

From Sensors to Digital Twins: How AI Is Transforming Industrial Automation

[Watch Webinar Recording Here](#)

Mostafa Jamshidian
EIT Senior Lecturer



About EIT

We are dedicated to ensuring that you receive a world-class education and gain skills that you can immediately implement in the workforce.



World-Class Australia Accredited Education

Our vocational programs and higher education degrees are registered and accredited by the Australian Government. We have programs that are also recognized under three international engineering accords.



Engineering Specialists

EIT is one of the only institutes in the world specializing in Engineering. We deliver professional certificates, diplomas, advanced diplomas, undergraduate and graduate certificates, graduate diplomas, bachelor's and master's degrees, and a Doctorate of Engineering.



Industry Experienced Lecturers

Our lecturers are highly experienced engineers and subject specialists with applied knowledge. The technologies employed by EIT, both online and on-campus, enable us to source our lecturers from a large, global pool of expertise.



Industry Oriented Programs

Our programs are designed by industry experts, ensuring you graduate with cutting-edge skills that are valued by employers. Our program content remains current with rapidly changing technology and industry developments.



Unique Delivery Model

We deliver our programs via a unique delivery methodology that makes use of live and interactive webinars, an international pool of expert lecturers, dedicated learning support officers, and state-of-the-art such as hands-on workshops, remote laboratories, and simulation software.



ECT delivers interactive and online **UK qualifications**. ECT is committed to providing students with a world-class education, where they acquire the knowledge and skills that are applicable and valued in industry.

- Bachelor of Engineering (Honours) in Industrial Automation
- Bachelor of Engineering (Honours) in Electrical Engineering
- Master of Science (Power System Analysis and Renewable Integration)
- Master of Science (Industrial Automation and Instrumentation Control)

Learn more [here](#).

Registered UK Higher Education Provider | UKPRN: 10089771



ECST delivers a **South African accredited qualification** on-campus. ECST is committed to providing students with a world-class education, where they acquire the knowledge and skills that are applicable and valued in industry.

- Bachelor of Engineering Technology in Electrical Engineering (SAQA ID 123645)
- Bachelor of Engineering Technology in Mechanical Engineering (SAQA ID 126163)

Learn more [here](#).

The Engineering College of Science and Technology (Pty) Ltd is provisionally registered with the Department of Higher Education and Training until 31/12/2028 as a private higher education institution under the Higher Education Act, 1997. Registration certificate no. 2025/HE07/007.

IDC Technologies – Practical Engineering & Technical Training



Founded in 1992 to deliver engineering and technical training that supports industry needs.

Specializes in professional development across:

- Electrical Engineering
- Instrumentation & Process Control
- Information Technology
- Mechanical Systems
- Project Management

Focuses on practical, real-world learning with skills that can be applied immediately in the workplace. Courses, workshops, and conferences are developed in consultation with industry to ensure relevance and impact. Supports engineers, technicians, and technical professionals in building job-ready expertise. Over 30 years of training experience with a strong presence across Australia and international markets. Continues to play a key role in upskilling the engineering workforce and strengthening technical capability across industries



Disclaimer



The courses and qualifications mentioned in this presentation are offered by separate legal entities operating in different jurisdictions – one in Australia, one in South Africa and one in the United Kingdom. Each entity is subject to its own local regulatory requirements and accreditation standards.

Prospective students should refer to the relevant institution's official website for accurate, up-to-date information specific to their location, including course availability, fees, regulatory status, and enrolment conditions.

- For the Engineering Institute of Technology (EIT) visit: <https://www.eit.edu.au/>
- For the Engineering College of Technology (ECT) visit: <https://www.ect.ac.uk/>
- For the Engineering College of Science and Technology (ECST) visit: <https://www.ecst.ac.za/>

Introduction – Presenter

Dr. Mostafa Jamshidian

Senior Lecturer | Computational Mechanics & Digital Engineering

Advancing Data-Driven Engineering, Digital Manufacturing & Healthcare Engineering

10+ years of academic teaching experience, with industry-focused research spanning computational mechanics, advanced materials, manufacturing, and healthcare engineering.

PhD in Mechanical Engineering, Master of Education in Tertiary Teaching, FHEA

Engineering & Research Expertise

Computational Mechanics | Data-Driven Engineering | Digital Manufacturing | Advanced Materials | Healthcare Engineering

Applied Research & Industry Collaboration

Contributed to applied research at A*STAR with industry partners including Boeing, Johnson & Johnson, TE Connectivity, and Asahi Glass, addressing challenges in advanced materials, manufacturing, and computational simulation.

Healthcare & Digital Engineering

Collaborates with hospitals in Perth and Europe on computations for medicine, AI in healthcare, and patient-specific biomechanics, translating advanced engineering methods into practical applications.



Why industrial automation is changing

- Industrial systems now generate continuous operational data
- ML can support prediction, inspection, and optimization
- Digital twins connect physical and virtual operations
- Edge AI brings intelligence closer to machines
- Smart automation still depends on engineering fundamentals

