describes the concepts and also the relationships that hold between those concepts observed in the domain of vehicle fault diagnosis. In order to develop an ontology system for the fault diagnosis of automobile systems, it is necessary to analyse numerous concepts and relationships exhibited.

### B. Ontology-Based Text Mining

#### i. Document annotation

The document annotation helps to filter out the information that is not related for analysis and it provides a specific background for the reliable understanding of the data.

#### ii. Term extraction

Using this phrase, the vital terms desirable for the development of a D-matrix, i.e., symptoms and failure modes are extracted by using the term extractor algorithm.

#### iii. Phrase merging

Here the same failure mode phrases that are generally written with the help of an conflicting vocabulary are merged into a single, consistent failure mode phrase using phrase merging algorithm.

## 4. Conclusion

In this paper, we have presented an approach of Development of D- matrix using text mining which is based on ontology by which we can store unstructured information obtained during fault recognizing & fault solving practices.

Identification of faults and its correction is a subfield of control engineering which relate itself with supervising a system, identifying when a fault has occurred, what are the reasons behind it and find out the type of fault and its location. Manually it is impossible every time to fetch out the relevant information from raw data. As no one is familiar to every defect and its symptoms, exact match of faults and its related solution can only be obtained by D-matrix.

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