Are Standards Beneficial for AI in PHM?

Moderators

Greg Vogl (Project Leader, Engineering Lab, NIST)

Jeff Bird (Consultant, TECnos)

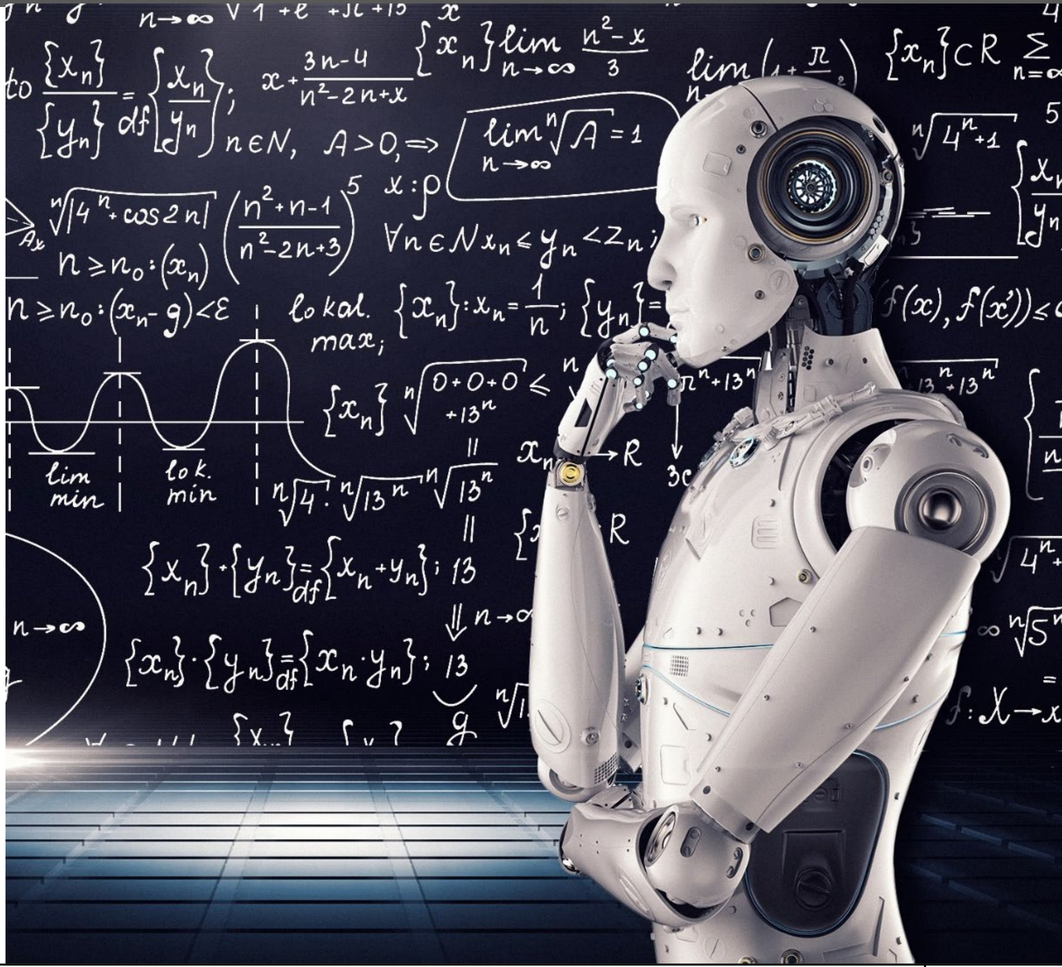
Panelists

Peter Bajcsy (Project Leader, IT Lab, NIST)

Kai Goebel (Director, Intelligent Systems Lab, SRI Intl.)

Neil Eklund (Principal Scientist, Oak Grove Analytics)

Xiaodong Jia (Assistant Professor, U. Cincinnati)



Panel outline

- 90-minute session
  - 5 minutes about standards for AI
  - 55 minutes of talks from 4 panelists
  - 30 minutes of Q&A with the audience
- **GOAL:** Top priorities for PHM AI standards

Peter Bajcsy

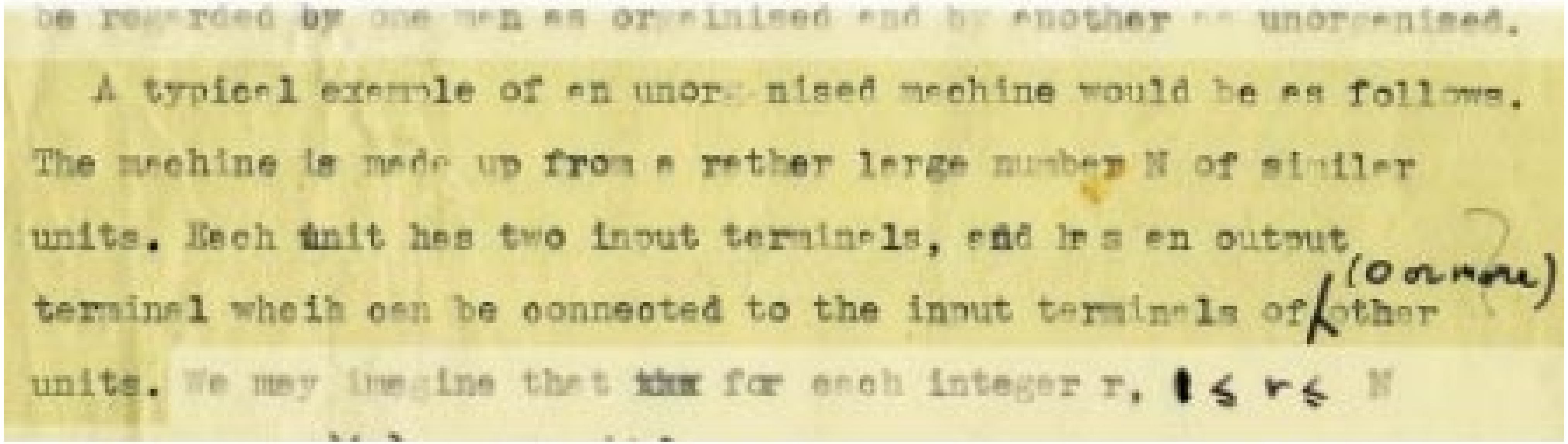
Kai Goebel

Neil Eklund

Xiaodong Jia

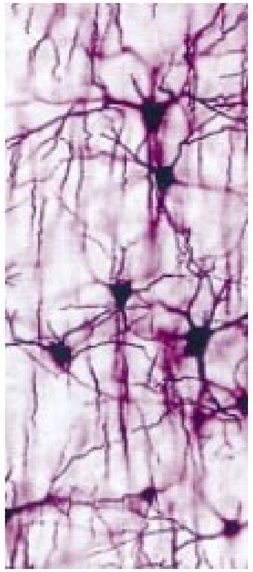
Fun fact!

➢ Alan Turing, the father of modern computing, had anticipated computation for the brain. His unpublished papers, discovered 14 years after his death, anticipated development of connectionist architectures (deep learning!):



be regarded by one man as organised and by another as unorganised.

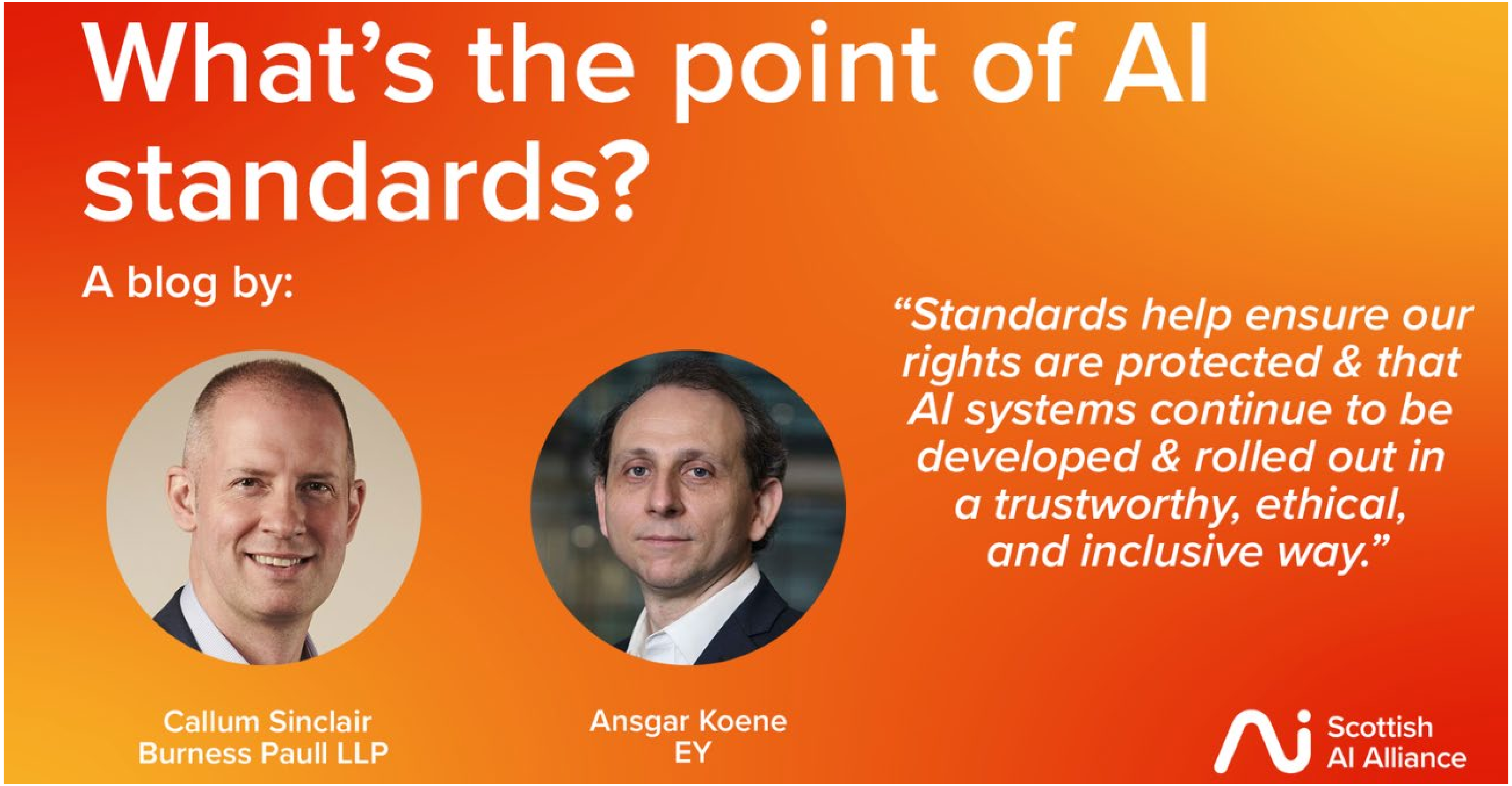
A typical example of an unorganised machine would be as follows. The machine is made up from a rather large number N of similar units. Each unit has two input terminals, and has an output terminal which can be connected to the input terminals of (0 or more) other units. We may imagine that for each integer r, 1 ≤ r ≤ N