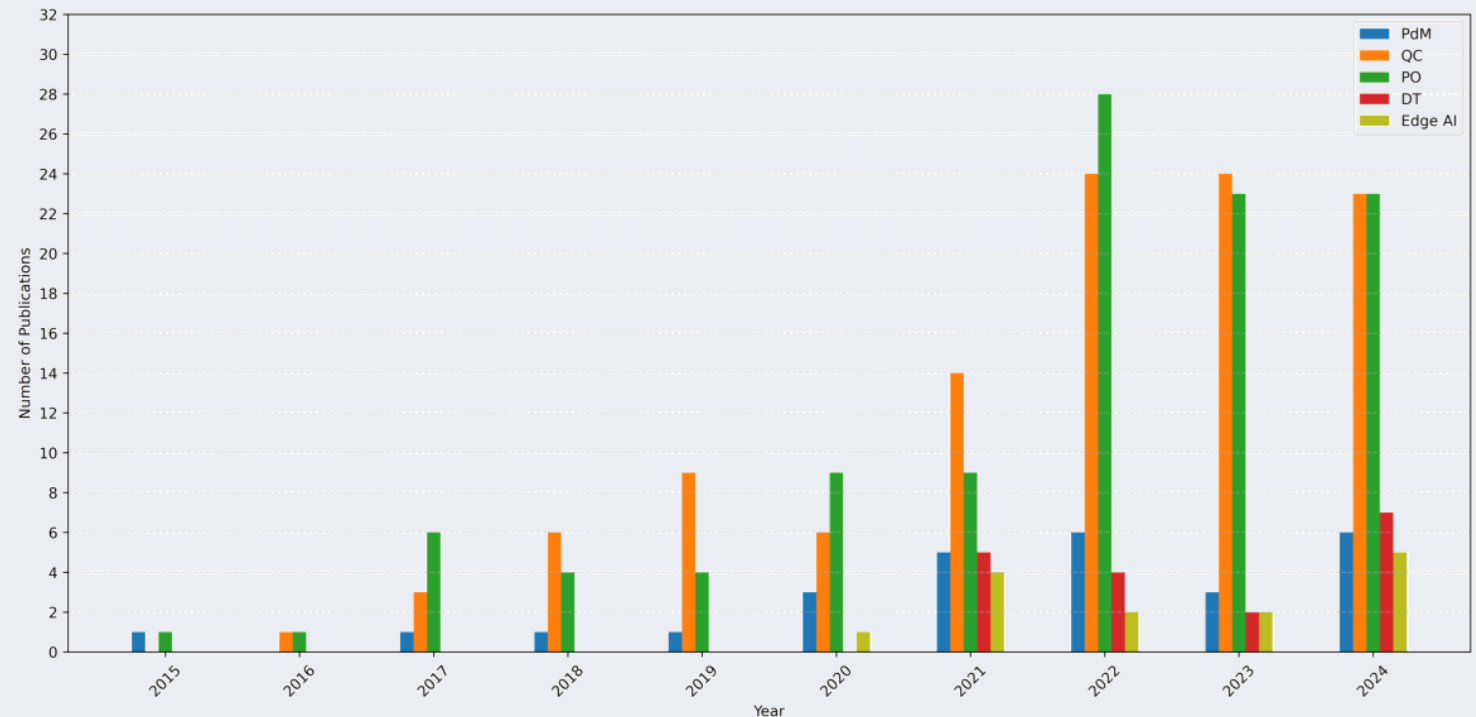


Figure: reproduced from [R1], Fig. 1.

Sources: [R1]. Figure: reproduced from [R1], Fig. 1.

From traditional automation to smart automation



- Traditional automation uses fixed rules and control logic
- Smart automation adds data-driven learning and prediction
- Control remains essential for stable physical operation
- AI supports decisions around assets, quality, and processes
- The goal is informed action, not technology for its own sake

Sources: [R1], [R2], [R3], [R4].

What makes a factory "smart"?

- Connected assets provide real-time visibility
- Data models translate signals into useful information
- Analytics support monitoring, prediction, and optimization
- Human expertise remains part of decision-making
- Cybersecurity and safety must be designed in

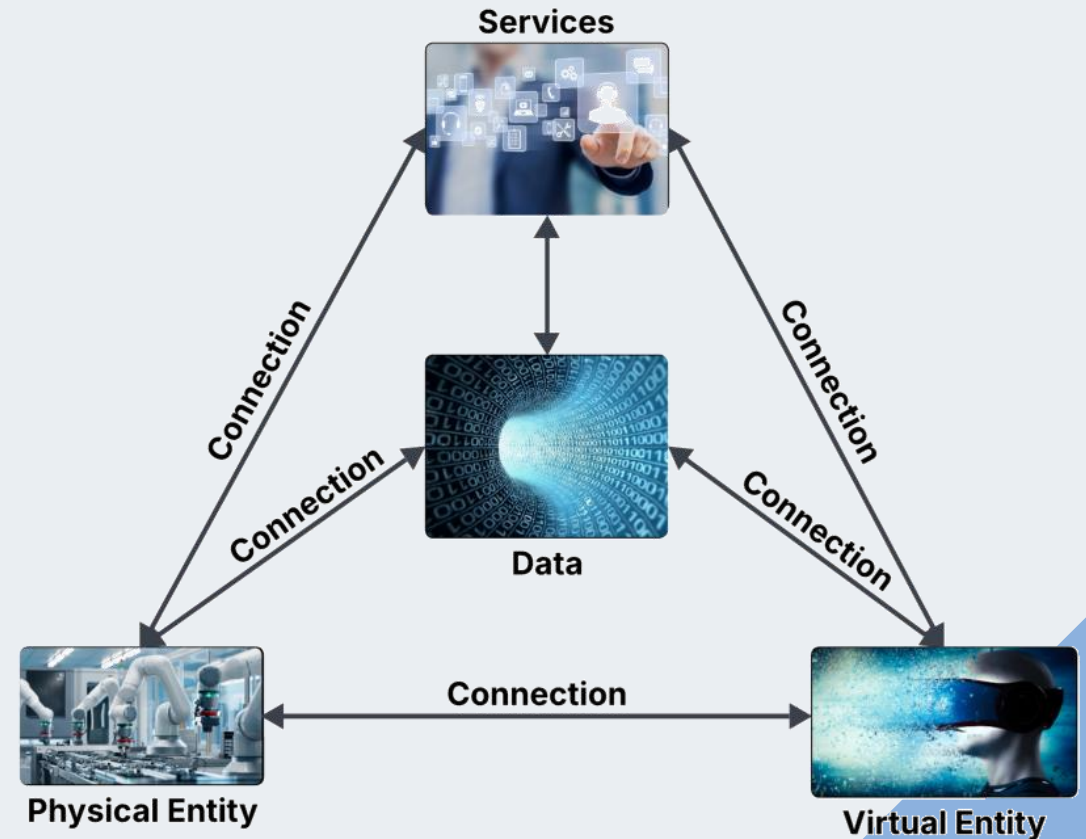


Figure: reproduced from [R1], Fig. 4.

Sources: [R1], [R2], [R4]. Figure: reproduced from [R1], Fig. 4.

The automation system starts with the control loop

- Sensors measure controlled variables from the process
- Controllers compare measurements with set-points
- Actuators manipulate valves, motors, switches, or drives
- HMI and historians support monitoring and analysis
- Automation data begins in the physical process

