

Positioning Physical, Information and Communication System Objects Toward Interdisciplinary Residual Lifecycle Artefacts

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Introduction

Data powers autonomous decision making across the whole product lifecycle, gathered from a heterogeneous range of sources. At the University of Bradford's Automotive Research Centre, in the Advanced Automotive Analytics (AAA) research unit, we address this multidisciplinary problem with a constituent-based domain-independent framework, confronting the challenge at the object-level of design.

Physical System (PS) Objects

Engine \rightarrow DOC \rightarrow DPF \rightarrow SCR \rightarrow ASC



Figure 1. PS - Aftertreatment Subsystem

Problem

The Multidisciplinary Problem in PIC Systems (an Automotive Perspective)

- Physical, Information & Communication (PIC) systems are divergent disciplines. They contrast in functional & non-functional product lifecycle requirements.
- Data comes from heterogeneous sources, increasing exponentially apace with customer expectations.

At AAA we address the issue with a multidisciplinary artefact.

Information System (IS) Objects

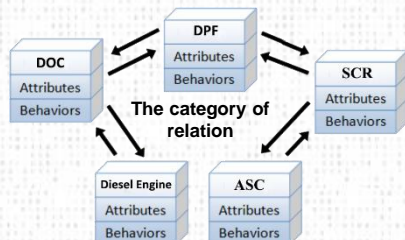


Figure 2. IS - Aftertreatment Subsystem

Solution

Methodology: Using ontological design & axiomatic categorisation we apply low-level logic to data objects for other, more complex, mathematical statements in higher level applications.

Aims and Objectives

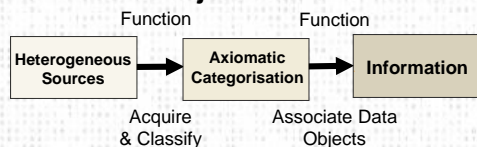


Figure 3. Function Model - Analytic Model (Bottom Up): Supports Data Acquisition, Classification, & Object Association processing

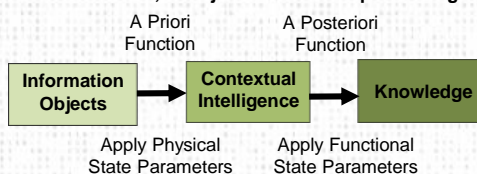


Figure 4. Function Model - Synthetic Model (Built on top): Supports the Management & Governance of contextual intelligence

Methodology

Axiomatic Categorisation

In this case, logical axioms are determinations of time according to rules, which relate to:

- the series in time
- the content in time
- the order in time &
- the complex or totality in time

Axiomatic categorisation provides IS objects with simple logic (mathematical statements) that serves as a starting point for more complex statements in higher-level applications. Dynamic data is associated with PS components (Fig 1) through IS objects (Fig 2) - inheriting associations with other components, thus other data, via their parent component associations.

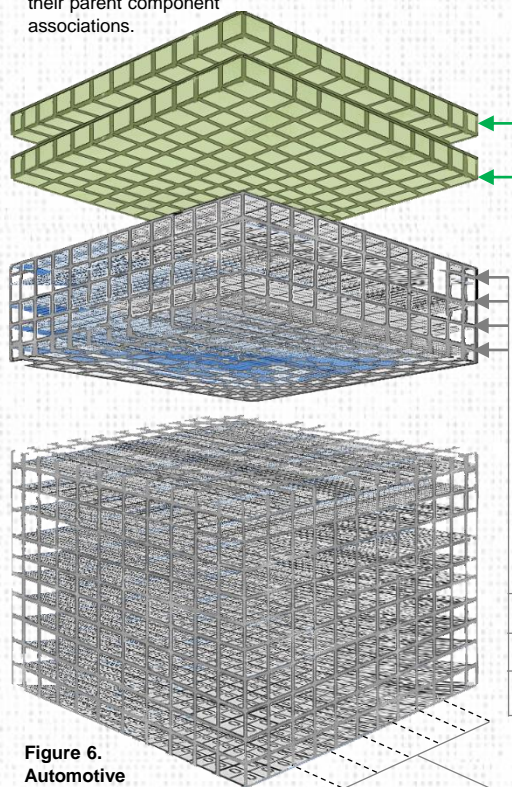


Figure 6. Automotive Analytics Factory

Future Work

Physical System State Parameters (PSSP)