http://www.cs.virginia.edu/~robins/Alan_Turing%27s_Forgotten_Ideas.pdf

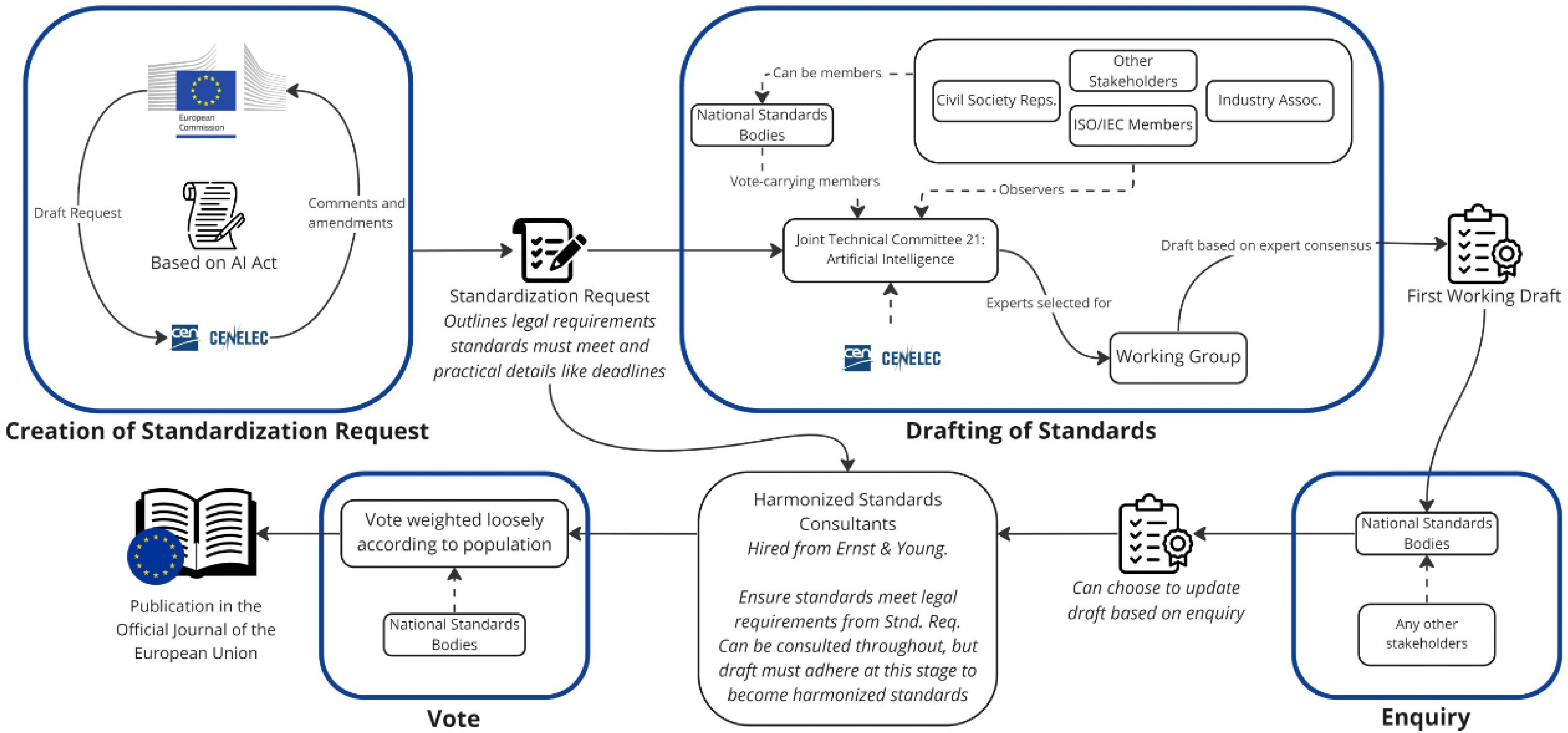
https://medium.com/intuitionmachine/challenges-for-ai-standardization-eab1de4fab0b

Standards can help AI to be trustworthy, etc. …



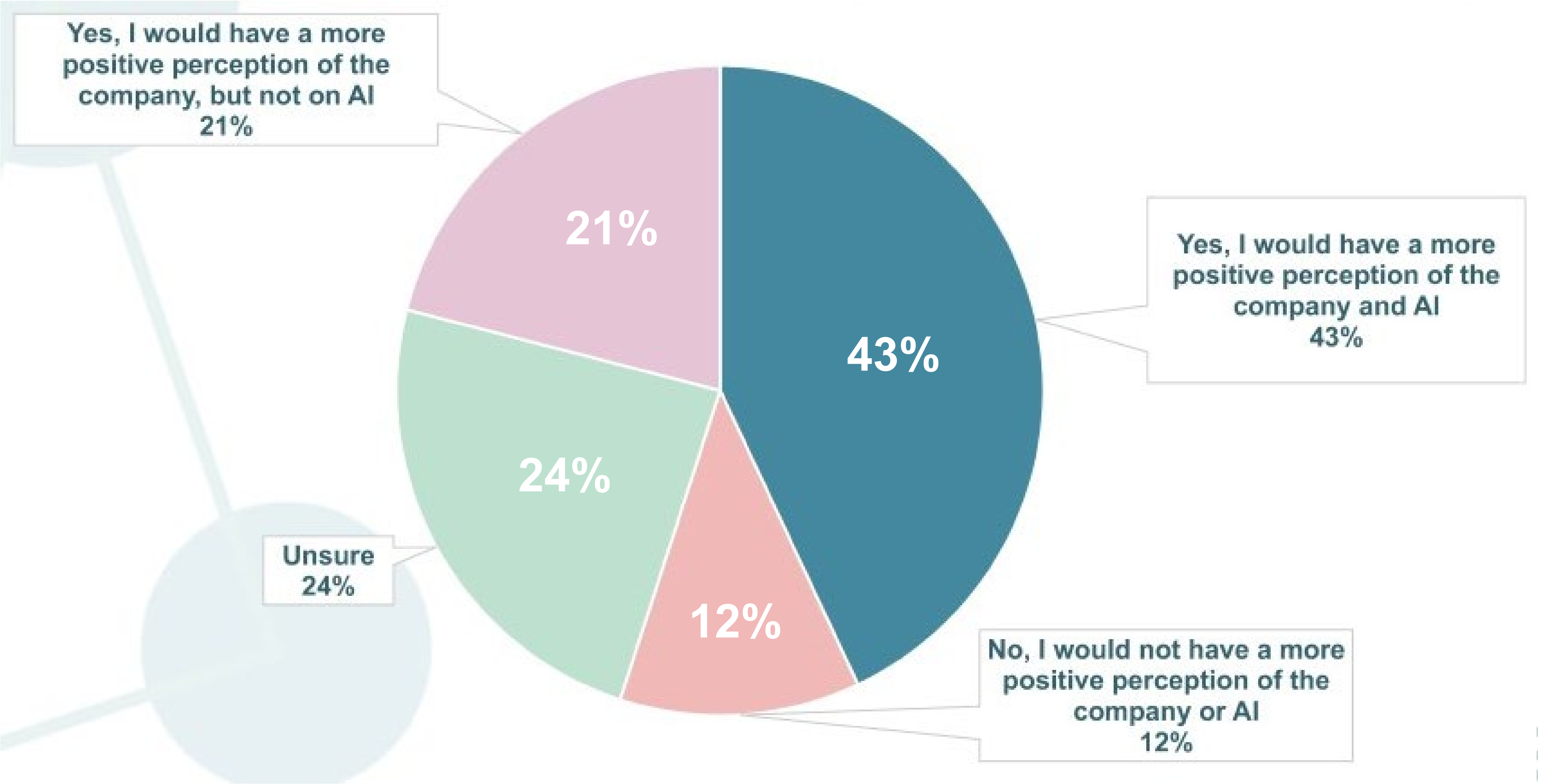
https://www.scottishai.com/news/whats-the-point-of-ai-standards

… but standards development process is LOOOOOOONG!



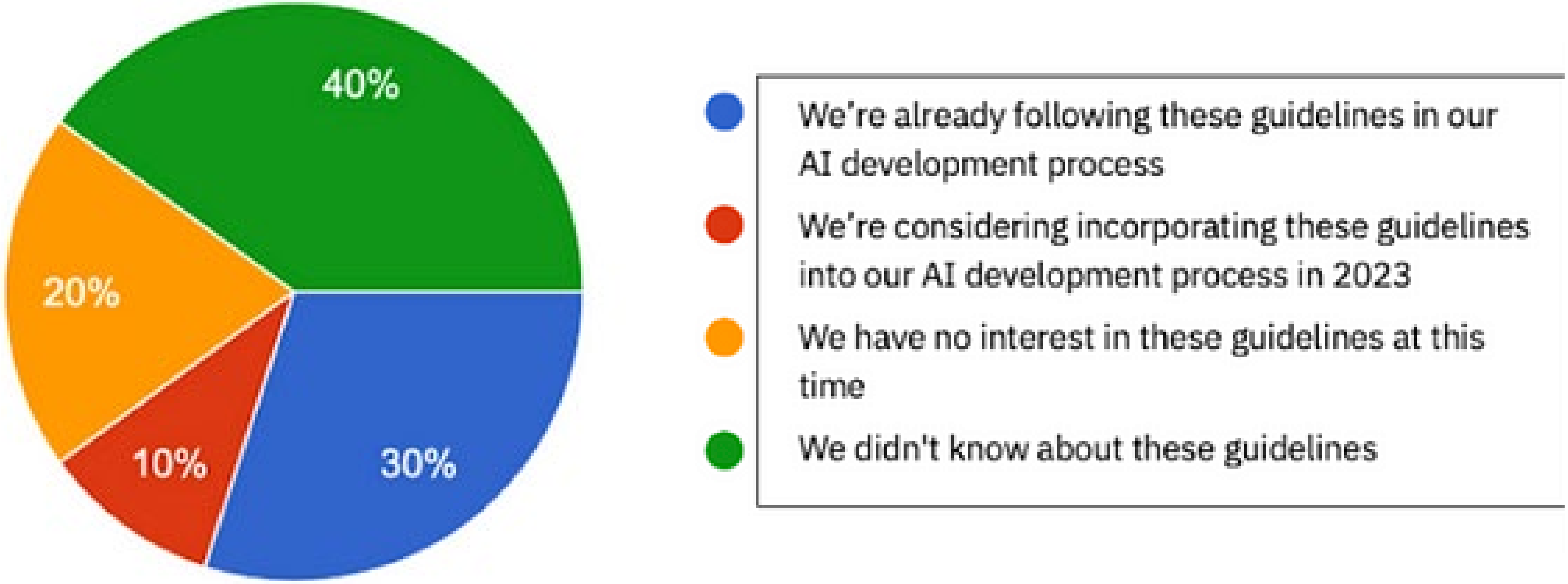
https://artificialintelligenceact.eu/standard-setting/