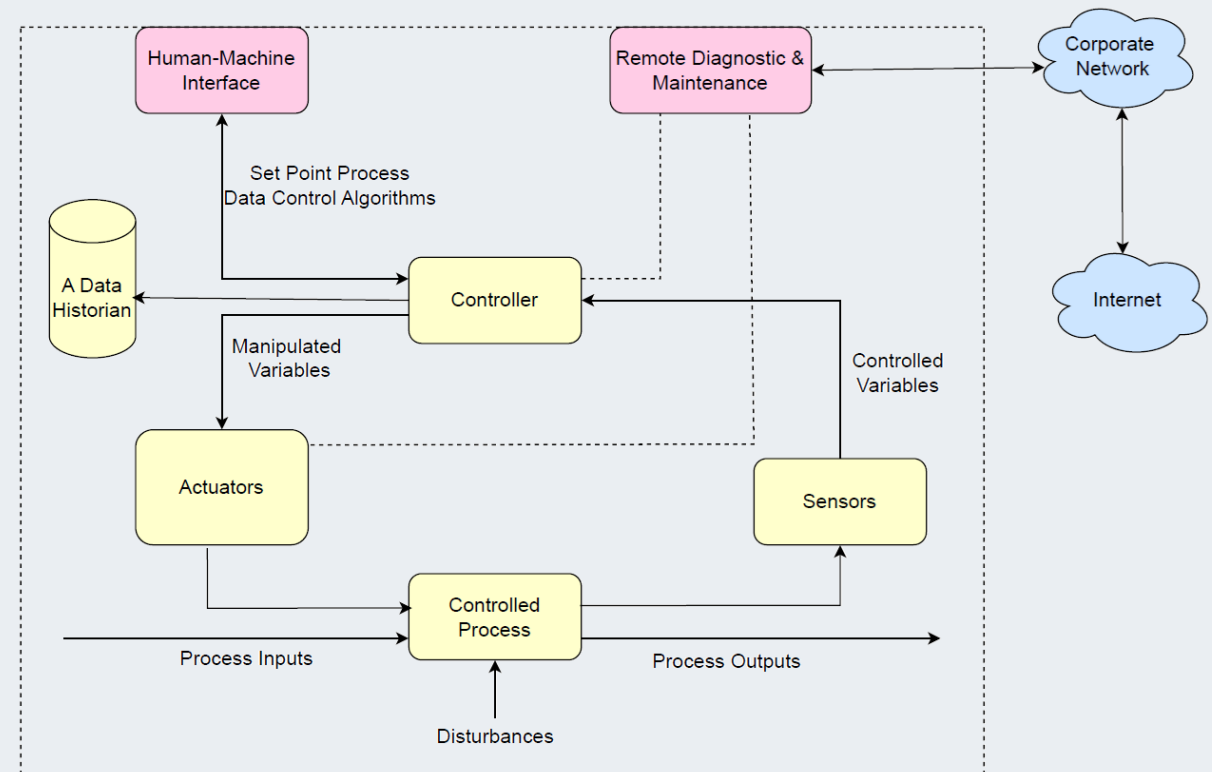


Figure: reproduced from [R4], Fig. 1.

Sources: [R4]. Figure: reproduced from [R4], Fig. 1.

Sensors and instrumentation: the evidence layer



- Instrumentation converts physical phenomena into usable signals
- Signal quality affects every downstream AI result
- Common variables include vibration, current, temperature, and flow
- Industrial signals are often noisy and context-dependent
- Good analytics begins with good measurement practice

Sources: [R1], [R3], [R4].

PLCs: local logic and deterministic control

- PLCs monitor inputs and control outputs
- Programs implement sequences, logic, timing, and interlocks
- Modern PLCs can connect to wider industrial networks
- Connectivity enables data use but increases security exposure
- AI should complement, not bypass, reliable control logic

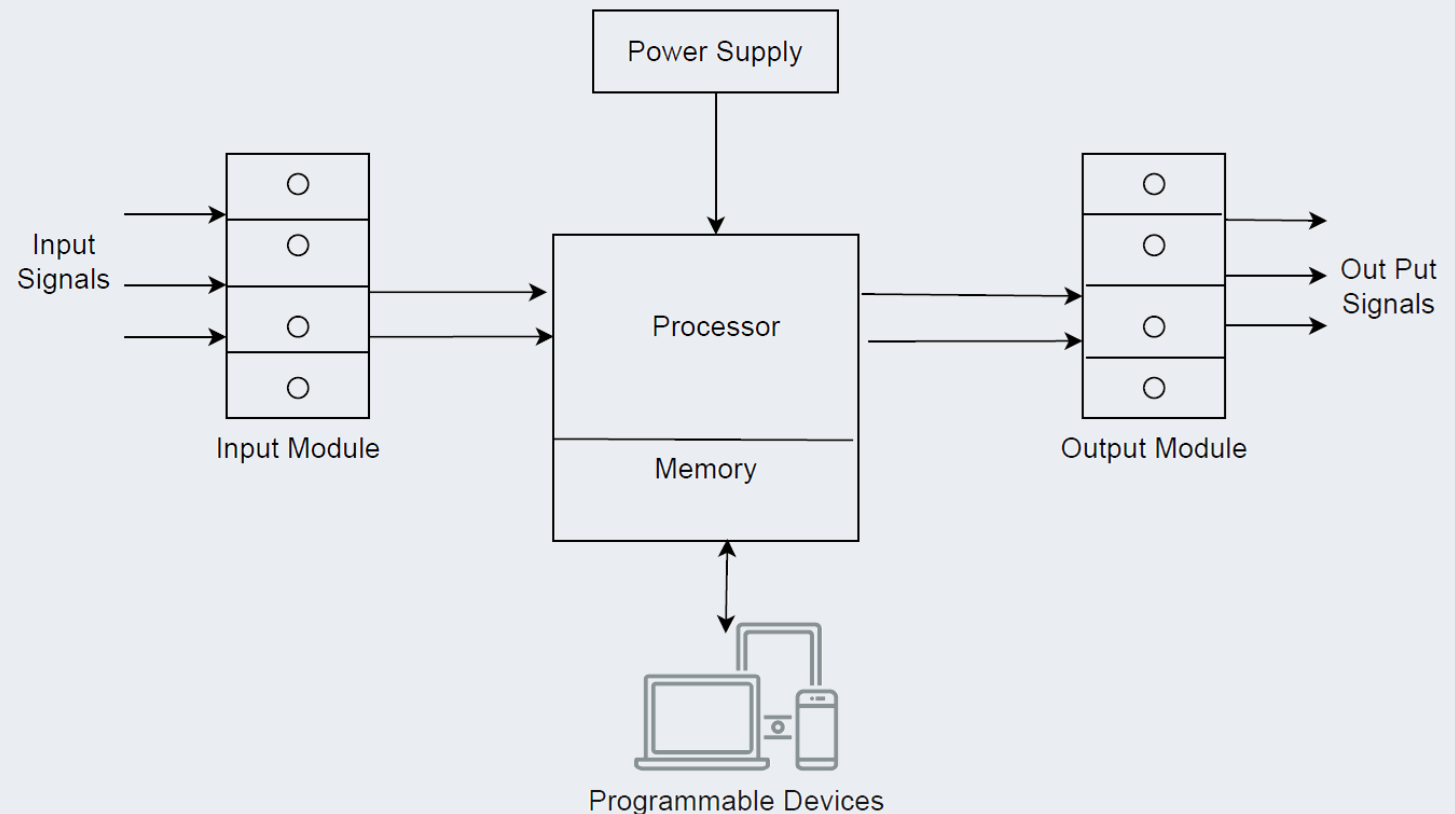
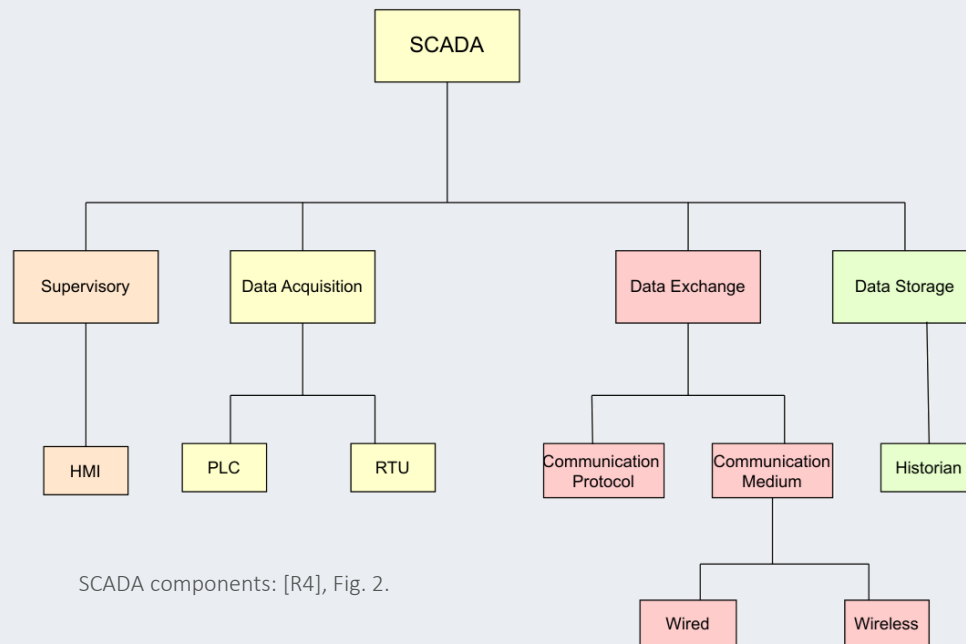


