Proceedings for Panel: Education and Professional Development Workshop- PHM Taxonomy

Aim: To summarize for the wider community the issues identified by the panelists and the audience and identify collective priorities and recommendations for way(s) forward in a concise format for the panel chair to complete and submit

Panel Summary

The PHM Society mission emphasizes free and unrestricted access to PHM knowledge, promotion of interdisciplinary and international collaboration in PHM and leading the advancement of PHM as an engineering discipline. 'Products' for PHM education and professional development accessible to the whole community contribute to all of these aims.

The PHM Taxonomy under development offers a common basis for understanding PHM domains, and skill levels and advancement. The PHM Continuing Professional Development Guidelines offer personal and organizational career planning and enhancement for the PHM community as a whole.

This workshop format will validate and advance the scope, content and applications of these two products to serve the widest domains of PHM and its stakeholders. Draft versions of the products will be made available in advance through updates to the existing PHM Society forums

Speakers/Presentations

Karl Reichard and Jamie Coble (Chairs and members of the PHM Board Committee on Education and professional Development): Introduction- PHM Needs, Taxonomy proposal, Why a taxonomy- employers, practitioners, trainer, Competencies- entry, working and mastery levels, Domains within PHM, Target Domains for this workshop, Workshop format/process.

Summary of Key Issues

The two chairs and nine dedicated volunteers workshopped the taxonomy details for two of the domains:

1. Analytics with sub-domains:

    a. Data pre-processing

    b. Feature extraction

    c. Feature selection

    d. Classification- methods, metrics

    e.   Regression- methods, metrics

    f.   Optimization- methods, metrics

    g.   Model Fusion

    h.   Anomaly Detection

    i.   Fault Isolation- observability, coverage

    j.   Prognostics- specialized methods, metrics (e.g. latency)

    k.   Data Fusion by data types

    l.   Special Issues with time series data

    m. Special Issues with nominal data types

    n.   Reasoners- meta-classifiers, Bayesian, fuzzy logic

2.   Verification and Validation with sub-domains

    a.   Needs analysis

    b.   Risk Analysis

    c.   Metrics, uncertainty/confidence and evaluation

    d.   Methods

Results

Results of discussions are included for general comments as well as specific inputs for the Entry-, Working- and Mastery-level capabilities.

Verification and Validation

a. Needs analysis - Change to REQUIREMENTS analysis (what goes into writing the requirements?) Definition of metrics and confidence levels is part of requirements definition.

E - Compile requirements. Prioritize requirements.

W - Define metrics for demonstrating requirement met. <-- does this go here or in c?

M - Translate from systems view (or other domain) to analytics view. Understand how requirements impact the project and work - resource allocation, team development, time required. Evaluate what gets "the most bang for the buck" among requirements/needs. Understand function, integration, safety, etc. - with significant domain knowledge. Understands limitations of PHM capabilities to create realistic requirements.

b. Risk analysis - Two levels of risk analysis: (1) how things fail (FMECA) (2) how false negatives happen in high risk events

> E - Conduct FMEA and compile results.
>
> W - Understand the impact on the system and direct impact on other systems.
>
> M - Understand how false negatives happen in high risk events. Integrate regulatory constraints on risks identified in the analysis.

c. Metrics, uncertainty/confidence, evaluation - what do we mean by "metrics"? Should metrics really be included in requirements? Maybe this is demonstrating compliance with metrics?

> E - Execute V&V activities (defined by someone else).
>
> W -
>
> M - Defining V&V cases to demonstrate compliance with requirements and metrics.

d. Methods (no inputs)

e. Communication and reporting?

> E -
>
> W -
>
> M - Clearly communicates results to a variety of stakeholders

f. DOE and testing

> E - Implements a test plan
>
> W - Defines a test plan
>
> M - Models uncertainties and evaluates confidence from test plan results

General comments

1. Can we divorce V&V from analytics/FMECA?
2. Should we separate validation from verification?

   Validation - do we have the right requirements (front end)?

   Verification - did we build it correctly (back end)?

3. What things are really unique to PHM versus basic engineering skills?
4. How does this generalize across various fields and maturity of organization?

5. How do we account for complexity of the system (component versus full system) in entry through mastery levels? Maybe the line between working and mastery is most affected by system complexity?

Analytics

Generic level definitions

Entry level - Use existing tools on well-conditioned data sets

Working level - Can deal with poorly defined data or situations (poorly conditioned data), using existing techniques and tools. Use heterogeneous data sets (e.g., time series data and maintenance records)

Mastery - Use new techniques and tools, combine existing tools in new ways

a. Data pre-processing

Use generic

b. Feature extraction

Use generic

c. Feature selection - progress through increasingly complex systems. W/M - appreciate interactions of subsystems and components.

E -

W - Use domain knowledge to ensure features are physically meaningful. Appreciation of limitations imposed by data - noise, space covered, etc.

M - Understand and account for interactions of subsystems and components. Define data or tests necessary to demonstrate and validate feature importance.

d. Classification - methods and metrics

Use generic

e. Regression - methods and metrics

Use generic

f. Optimization - methods and metrics

use generic

g. Model fusion - is this a mastery level skill for other subdomains?

E - No entry-level option!

W -

M -

h. Anomaly detection

     Use generic

i. Fault isolation - observability and coverage <- progress with complexity of the system.

     E -

     W - Define measurement needs to improve observability and coverage?

     M -

j. Prognostics - specialized methods and metrics (e.g., latency) – no input

k. - Data fusion by data types – no input

l. Special issues with time series data – no input

m. Special issues with nominal data – no input

n. Reasoners - meta-classifiers, Bayesian, fuzzy logic <-- Is this an EXPERT-level for d. classification?

General Comments

1. Where does data simulation fall to support analytics? (possibly in modeling)

2. IS THERE A MINIMUM LEVEL OF KNOWLEDGE IN EVERYTHING (across all domains) NEEDED TO BE A "MASTER" or PHM PRACTITIONER?

Recommendations for Way Forward

1. Continue Society involvement in education and professional development, especially to complete the taxonomy under the existing EPD Committee of the Society Board.

2. Activate an education and professional development interest group from the broad PHM community starting with the attendees and interested registrants from past PHM conferences

3. Continue EPD oriented panels or workshops at all PHM events

4. Implement an EPD portal on the PHM website as an entry point for EPD information and past activities in this domain.

Prepared by the panel chairs with help from the EPD Chair, Jeff Bird.