AI policies affect consumer perception of companies …



https://venturebeat.com/ai/report-43-of-consumers-feel-transparency-is-key-for-positive-ai-innovations/

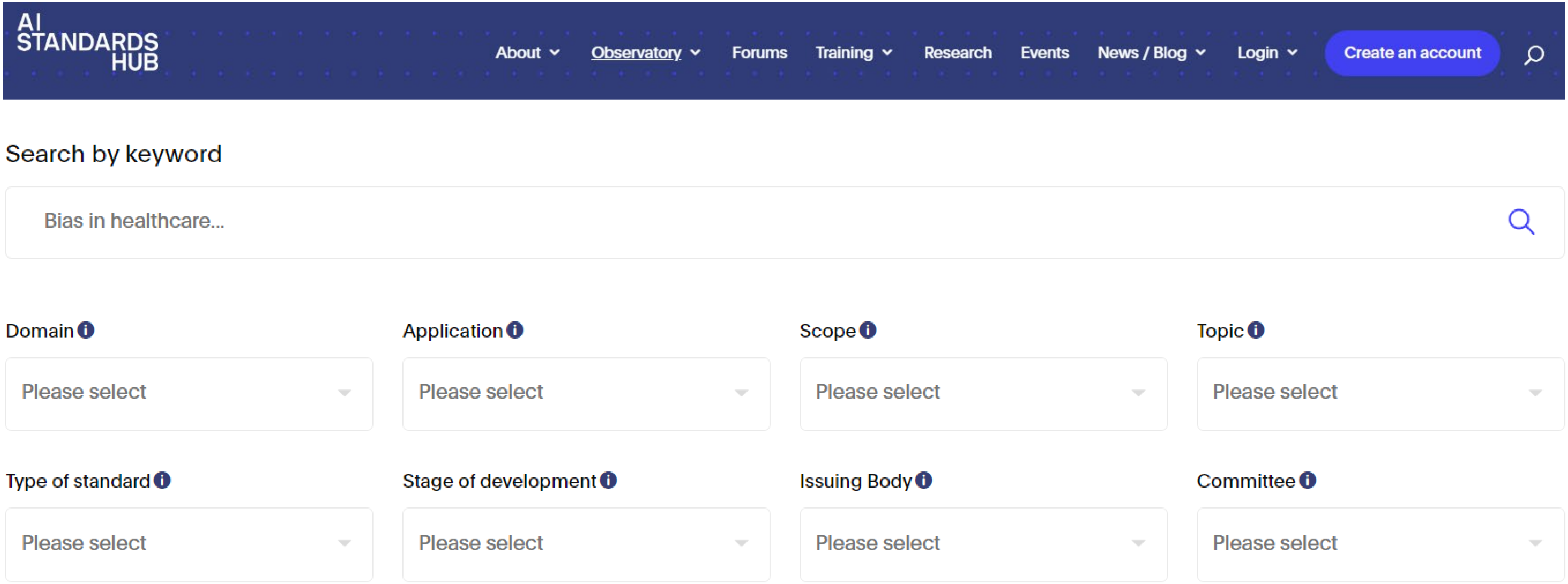
… but many companies aren't aware of AI standards



https://blog.citadel.co.jp/an-overview-of-ai-standardization-and-regulation-in-2023-2fc6ddc88708

Did you know that 300+ AI-related standards exist?

- Free searchable **AI Standards Hub** by The Alan Turing Institute (UK)



https://aistandardshub.org/ai-standards-search/

Standards development organization (SDOs)

➢ So far, 22 standards-issuing bodies for AI, including:

https://www.holisticai.com/blog/ai-governance-risk-compliance-standards

Example AI-related standards

- **Foundational standards** (terminologies, foundational concepts, etc.)
  - ISO/IEC 22989: Establishes definitions and terminologies of aspects of AI systems. Covers 110+ concepts used in AI such as datasets, bias, transparency, & explainability.
  - ISO/IEC 23053: Provides framework to explain AI systems that use ML. Outlines various system components and respective roles within broader AI ecosystem.
- **Process standards** (management, design, quality control, governance, etc.)
  - ISO/IEC CD 42001: Template for responsibly integrating and using AI management systems. Currently at draft stage. Useful for conformity with laws, e.g., EU AI Act.
  - ISO/IEC 23894:2023(E): Guidance to manage risks from development, deployment, and usage of AI systems. Describes processes for AI Risk Management.
  - NIST AI Risk Management Framework (AI RMF): Framework to incorporate trustworthiness into design, development, use, and evaluation of AI systems/services.

https://www.holisticai.com/blog/ai-governance-risk-compliance-standards

Example AI-related standards (cont.)

- **Measurement standards** (measuring AI system's performance)
  - ISO/IEC DTS4213: Provides methodologies and metrics for measuring and assessing performance of classification algorithms and ML models.
  - ISO/IEC TR 24027: Provides measurement techniques and metrics for assessing bias in AI-enabled decision-making.
- **Performance standards** (thresholds for satisfactory AI system, etc.)
  - IEEE 2937: Establishes methodologies and requirements for benchmarking performance of AI servers and other AI High-Performance Computing (HPC) systems.
  - ISO/IEC AWI 27090: Guidance to address, detect, and mitigate information security risks, threats and failures in AI systems. Currently under development.

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Principal Scientist
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Xiaodong Jia
Assistant Professor
Univ. Cincinnati

Panelist Presentations

Standards for AI – Useful for Health Management?

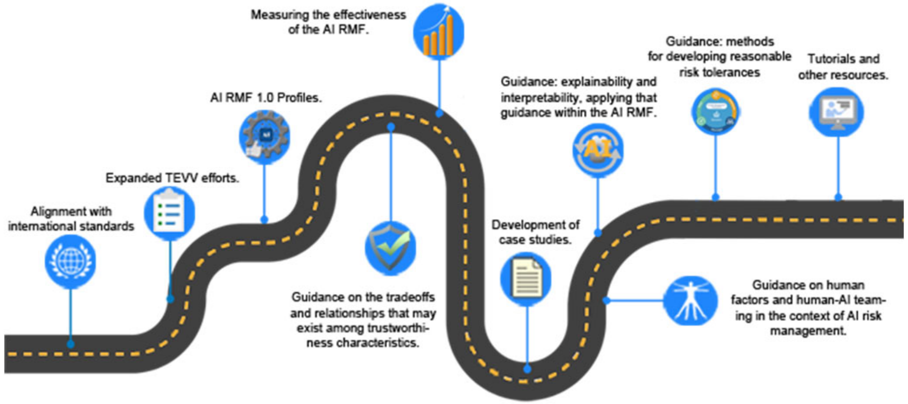
Peter Bajcsy, Ph.D.

National Institute of Standards and Technology (NIST)

The 15th annual conference on prognostics and health management society (PHM Society)
October 30, 2023

AI Activities @ NIST

- As mandated by Congress, NIST has developed a voluntary **AI risk management framework (AI RMF)** through collaboration with others across public and private sectors.
- On March 30, 2023, NIST launched the **Trustworthy and Responsible AI Resource Center**, which will facilitate implementation of, and international alignment with, the AI RMF
- **Testimonials:** Joint Oversight & Investigations and Research & Technology Subcommittee Hearing - Balancing Knowledge and Governance: Foundations for Effective Risk Management of Artificial Intelligence, October 18, 2023, URL



Standards for AI – Useful for Health Management?

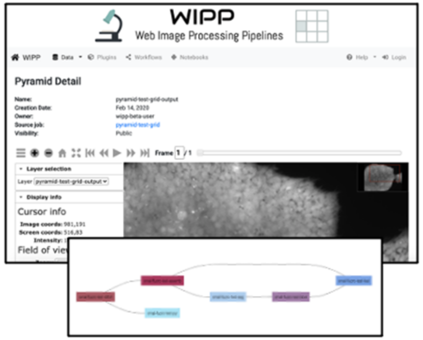
1. *Reproducible* Artificial Intelligence

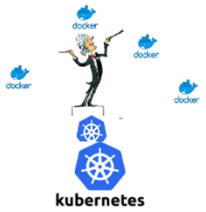
- Web Image Processing Pipeline (WIPP) Computational Environment

Design: WIPP Platform, Plugins, and Plugin Registry

WIPP Platform

Open-source web-based algorithmic plugin platform for distributed computations, online data exploration and trusted image-based measurements from terabyte-sized images





Cluster and cloud-ready

Source code plus deployment instructions:
https://github.com/usnistgov/WIPP

WIPP Plugins

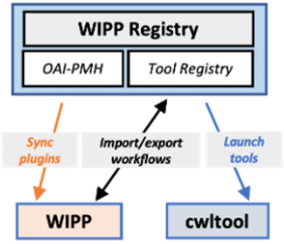
Interoperable containerized algorithmic plugins associated with a JSON plugin manifest .

Compatible with Docker, Singularity, Kubernetes, Slurm and Common Workflow Language (CWL).