Figure: reproduced from [R4], Fig. 8.

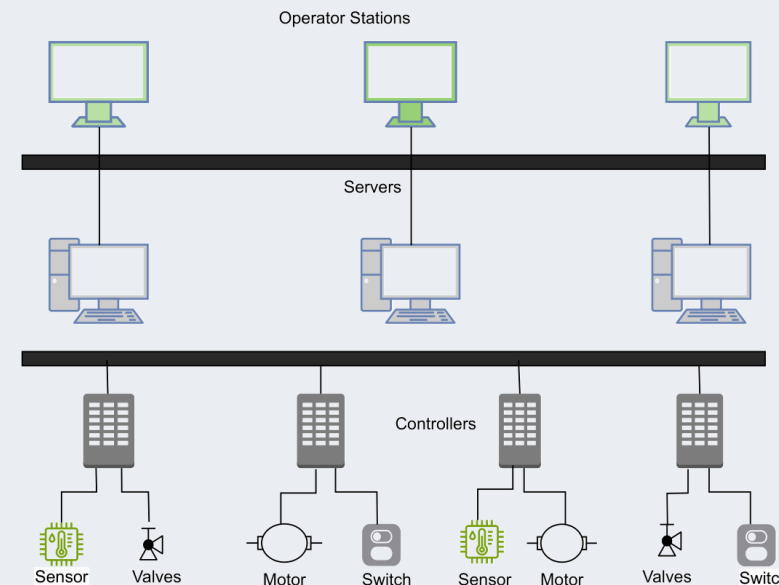
Sources: [R4]. Figure: reproduced from [R4], Fig. 8.

SCADA and DCS: supervisory and distributed control

- SCADA gathers remote data for monitoring and control
- DCS coordinates many distributed process variables



- HMIs help operators observe status and alarms
- Historians store process data for later analysis
- These systems provide the operational data backbone



Sources: [R4]. Figures: reproduced from [R4], Figs. 2 and 7.

Industrial communication networks: the nervous system

- Industrial data must move between devices and systems
- Protocols support monitoring, control, and interoperability
- Examples include Modbus, DNP3, MQTT, and OPC
- Legacy protocols may lack modern security features
- Data movement is both an enabler and a risk

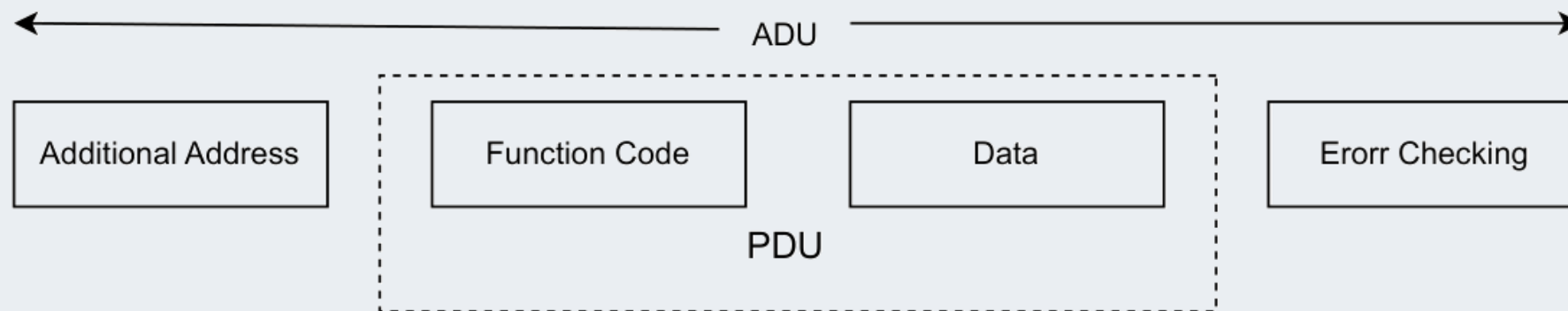


Figure: reproduced from [R4], Fig. 10.

Sources: [R4]. Figure: reproduced from [R4], Fig. 10.

IIoT: connecting equipment, data, and services

- IIoT extends sensing and connectivity across assets
- Messaging patterns support distributed data exchange
- Cloud platforms can support storage and analytics
- Edge devices can support local inference and control
- Architecture choices affect latency, security, and cost