P: The physical interaction between components

E: Energy transferred from one component to another

I: The information is transferred at the interface

M: There is a material exchange

PS components represented as IS objects are connected via the PSSP (Fig. 5). Future work will extend the PSSP model to include functional interdependencies, while real time data detects faults through the reciprocity of action & reaction between physical components & associated data, whereby:

- reciprocal causality of physical component failure in respect of fault detection events, is the coexistence of the determinations of one component with that of another, &
- causality of fault detection event, when posited, is always followed by something else (other events in other components), insofar as a 'particular cause' must be concurrent with or antecedent to a 'particular event'.

The fingerprinting model in Fig. 7 represents 5 fault detection scenarios, each one corresponding to a particular event (i.e., zone 1 = fault in Diesel Engine; zone 2 = fault DOC; etc.).

Categorisation provides structure to contextualise observed events.

In the Category of:

Quantity

- Universal
- Particular or
- Singular

Relational

- Categorical
- Hypothetical
- Disjunctive

Quality

- Affirmative
- Negative or
- Infinite

Modality

- Problematic
- Assertoric
- Apodictic

Axioms are the subject:

Of Quantity

- Unity
- Plurality &
- Totality

Of Relation

- Inheritance
- Causality &
- Community

Of Quality

- Reality
- Negation &
- Limitation

Of Modality

- Possibility
- Existence &
- Necessity

Connecting Everything

Axioms in the Category of *relation* associate IS objects to each other in all time through:

- Inheritance / Subsistence** - is the permanence of the real in time, the idea of substance is the idea that something 'is', it has an 'enduring identity', continuity in time
- Causality** - of a thing as the real which, when posited, is always followed by something else, the cause must be the concurrent with, or antecedent to the effect.
- Community** - as the reciprocal causality of substances in respect of their events, is the coexistence of the determinations of the one with those of the other (reciprocity of action & reaction).

Machine Learning

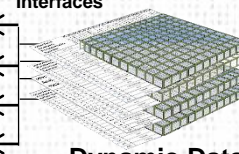
- Life Prediction Modelling
- Stochastic Simulation
- Bayesian Networks
- Data Governance

	A1	A2	A3	A4	A5
Interface Analysis Aftertreatment System (PSSP)					
A1 Diesel engine					
A2 Diesel Oxidation Catalyst					
A3 Diesel Particulate Filter					
A4 Selective Catalytic Reduction					
A5 Ammonia Slip Catalyst					

Figure 5. PSSP Boundary Interfaces

PSSP Relationships

- Powertrain System
- Lubrication system
- Oil & Vacuum Pump
- Aftertreatment System



Dynamic Data

- Input Real Time Data
- Engine control Unit (ECU)
- Data Over the Air (DOTA)

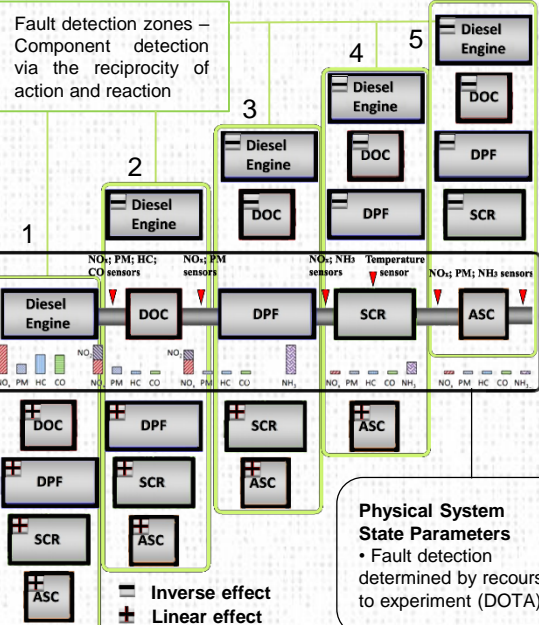


Figure 7. Component Fault Detection & System Failure Prediction Model