Template:
https://github.com/usnistgov/fair-chain-compute-container

WIPP Plugin Registry

Registry for storing, sharing and searching interoperable containerized plugins and computational workflows



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https://cdcs.nist.gov/

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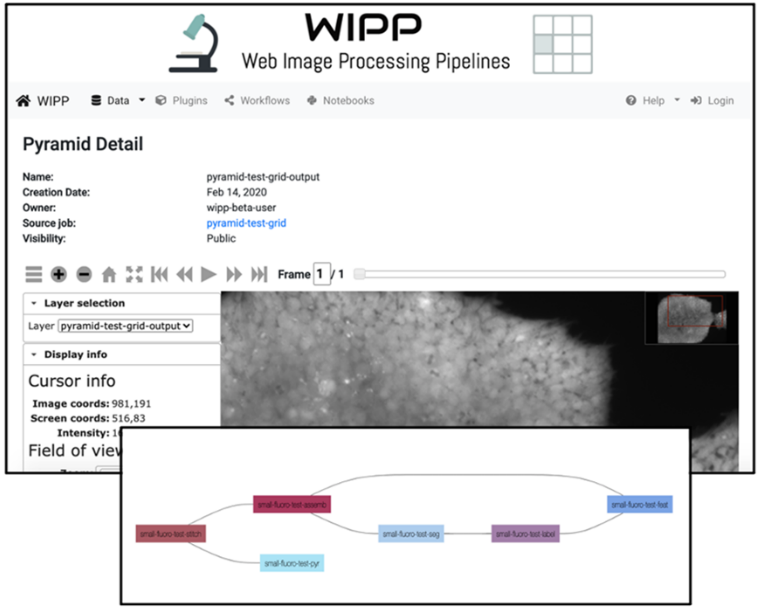
WIPP Platform

NIST



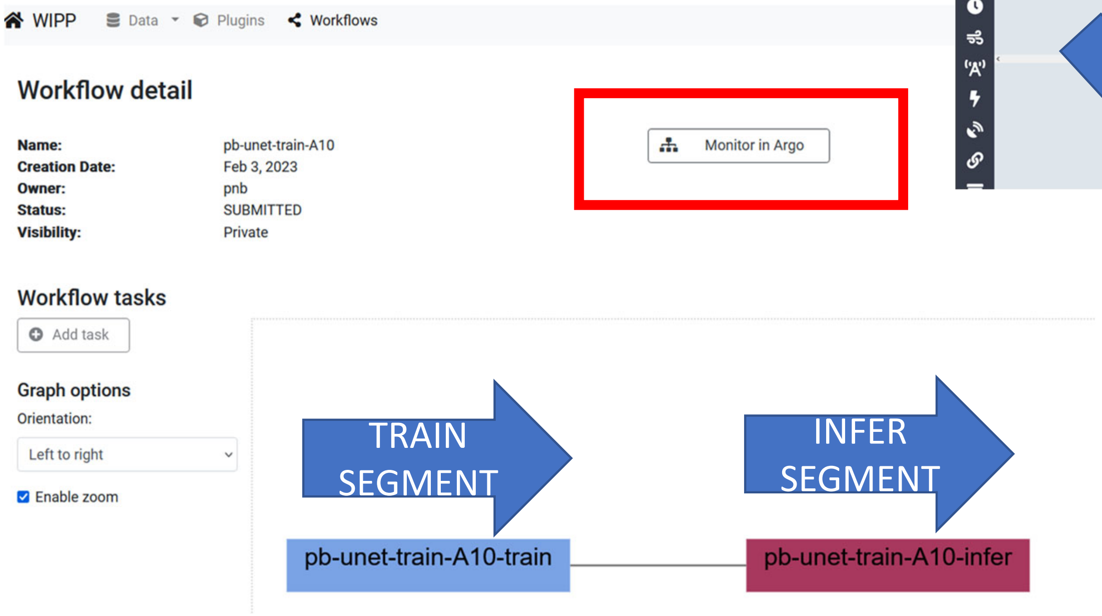
***From lab to cloud**: WIPP leverages **containerization** and **container orchestration** technologies **Docker and Kubernetes**, and its **cloud-agnostic design** allows for deployments on premises or in the cloud.*

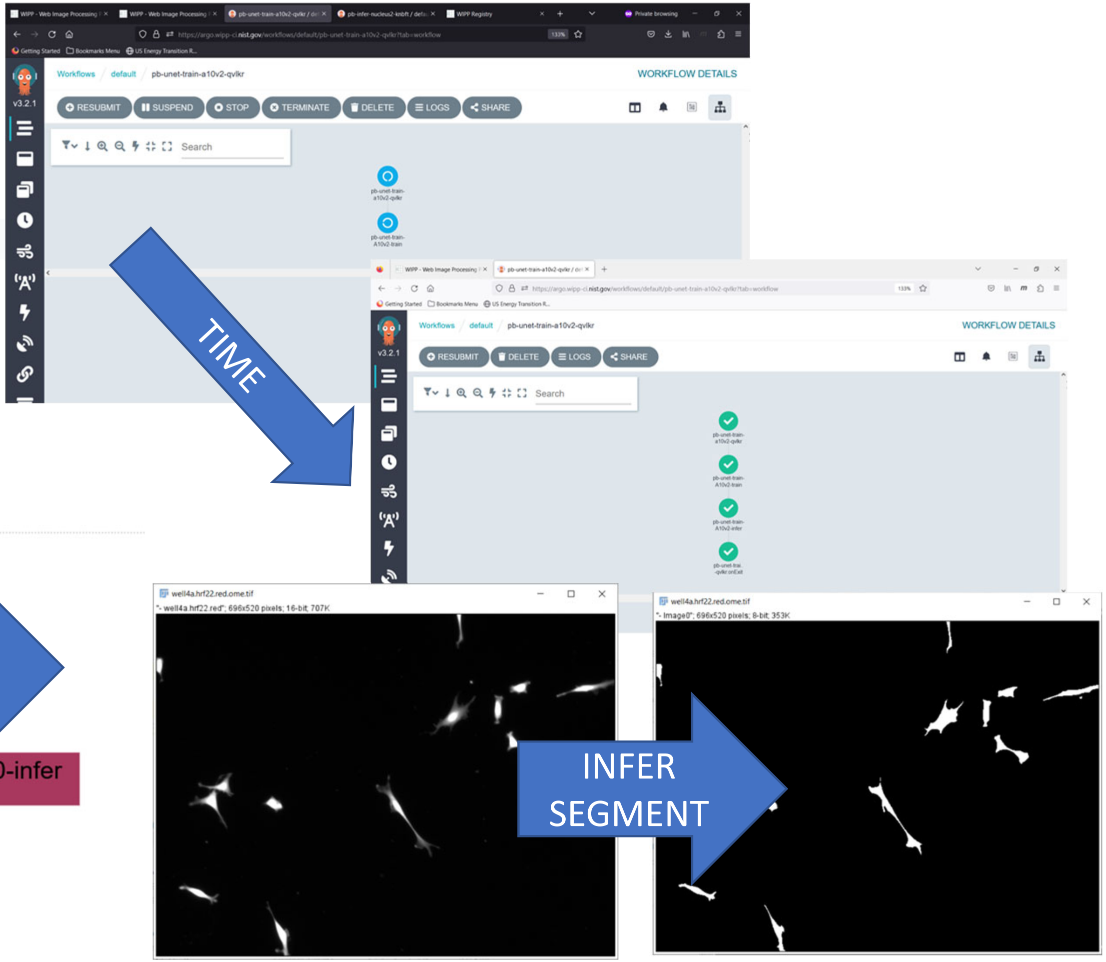
WIPP (*Web Image Processing Pipelines*) is a web-based and scalable open-source platform for distributed image processing computations, trusted measurements and online data exploration:

- User private workspaces (data upload and download, data visibility configuration),
- Online configuration and remote execution of workflows using containerized computational plugins,
- Data exploration tools (web based deep zoom interactive visualization of image datasets),
- AI-enabled (GPU support, TensorBoard integration, and image annotation tools).

WIPP Instance: Train & Infer Segmentation

Create a Workflow





- Interoperable plugins
- DAG workflow representation

Design: WIPP Platform, Plugins, and Plugin Registry

NIST

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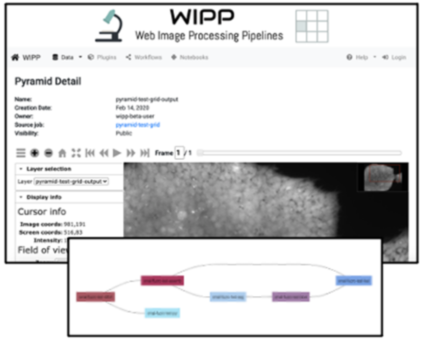

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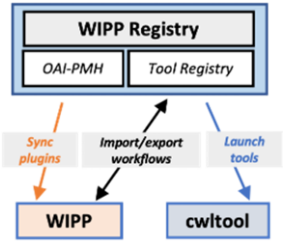

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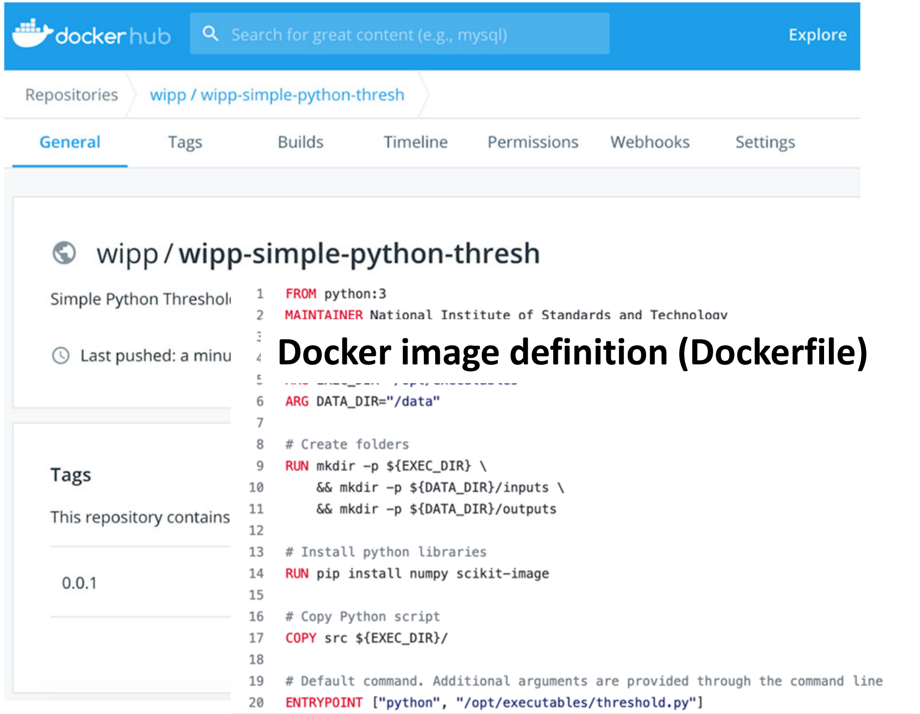
WIPP Plugins: FAIR Containerized Computational Software

Structure of a WIPP Plugin: Code packaged in a **container image** + **JSON plugin manifest** describing inputs, outputs and general information about the plugin



WIPP plugin as a Docker image available on DockerHub


```json
{
    "name": "wipp/wipp-simple-python-thresh",
    "version": "0.0.1",
    "title": "Simple Python Thresholding",
    "author": "Mylene Simon",
    "institution": "National Institute of Standards ar
    "repository": "https://github.com/usnistgov/WIPP-s
    "website": null,
    "citation": null,
    "description": "Simple manual thresholding",
    "containerId": "wipp/wipp-simple-python-thresh:0.0.1",
    "inputs": [
        {
            "name": "inputImages",
            "type": "collection",
            "required": true,
            "description": "Input images"
        },
        {
            "name": "threshold",
            "type": "number",
            "required": true,
            "description": "Threshold value"
        }
    ],
    "outputs": [
        {
            "name": "output",
            "type": "collection",
            "description": "Output images"
        }
    ],
    "ui": [
        {
            "key": "inputs.inputImages",
            "title": "Images collection: ",
            "description": "Pick a collection..."
        },
        {
            "key": "inputs.threshold",
            "title": "Threshold value: "
        }
    ]
}
```