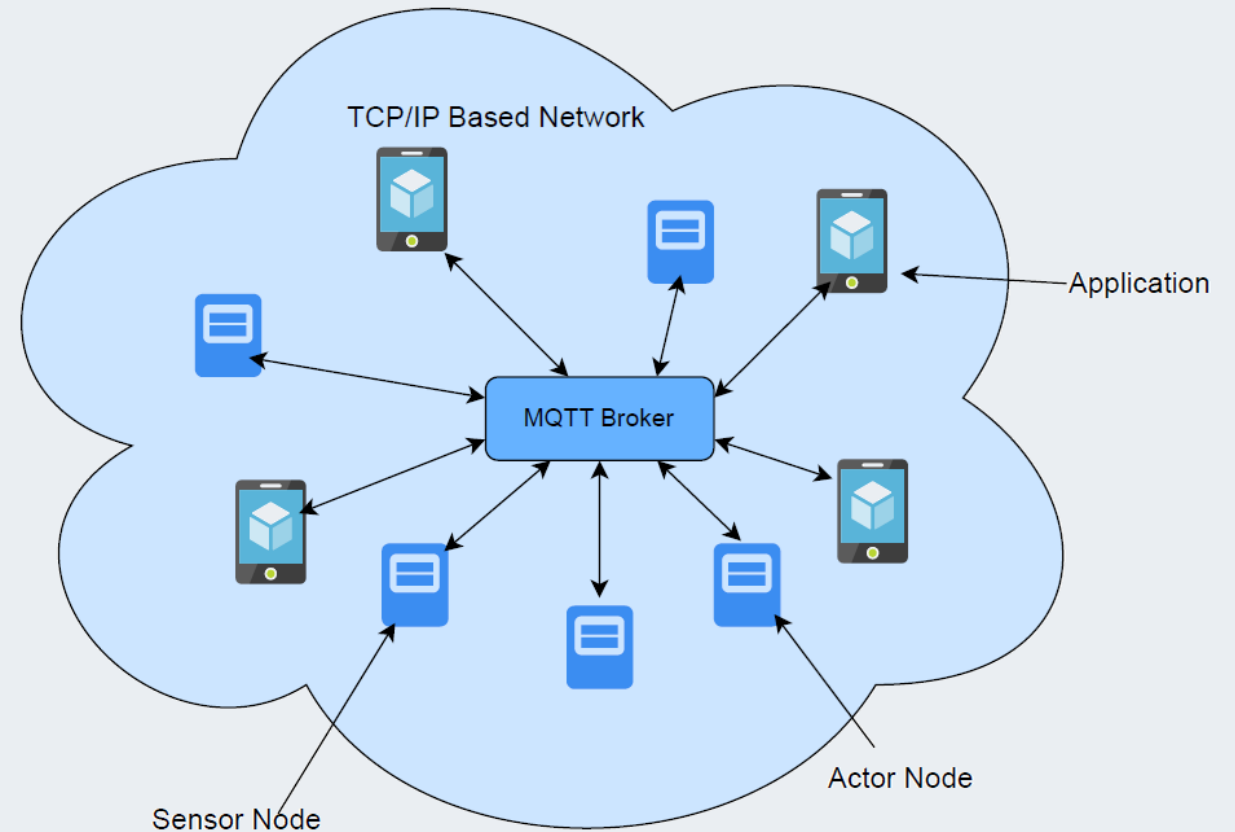


Figure: reproduced from [R4], Fig. 11.

Sources: [R1], [R4]. Figure: reproduced from [R4], Fig. 11.

Data acquisition: from plant signals to usable records

- Plant data must be captured, synchronized, and stored
- Historians preserve time-stamped process information
- OPC supports interoperability across industrial systems
- Analytics needs context, not only raw values
- Missing metadata can limit model transferability

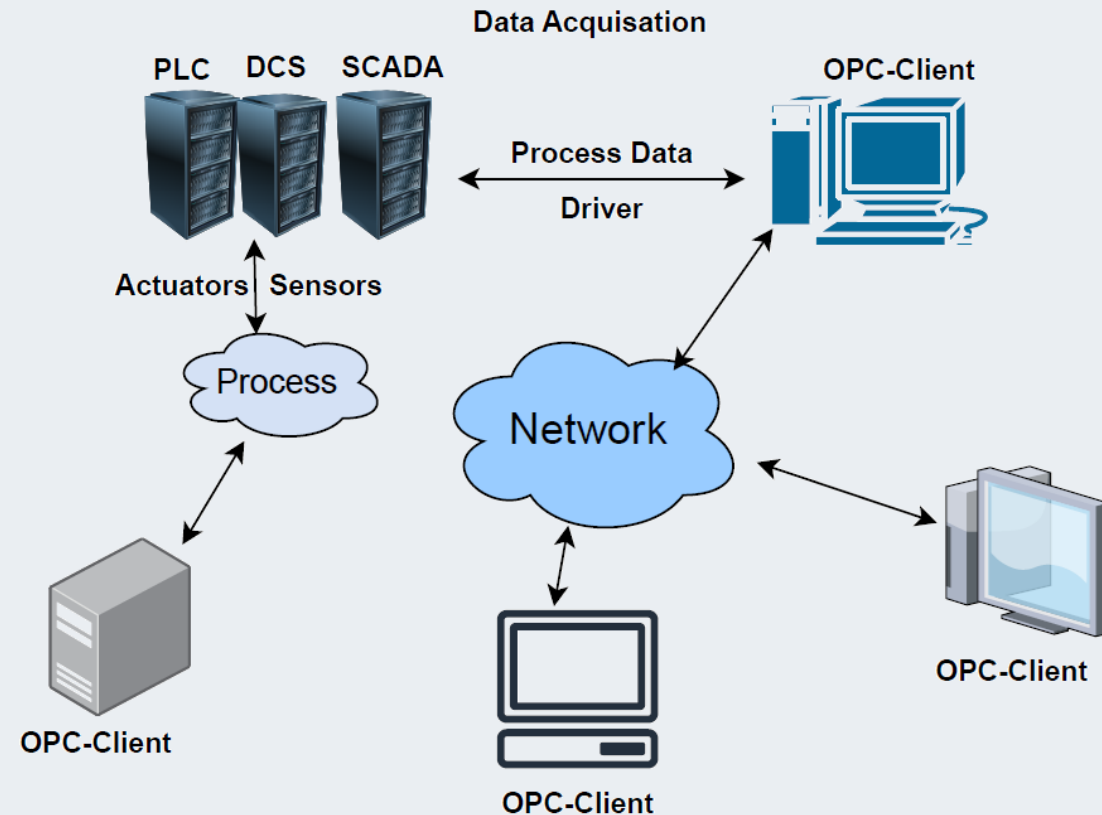


Figure: reproduced from [R4], Fig. 12.

Sources: [R3], [R4]. Figure: reproduced from [R4], Fig. 12.

Why industrial data is different from ordinary data



- Signals are multivariate, time-dependent, and often noisy
- Failure examples may be rare or expensive to obtain
- Operating conditions can drift over time
- Labels may depend on expert maintenance records
- Safety-critical decisions require interpretability and validation

Sources: [R1], [R2], [R3].

Machine learning basics for automation engineers

- Supervised learning maps inputs to labeled outputs
- Unsupervised learning detects structure without labels
- Deep learning handles images, signals, and time series
- Reinforcement learning optimizes sequential decisions
- Hybrid models combine data and engineering knowledge