Information about the plugin:
- name, version, description
- Docker image to use

Inputs description
- name, type, description

Outputs description
- name, type, description

UI description
- additional information to display on the form

WIPP plugin manifest (JSON file)

Design: WIPP Platform, Plugins, and Plugin Registry

NIST

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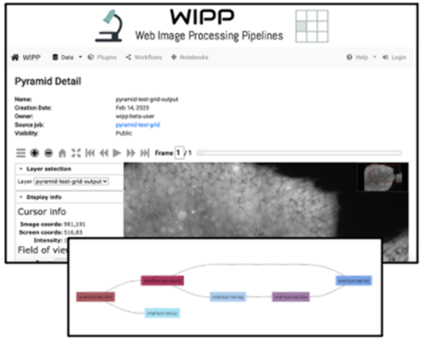

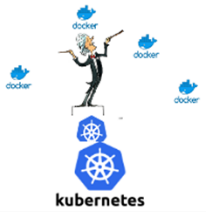

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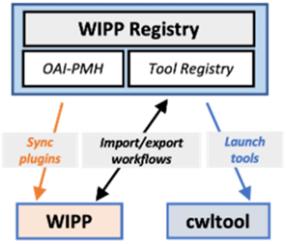

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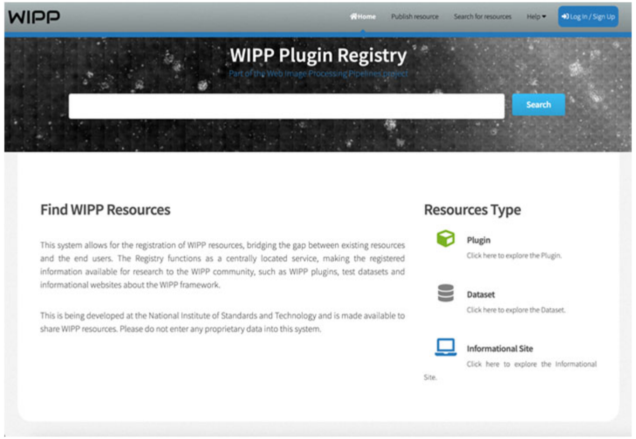
WIPP Plugin Registry

- **Challenge:** Finding and sharing reusable computational plugins and workflows of software-heterogenous algorithms.
- **Solution:** The **Web Image Processing Pipelines (WIPP) Registry** for WIPP Plugins, Datasets, and Workflows.



The **WIPP Registry** is based on the **NIST Configurable Data Curation System (CDCS)**, which supports:

- **FAIR** Data Principles (Findable, Accessible, Interoperable, and Reusable),
- **OAI-PMH** (Open Archives Initiative Protocol for Metadata Harvesting) Protocol for Data Exchange and Harvesting between registries, and
- **REST API** for data curation and exploration.

The WIPP Registry is powered by the NIST Configurable Data Curation System (CDCS)

https://cdcs.nist.gov/

Coming next:

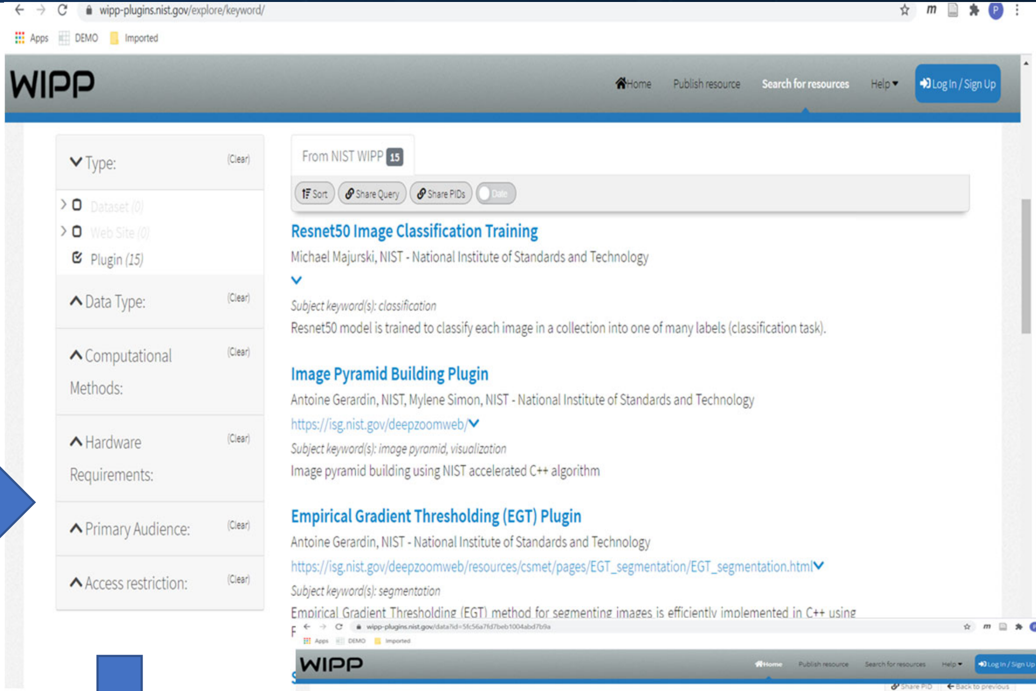
- **Global Alliance for Genomics and Health (GA4GH) Tool Registry API** integration (minimal API definition for exchanging, indexing, and searching containerized tools and workflows).

WIPP Plugin Registry

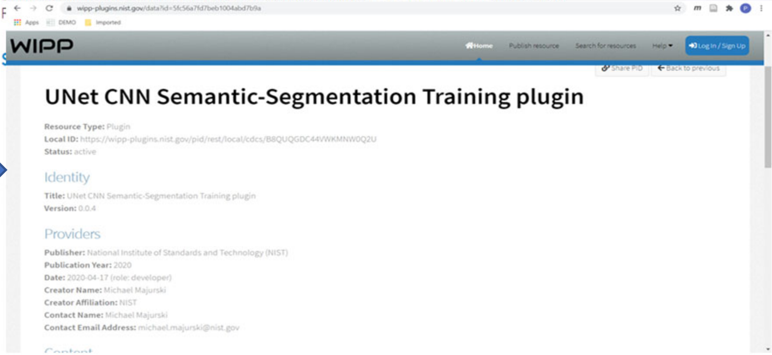
NIST

@NIST: https://wipp-plugins.nist.gov/

SEARCH



Register in WIPP



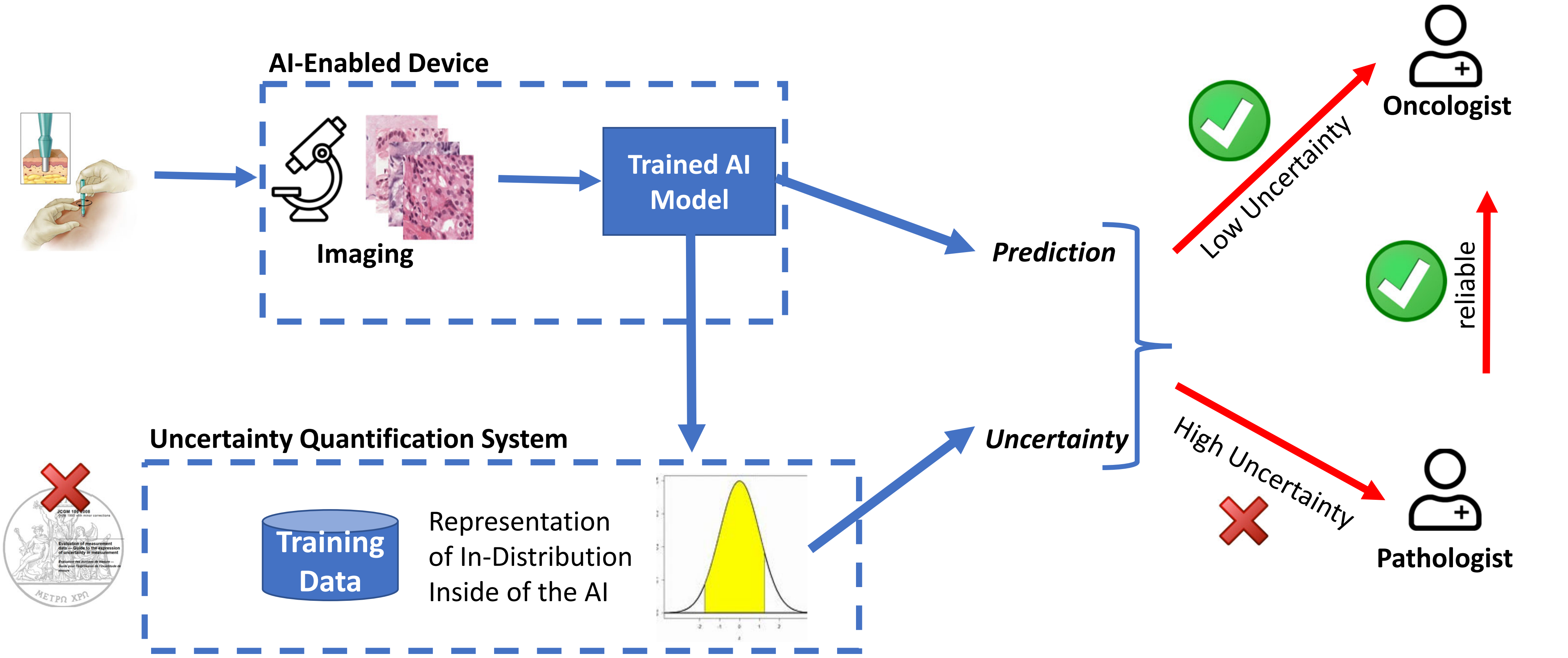
Standard programmatic interface

Standards for AI – Useful for Health Management?

2. *Standards* for Artificial Intelligence

- Guidelines for Uncertainty Estimation (GUM) for AI
- Information Representation & File formats
- Application Programming Interfaces (APIs)

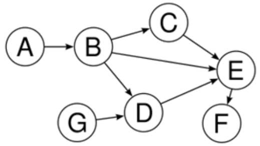
GUM for AI: AI-Enabled Medical Devices (Biopsy + Histology Based Diagnosis)



Standards in WIPP: Representations

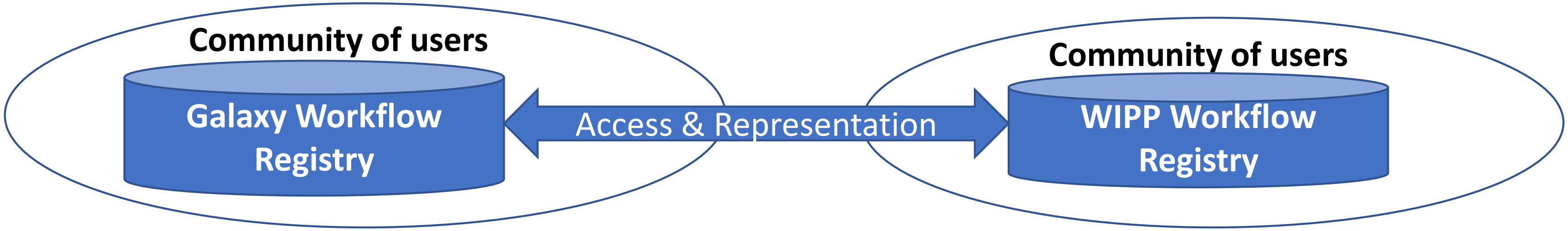
NIST

- **Data types**
  - AI models: Tensorflow, PyTorch, Open Neural Network Exchange
  - Image files: Open Microscopy Environment standard
  - Scalable pyramids: Deep Zoom .DZI, Pyramidal TIFF
  - Generic data
- **Software Containers**
  - Container size for transfer efficiency: Best practices for containerization
  - Interoperability of containerized algorithms
- **Computational Workflows**
  - Directed acyclic graph (DAG) representation
  - Current backend implementation: Argo Workflows, Common Workflow Language (CWL) export



Standards in WIPP: Interfaces

- **Software - Job schedulers:**
  - **Cloud**: Kubernetes + Argo (Past: HTCondor + Pegasus)
  - **HPC:** SLURM workload manager (in testing)
- **API standards**
  - Access AI models: Model Zoo Facebook, HuggingFace, BioImage. …
  - Access functionalities: REST APIs (Hypermedia as the engine of application state - HATEOAS, OpenAPI Specification - OAS)
  - Access workflows: Global Alliance for Genomics and Health (*GA4GH*)
  - Access image tiles: International Image Interoperability Framework API
  - Synchronize repositories & perform federated search: Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH)



Building Community Standards

- Collaboration with NCATS NIH on plugin development
- Deployment of WIPP at NIH, Cardiff University, Georgia Tech, etc.
- December 5-7, 2023: 2nd International Workshop on FAIR Containerized Computational Software

Interoperability of Web Computational Plugins for Large Microscopy Image Analyses

The workshop will bring together multiple research and development (R&D) communities focusing on big image analyses in computer cloud environments. Such analyses are frequently supported by implementing web client-server systems executing a wide spectrum of algorithms designed to extract image-based measurements, and perform image classification, object detection, object registration, object tracking, and object recognition. The purpose of this workshop is to discuss the bio-medical and bio-materials science application needs for big image analysis solutions, current open-source technical solutions, and community-wide R&D interests in defining inter-operable algorithmic plugins for web client-server systems designed for big image analyses.

Background:

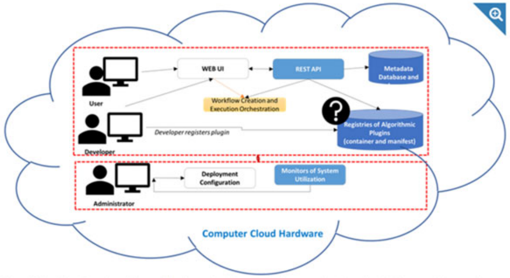


Figure 1: Workshop focus (question mark) in the context of users, developers, and system administrators analyzing very large images in computer cloud environments using a variety of client-server systems

There is an increasing interest in enabling discoveries from high-throughput and high content microscopy imaging of biological specimens and bio-material structures under a variety of conditions. As automated imaging across multiple dimensions increases its throughput to thousands of images per hour, the computational infrastructure

Read the Code of Conduct for NIST Conferences.

WORKSHOP

December 5 - 6, 2019

NIST, 100 Bureau Drive,
Gaithersburg, MD 20899
(Administration Building 101)

Registration closed on November 24, 2019.
Registration is $120 and includes
two Continental Breakfast and PM Refreshments

All visitors to the NIST campus must be pre-registered. There is no onsite registration for meetings held at NIST.

REGISTRATION CONTACT

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(301) 975-6602

TECHNICAL CONTACT

2nd International Workshop on FAIR Containerized Computational Software

With the increasing size of collected data, distributed computational environments provide an acceleration option for completing data analyses over very large data collections and for federated learning over many data collections. To run heterogeneous analysis tools written in multiple programming languages and with many dependencies on other software libraries, containerization of tools offers a valuable solution for software execution in distributed computational environments with heterogeneous hardware and software configuration at each computational node. To facilitate reuse of tools and creations of increasingly complex computational analyses (workflows), *containerized software tools must be interoperable as they are chained into workflows*. This topic led to the 1st workshop on Interoperability of Web Computational Plugins for Large Microscopy Image Analyses. The workshop report can be found at https://www.nist.gov/publications/interoperability-web-computational-plugins-large-microscopy-image-analyses.

The main goal for the workshop is to establish a community consensus on creating interoperable containerized computational tools that can be chained into scientific workflows/pipelines and executed over large image collections regardless of the cloud infrastructure components.

The discussion is intended as a follow-up on the 1st workshop on Interoperability of Web Computational Plugins for Large Microscopy Image Analyses and Request For Feedback/Comments on the preliminary manifest file specification posted at in the Federal Register (and in the specification GitHub repository).

Read the Code of Conduct for NIST Conferences.

WORKSHOP

December 5 - 7, 2023

Virtual Only

Register

This is a free event but registration is required to join.

REGISTRATION CONTACT

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TECHNICAL CONTACT

Peter Bajcsy
peter.bajcsy@nist.gov
(301) 975-2958

Challenge Questions

Challenge Questions

NIST

- How can standards enable FAIR AI-based measurements useful for health management?
  - **Concerns: findable, accessible, interoperable, reproducible (FAIR) attributes**
  - **Approach:**
    - 2nd International Workshop on FAIR Containerized Computational Software, December 5-7, 2023 (virtual), URL
    - Collaboration with FAIR Digital Objects Forum, URL
- How can metrology improve deployments of AI-enabled devices, systems, and systems of systems?
  - **Concerns: safety of deployments**
    - 692 FDA approved AI-enabled medical devices (October 2023)
    - 2022 Accident Stats report out of 400 crashes, 273 of these accidents involved Teslas, 70% of which used the Autopilot beta at the time.
  - **Approach:**
    - Foundational metrology to estimate uncertainty of each prediction
    - Work-in-progress

Questions:

peter.bajcsy@nist.gov

Live Demo

Registry: https://wipp-plugins.nist.gov/explore/keyword/653f0d4bb6eb4c00da2c7139

Plugins in WIPP: https://wipp-dev.nist.gov/plugins/6168f8b52e5f363929997b03

WF: https://wipp-dev.nist.gov/workflows/detail/6515824d71c5195befbfc0e3

WF Monitor: https://argo.wipp-dev.nist.gov/workflows/wipp/i2k-prep-2-7gzbl?tab=workflow

Result: https://wipp-dev.nist.gov/pyramids/651583e971c5195befbfc0f8

Standards for AI

Useful for Health Management?

Kai Goebel, PhD

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What is different about AI in PHM?

… and how can Standards help?

- Data
  - AI needs to deal with small data situations (e.g., few run-to-failure examples)
  - Standards
    - Articulate best practices for training (including LLMs)
    - Specify a framework for benchmarking and setting performance metrics
    - Define common data formats
    - Provide pathway for data integration and compatibility
- Open world
  - AI in PHM may need to deal with surprises in open-world situations
  - Standards
    - Show guidelines for dynamic learning algorithms
    - Provide guidelines for scalable AI solutions
    - Set benchmarking criteria and best practices for open-world AI in PHM
- Safety
  - AI in PHM may be bounded by regulatory constraints, performance guarantees, etc.
  - Standards
    - Define formal methods for V&V, traceability,
    - Set guidelines for the safe implementation
    - Provide mechanisms for Interoperability
    - Prepare recommendations to navigate regulatory requirements

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How Can Standards Support Innovation?

While standards can sometimes be seen as stifling, they could provide framework for innovation.

- **Common Framework for Collaboration**
  - Standards provide common framework that multiple stakeholders can use to collaborate.
  - With shared understanding of rules, AI developers can in principle work more effectively together.
  - Collaboration often leads to pooling of expertise and resources, which can drive innovation
- **Reduced R&D Uncertainty**
  - Clear guidelines and objectives help reduce uncertainty.
  - When researchers know what criteria a new product or technology must meet, they can focus their efforts more efficiently.
- **Benchmarking and Competition**
  - Some standards in AI, hopefully, provide benchmarks.
  - Competition to exceed these standards can drive innovation as companies seek to differentiate themselves by offering better, more efficient, or more sustainable products or services.

Standard
Package

Evening Standard

STANDARD

Ideal
STANDARD

Pakistan Standards

A KANSAS COMPANY SINCE
1949
STANDARD
BEVERAGE
SPIRITS WINE BEER

STANDARD

STANDARD
FIRE WORKS

Standard Life

STANDARD

STANDARD PROFIL

standard
logistics

Global Recycled
Standard

ROYAL
STANDARD

StandardAero

Standard Bank

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Oak Grove Analytics, LLC

Pros of General AI Standards

1. **Safety and Reliability**:
   Standards can provide a framework for developing and testing AI systems to ensure they operate safely and as intended. This is especially critical for systems used in healthcare, transportation, or any area where human lives may be at risk.
2. **Interoperability**:
   Standards can facilitate the interaction of AI systems from different vendors. For instance, if two AIs need to communicate, standards can ensure they "speak the same language."
3. **Transparency and Accountability**:
   With standard procedures and benchmarks, it's easier to understand how an AI system makes decisions. This can help in holding AI developers and vendors accountable for their products.
4. **Innovation Boost**:
   Standards can provide a baseline for development, allowing companies to innovate on top of a known foundation. This can speed up the development cycle and reduce redundant efforts.
5. **Ethical and Societal Considerations**:
   A unified standard can incorporate ethical guidelines, ensuring that AI developments consider human rights, privacy, fairness, and other critical societal values.

Cons of General AI Standards

1. **Stifling Innovation**:
   Overly rigid standards can hamper creativity. If companies have to adhere strictly to a particular standard, they might not explore potentially revolutionary avenues.
2. **Premature Standardization**:
   AI is a rapidly evolving field. Setting standards too early can lock the industry into technologies or methods that become obsolete or are later found to have issues.
3. **Potential for Bias**:
   If dominant players or certain countries overly influence the standard-setting process, it might lead to standards that favor their specific interests over others.
4. **Overhead Costs**:
   Implementing and maintaining standards-compliant systems can be expensive, leading to increased costs for businesses and, potentially, consumers.
5. **Dynamic Nature of AI**:
   Unlike more static technologies, AI is inherently dynamic. The behavior of AI systems can change and evolve, making it challenging to pin them down to a fixed standard.