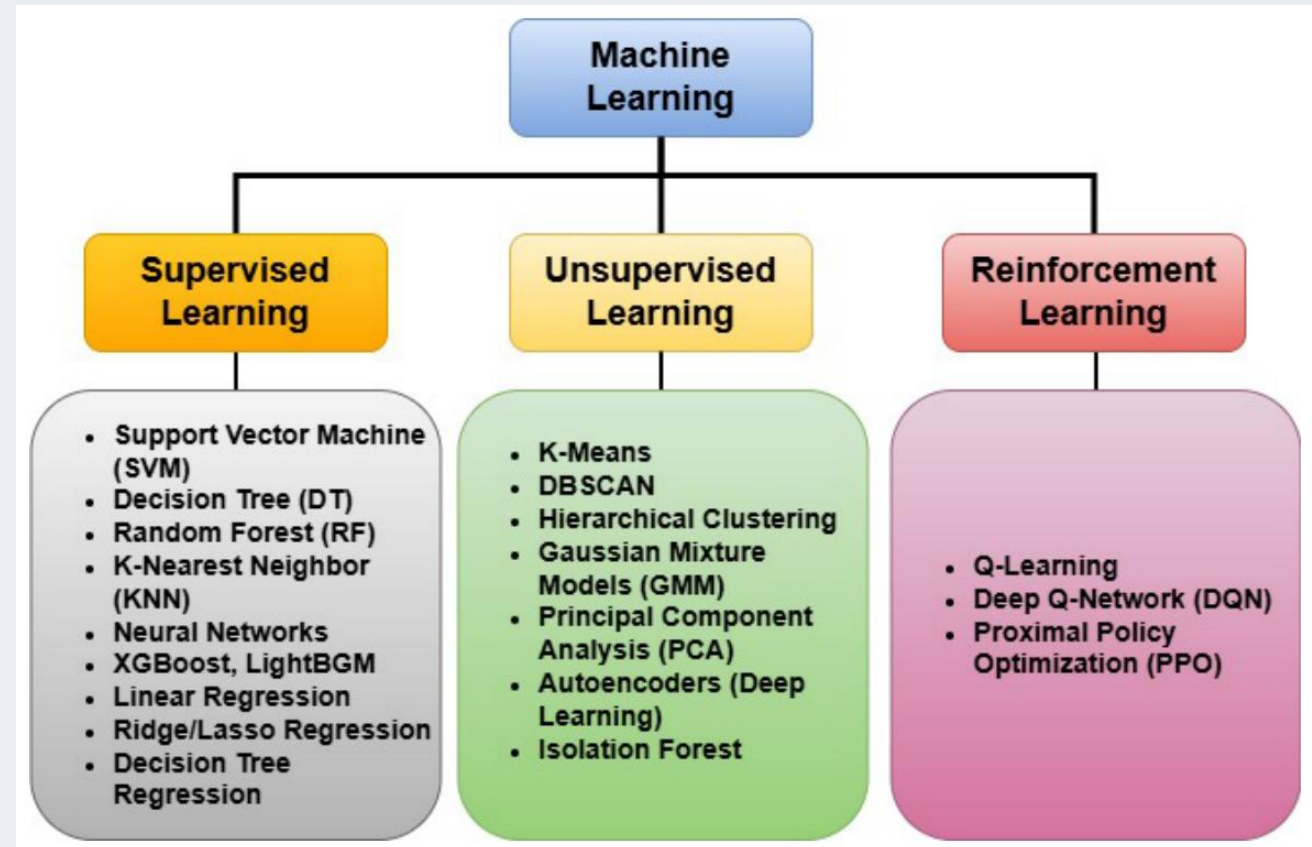


Figure: reproduced from [R1], Fig. 2.

Sources: [R1], [R2]. Figure: reproduced from [R1], Fig. 2.

Where ML fits in industrial automation

- Predictive maintenance estimates faults and remaining life
- Quality control detects defects and process deviations
- Process optimization tunes parameters and schedules
- Digital twins provide simulation and decision support
- Edge AI enables faster local inference

Sources: [R1], [R2], [R3].

Predictive maintenance: a practical AI entry point



- Corrective maintenance reacts after failure
- Preventive maintenance acts on fixed schedules
- Condition-based maintenance monitors current condition
- Predictive maintenance forecasts future degradation
- Remaining Useful Life supports proactive planning

Sources: [R3].

Predictive maintenance workflow

- Collect condition data from machines and processes
- Preprocess signals and extract informative features
- Train models for faults, health state, or RUL
- Validate robustness under changing conditions
- Convert predictions into maintenance decisions

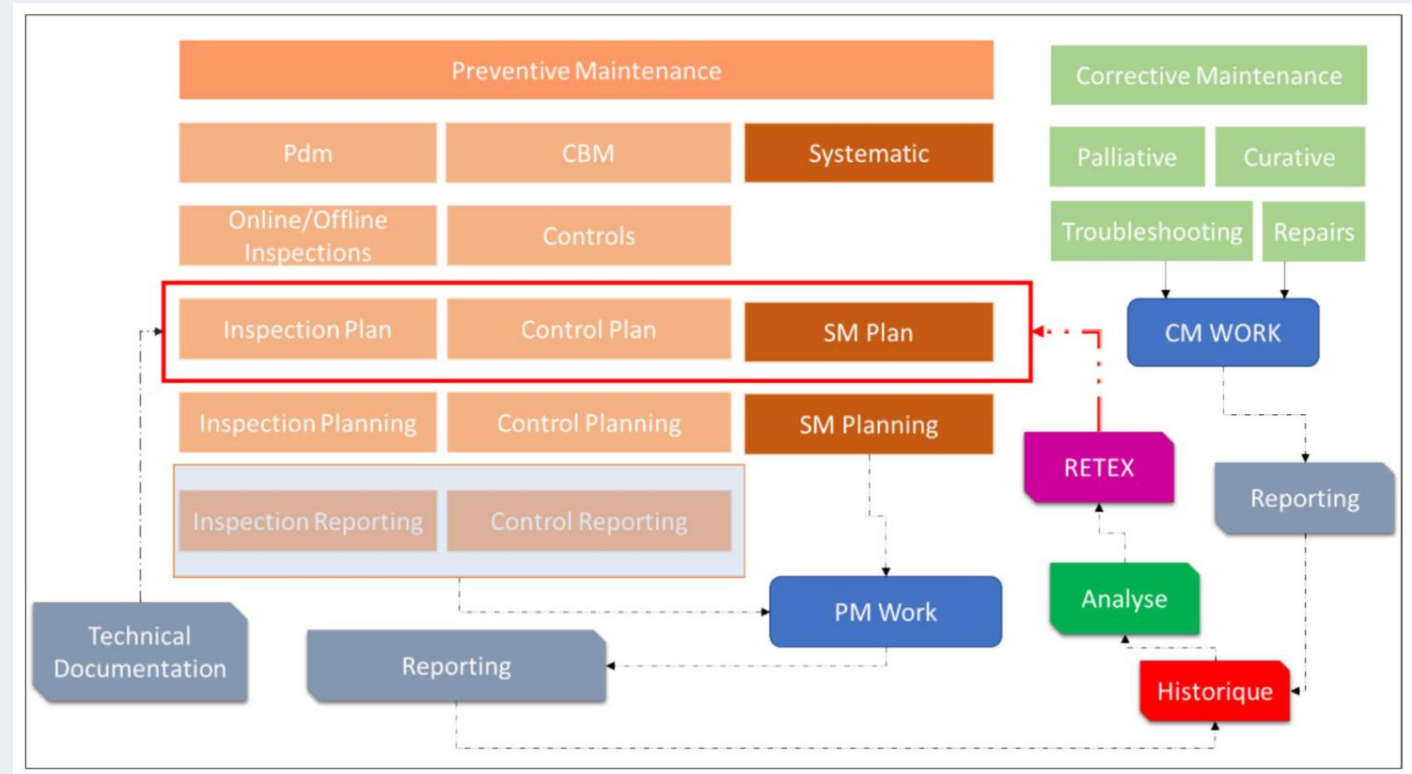


Figure: reproduced from [R3], Fig. 1.