Pros of AI Standards Specific to PHM

1. **Improved Accuracy**:
   Standards can provide benchmarks for AI systems, ensuring that their predictive abilities meet a minimum threshold. This can be critical in applications like predicting the failure of aircraft components, where high accuracy is non-negotiable.
2. **Consistency Across Platforms**:
   In large-scale operations, there might be multiple AI systems in place across various locations or departments. Standards can ensure that all these systems approach prognostics in a consistent manner, aiding in centralized decision-making.
3. **Data Sharing and Collaboration**:
   With standardized AI models and data formats, different stakeholders in PHM (e.g., manufacturers, maintenance teams, and operators) can more easily share information and collaborate on solutions.
4. **Transparency in Decision Making**:
   When an AI system recommends a particular maintenance action or predicts a failure, operators need to trust that decision. Standards can ensure the system provides justifications or evidence for its recommendations.

Cons of AI Standards Specific to PHM

1. **Complexity of Systems**:

   PHM covers a wide array of assets, from coal-fired boilers to aircraft. A one-size-fits-all standard might be too generic for specialized applications.

2. **Rapid Technological Advancements**:

   The technology in PHM (distinct from AI) also evolves rapidly. Standards might struggle to keep up with the pace of change, potentially becoming outdated soon after they're established.

3. **Barrier to Entry**:

   Startups or smaller companies might find it challenging to enter the PHM space if they need to conform to comprehensive AI standards, favoring established players and potentially reducing innovation.

AI Standards and Technology Needs in Prognostic and Health Management

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Industrial Artificial Intelligence Consortium to Advance High Mix Production

University of CINCINNATI

NIST

National Institute of Standards & Technology

Advanced Manufacturing Technology Roadmap Program

- $300,000 in initial funding to define the technology roadmap for the future of intelligent semiconductor manufacturing in the US.
- This roadmap will be leveraged to start a multi-million-dollar research and development institute focused on advancing semiconductor manufacturing in the US.
- The roadmap development team will collaborate with a vast array of semiconductor manufacturing interests (OEMs, fabs, technology providers, consortiums, and research labs, among others).

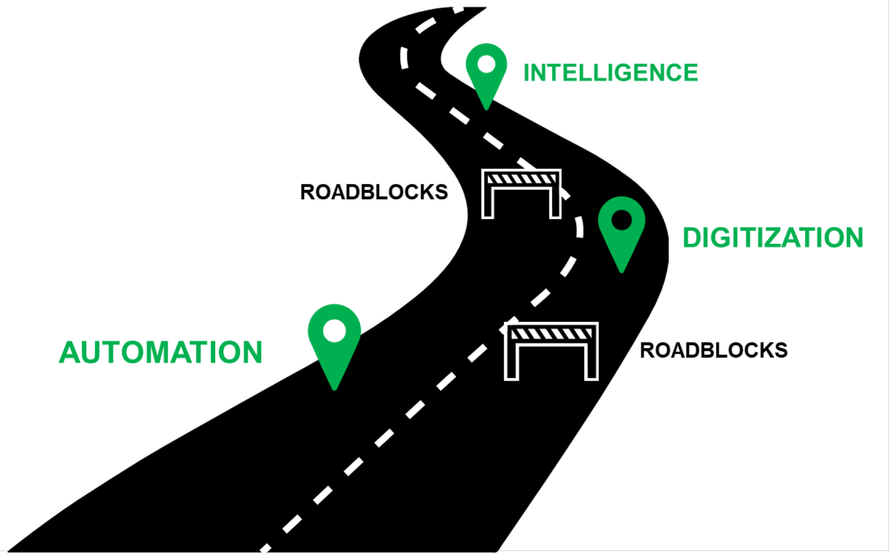
High Mix 3R Production

1. **Establish Industrial AI Consortium**
   - Key Opinion Leaders
   - Industry Advisory Board
2. **Roadmapping for Semiconductor Manufacturing**
   2.1 Teaming
   2.2 Top Needs, Killer Applications, R&D Priorities, and Enabling Technologies
   2.3 Roadmap development
3. **Translate the roadmap to other sectors**
   - Hybrid manufacturing
   - Medical products manufacturing
4. **Develop a Generalized Roadmap**
   - Vision and Roadmap
   - A list of high-priority projects

Resilient TO DISTURBANCES

Reconfigurable FOR DIVERSITY

Responsive TO DEMAND



ROADMAP DEVELOPMENT TEAM

University of CINCINNATI

UNIVERSITY OF MICHIGAN

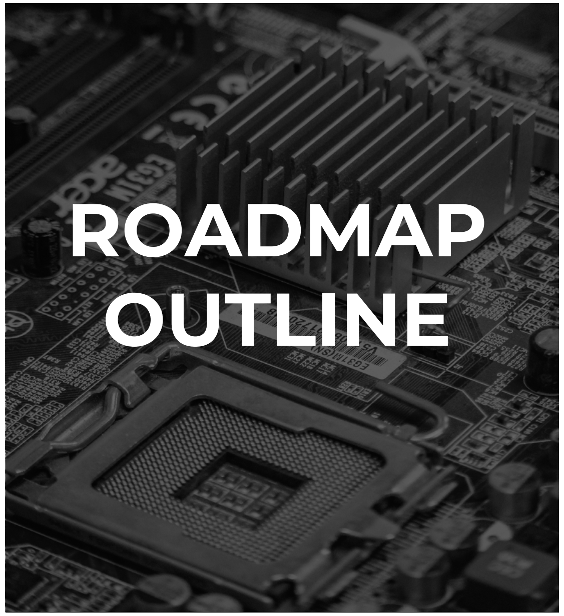
predictronics™ WE KNOW WHAT HAPPENS NEXT

North Carolina Agricultural and Technical State University

Industry Interviews and Roadmap Outline

University of CINCINNATI

APPLIED MATERIALS · GlobalFoundries · Seagate · Lam RESEARCH · SAMSUNG · Silfex (A Division of Lam Research Corporation) · SYNOPSYS · intel · KLA · HITACHI · ...

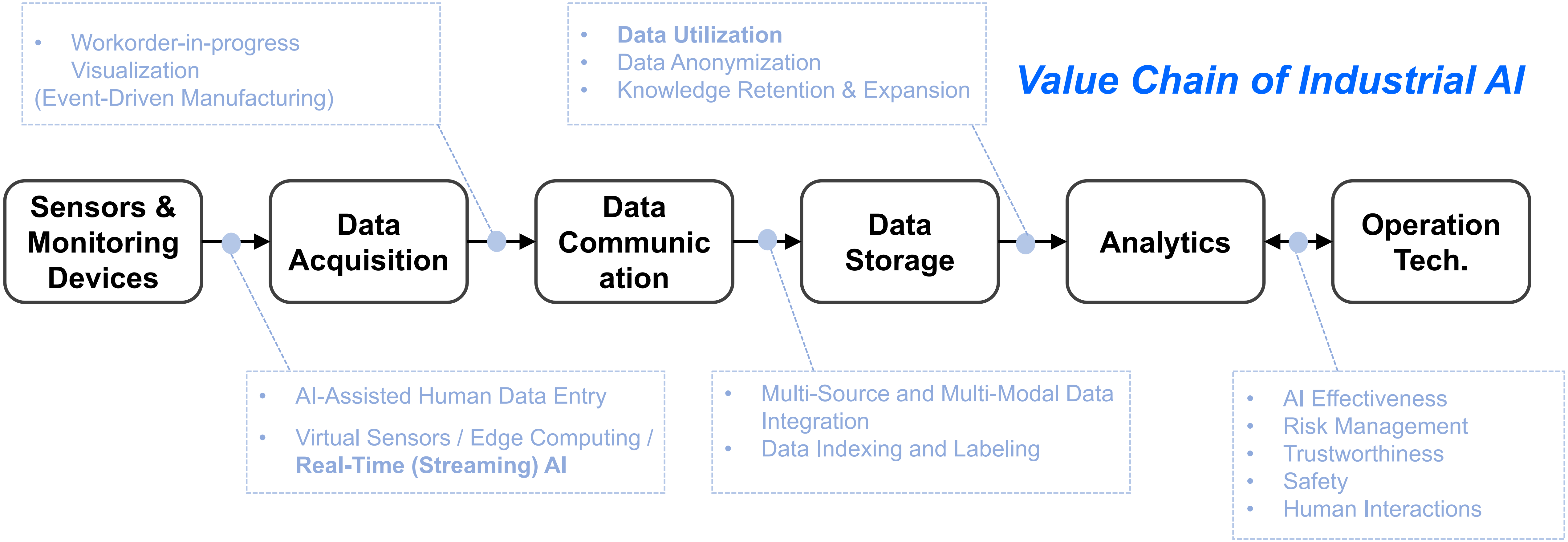


- Auto Defect Class. & Virtual Metrology
- Workforce Development & Training
- Yield Enhancement
- Optimized (Predictive) Maintenance
- Intelligent Metrology
- Chamber Matching & Optimization
- Equipment Design for High Mix Manufacturing
- Big Data Sharing and Security
- AI Effectiveness
- Fab Automation and Human/AI Integration
- Scheduling & Dispatch
- Fab Automation Human/AI Integration
- Digital Twin Simulation

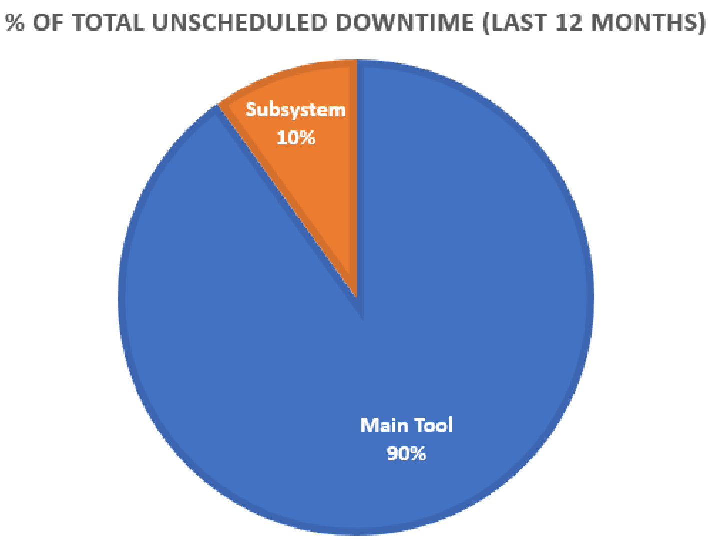
Challenges and Opportunities of Industrial AI