Sources: [R3]. Figure: reproduced from [R3], Fig. 1. Verify reuse permissions before public release.

Predictive maintenance models: no single best method



- Physics-based models use engineering degradation mechanisms
- Knowledge-based models encode expert rules and logic
- Data-driven models learn patterns from sensor histories
- Hybrid models combine physical and data-driven strengths
- Model choice depends on data, risk, and explainability

Sources: [R2], [R3].

Benefits and challenges of predictive maintenance

- PdM can support earlier fault detection and planning
- Deep learning is common for complex time-series signals
- Hybrid approaches can improve robustness and transparency
- Real-time deployment remains technically difficult
- Cybersecurity and organizational adoption matter

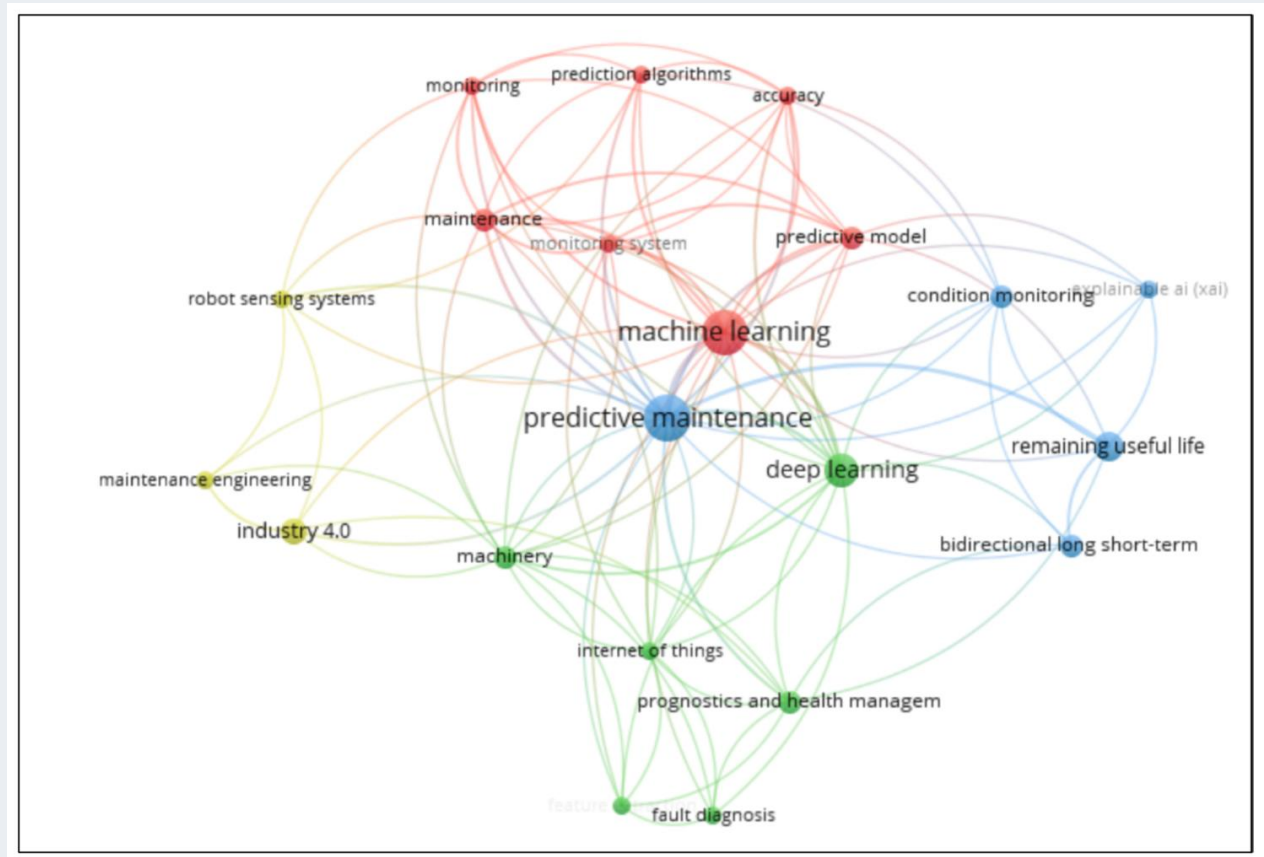


Figure: reproduced from [R3], Fig. 7.

Sources: [R3]. Figure: reproduced from [R3], Fig. 7. Verify reuse permissions before public release.

Quality monitoring and anomaly detection



- Quality control is moving toward real-time assessment
- Computer vision supports defect detection and inspection
- Signal analysis can detect process or equipment anomalies
- Online models can adapt to streaming production data
- Explainability is important for operator trust

Sources: [R1], [R2].

Process optimization using data-driven methods

- Optimization balances quality, cost, energy, and safety
- ML can predict process performance under changing conditions
- Digital twins allow safe simulation before action
- Reinforcement learning can support adaptive control tasks
- Engineering constraints must shape every optimization objective

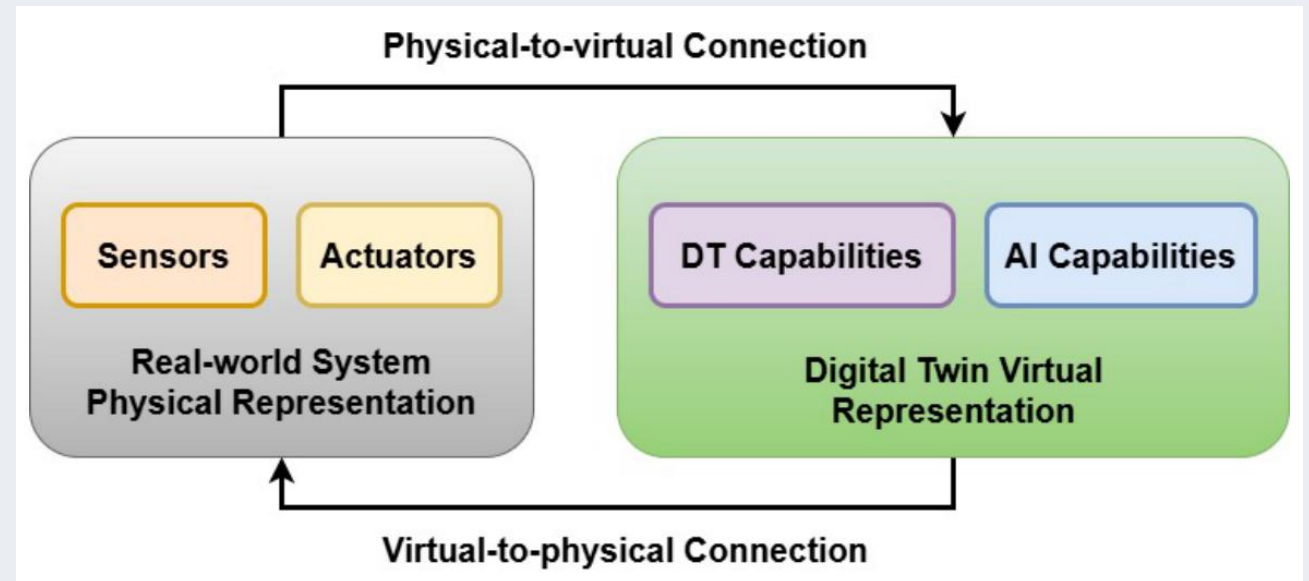


Figure: reproduced from [R1], Fig. 3.