University of CINCINNATI

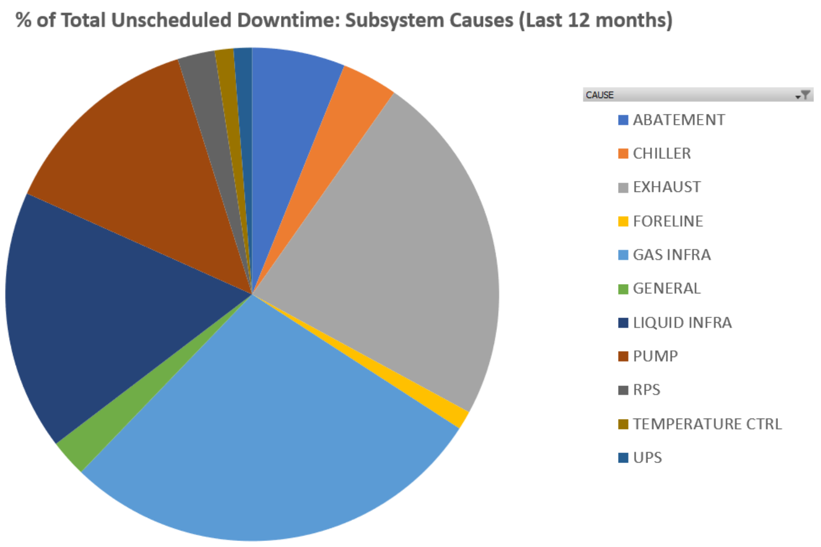
Value Chain of Industrial AI



Data Connection and Integration



Data Source: Global Foundries



Data Source: Global Foundries

Key Sub-Systems

- Gas Line
- Fore Line
- Exhaust Line
- Dry/Wet Pump
- Chiller
- Remote Plasma Source

……

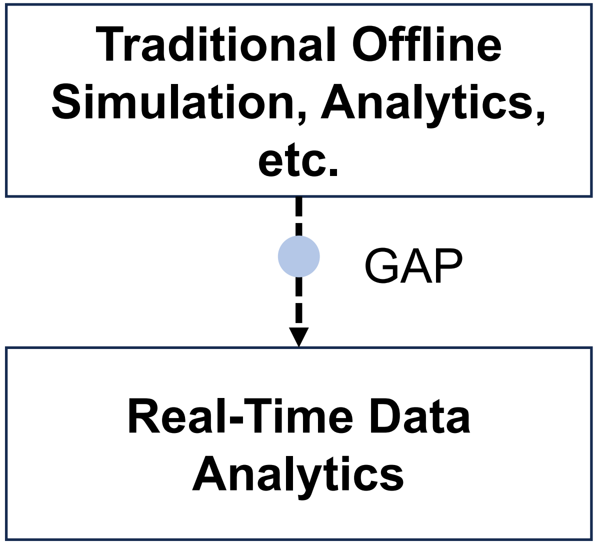
Problems:
- Lack of signal
- It is difficult to integrate signals into the main tools
- Tool design constraints
- Poorly defined alarms

Needs:
- Standards and roadmaps to make data available
- How to define plug & play streaming analytics
- Sub-system to main tool data integration

Streaming Data and Analytics – Semiconductor Fab

Per Equipment(Gigafab)
-- 500-1000 parameters per process equipment;
-- 1-10Hz sampling rate;
-- 10-29 active data acquisition plan
-- worst case, **10K samples per second**

Per Factory (Gigafab)
-- 500 -2000 process equipment;
-- 1-10Hz sampling rate;
-- 10-29 active data acquisition plan
-- worst case: **20M samples per second**



Streaming data processing software, hardware, and platform

Event stream with Kafka

Return on Investment (on Yield Excursion)
-- The average wafer per yield excursion is : **500 wafers/excursion**
-- The engineering time required to resolve yield excursion **160 hour**
-- Cost per excursion: **$174,000**
-- Excursion rate: **24 / year**
-- Total excursion cost: **$ 4.12M / year**

Data Source: Cimetrix at APCSM 2022 – Austin TX

Data Utilization

Interview Note: **Data utilization rate in 300mm fab is only 10%-20%.**

***Interview Note* : Domain knowledge requirement is high for chamber matching** (AI people have good AI knowledge but lack domain expertise)

Interview Note: **Modern process engineers need to understand data analysis**. Everyone is taking data analytics classes in-house, and learning python, etc.

New standards need to be developed to improve data utilization rate on the shop floor and facilitate AI-SME integration

Overall Data Effectiveness?

Data Generation Per Minute in a 300mm fab

Thank You !

Discussion and WHOVA notes

- Standards can help AI be viewed as more trustworthy particularly for findable, accessible, interoperable, reproducible (FAIR)
- But standard development can be a very long process in contrast to how fast AI is moving - Will standards become outdated and development futile and counterproductive?
- Maybe companies need to be more open about their use of AI
- Standards for AI are available - can search by domain, application, topic etc. [AI Standards Hub at Alan Turing Institute, https://aistandardshub.org/ai-standards-search/]
- Challenges in data connection and integration, streaming data and analytics, and data utilization
- What standards should a newcomer use?: Start with what exists through foundational PHM, AI, domain
- Standards are always meta standards – "wisdom of the crowd" principle applies by group development
- Difference in what is considered appropriate to monitor - different privacy concerns/approvals across globe
- Are companies willing to share data in order to establish the standards? - not usually
- Standards - Bureaucratic exercise or practical need? Need some tools
- How do we ensure that the perspectives and experiences shared by selected/participating domain PHM experts truly represent that diverse landscape of AI applications in this area and how relevant are these standards to practical implementation in real world situations?

PHM AI Standards for … ? [Poll of attendees]

Uncertainty, V&V and bias qualification and benchmarks to support trust [23 votes]

Resource maps for available/evolving standards in PHM and AI [17 votes]

Workflow documentation and data exchange for reuse and integration [10 votes]

Rapidly adaptable and updatable standards - dynamic learning, scalability [4 votes]

Wide applicability of standards driven by big players and big data [2 votes]

Device vs. decision support applications [1 vote]

By a show of hands and from WHOVA, what are your **top 2 priorities for PHM AI standards?**

Way forward: Get involved!

- IJPHM papers and communications
  - Submit an abstract
- Updates on standards in progress
  - PHM Standards Portal – want to contribute?
- Standards development process
  - Other SDOs – want to help represent PHM Society?
- What else would be useful?
  - Panel or workshop topics and leaders

Selected readings

- Reva Schwartz, National Institute of Standards and Technology
  - https://www.nist.gov/people/reva-schwartz
  - Co-wrote “Towards a standard for identifying and managing bias in artificial intelligence”: https://doi.org/10.6028/NIST.SP.1270
- Andrew Maynard, Professor of Advanced Technology Transitions, Arizona State University
  - https://search.asu.edu/profile/2670673
  - Co-wrote “AI-facilitated healthcare” in World Economic Forum’s Top 10 Emerging Technologies of 2023: https://www3.weforum.org/docs/WEF_Top_10_Emerging_Technologies_of_2023.pdf
- Erik Blasch, Air Force Office of Scientific Research
  - https://scholar.google.com/citations?hl=en&user=Po7s1TsAAAAJ&view_op=list_works
  - Co-wrote “Artificial Intelligence Strategies for National Security and Safety Standards”: https://doi.org/10.48550/arXiv.1911.05727
- Robert R. Hoffman, Institute for Human and Machine Cognition, Pensacola, FL
  - https://www.ihmc.us/groups/rhoffman/
  - Co-wrote “Methods and standards for research on explainable artificial intelligence: Lessons from intelligent tutoring systems”: https://doi.org/10.1002/ail2.53
- Pablo Rivas, Department of Computer Science, Baylor University, Waco, TX
  - https://onlinecs.baylor.edu/faculty/dr-pablo-rivas
  - Co-wrote “Planning a Center for Standards and Ethics in Artificial Intelligence”: http://104.196.114.195/pdfs/rivas2022planning.pdf
- Peter Cihon, Independent Consultant, San Francisco, CA
  - Wrote “Standards for AI Governance: International Standards to Enable Global Coordination in AI Research & Development”
  - https://www.fhi.ox.ac.uk/wp-content/uploads/Standards_-FHI-Technical-Report.pdf
- Joachim Roski, Booz Allen Hamilton, Washington, DC
  - https://www.boozallen.com/c/bio/professionals/joachim-roski.html
  - Co-wrote “Enhancing trust in AI through industry self-governance”: https://academic.oup.com/jamia/article/28/7/1582/6250922
- Heinrich Jiang, Google Research, Mountain View, CA
  - https://scholar.google.com/citations?user=RiDdF2YAAAAJ&hl=en
  - Co-wrote “Identifying and Correcting Label Bias in Machine Learning”: https://doi.org/10.48550/arXiv.1901.04966

Selected readings (cont.)

- Plamen P. Angelov, School of Computing and Communications, Lancaster University, Lancaster, UK
  - https://www.lancaster.ac.uk/lira/people/plamen-angelov
  - Co-wrote “Explainable artificial intelligence: an analytical review”: https://doi.org/10.1002/widm.1424
- Owain Evans, Future of Humanity Institute, University of Oxford, UK
  - https://www.research.ox.ac.uk/researchers/owain-evans
  - Co-wrote “Truthful AI: Developing and governing AI that does not lie”: https://doi.org/10.48550/arXiv.2110.06674
- Adrian Hopgood, University of Portsmouth, UK
  - https://www.port.ac.uk/about-us/structure-and-governance/our-people/our-staff/adrian-hopgood
  - Wrote a book, “Intelligent systems for engineers and scientists: a practical guide to artificial intelligence”: https://books.google.com/books?hl=en&lr=&id=nwhlEAAAQBAJ&oi=fnd&pg=PP1&ots=2Q51bUH58s&sig=rszHWxYqtNXxwbqvyMFScL3xWzU#v=onepage&q&f=false
- Markus Wenzel, Applied Machine Learning Group at the AI department of Fraunhofer HHI (Berlin)
  - https://www.hhi.fraunhofer.de/en/departments/ai/research-groups/applied-machine-learning/team/dr-markus-wenzel.html
  - Co-wrote “Toward Global Validation Standards for Health AI”: https://doi.org/10.1109/MCOMSTD.001.2000006
- Luca Nannini, Centro Singular de Investigación en Tecnoloxías Intelixentes (CiTIUS), Universidade de Santiago de Compostela, Madrid, Spain
  - https://citius.gal/team/luca-nannini
  - Co-wrote “Explainability in AI Policies: A Critical Review of Communications, Reports, Regulations, and Standards in the EU, US, and UK”: https://doi.org/10.1145/3593013.3594074
- Huiqi (Yvonne) Lu, Institute of Biomedical Engineering, Oxford University, UK
  - https://eng.ox.ac.uk/people/huiqi-yvonne-lu/
  - Co-wrote “Machine Learning-Based Risk Stratification for Gestational Diabetes Management”: https://doi.org/10.3390/s22134805