Sources: [R1], [R2]. Figure: reproduced from [R1], Fig. 3.

Edge AI in industrial environments

- Edge AI runs models near sensors and controllers
- Local inference can reduce latency and bandwidth use
- Edge processing can improve privacy and resilience
- Hardware constraints require compact, efficient models
- Critical control still needs validated fallback behavior

Sources: [R1], [R2]. Figure: reproduced from [R1], Fig. 3.

Digital twins: connecting physical and virtual systems

- A digital twin represents a physical asset or process
- Data exchange links the physical and virtual domains
- Models can support monitoring and simulation
- Bidirectional feedback enables decision support
- AI can make twins predictive and adaptive

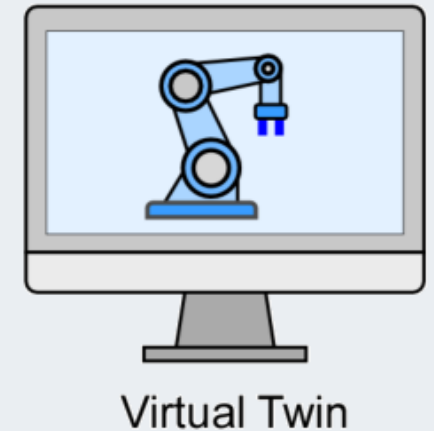
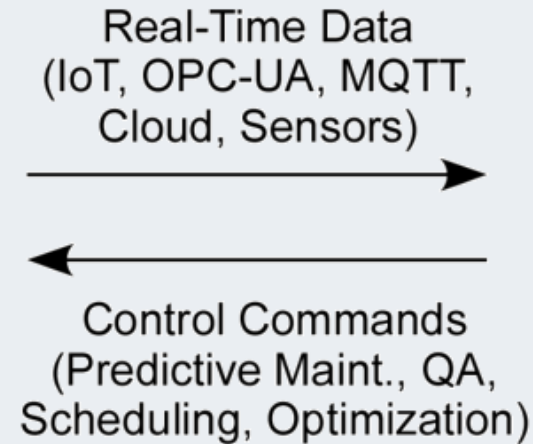
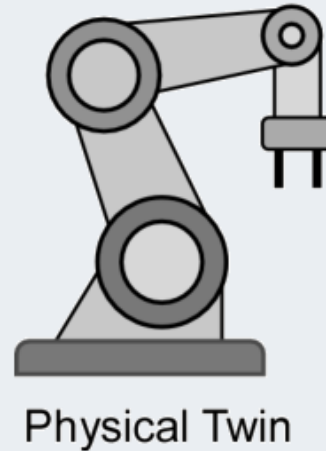


Figure: reproduced from [R2], Fig. 1.

Sources: [R1], [R2]. Figure: reproduced from [R2], Fig. 1.

Digital twin architecture: five dimensions

- Physical entity: the asset or process being mirrored
- Virtual entity: the digital model and behavior representation
- Data: real-time and historical information streams
- Services: analytics, simulation, and ML intelligence
- Connections: integration across the system lifecycle

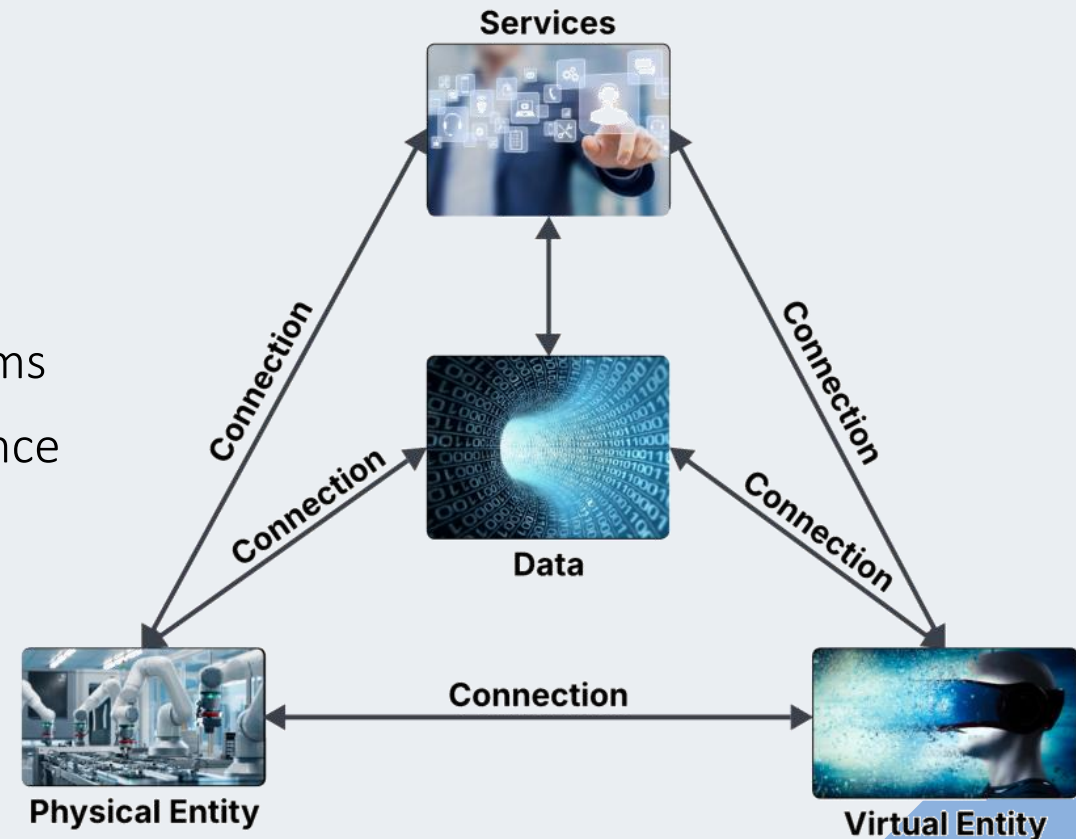


Figure: reproduced from [R1], Fig. 4.

Sources: [R1], [R2]. Figure: reproduced from [R1], Fig. 4.

AI-driven digital twins: beyond passive models



- AI helps twins learn complex system behavior
- Anomaly detection can identify abnormal operating states
- Prediction supports maintenance, quality, and performance
- Optimization can recommend better operating strategies
- Challenges include data fidelity, scaling, and explainability

Sources: [R1], [R2].

Digital twins across manufacturing levels

- Machine level: one asset or machine
- Cell level: coordinated machines, robots, or stations
- Shop-floor level: system-of-systems production environment
- Enterprise level: design, production, logistics, lifecycle
- The same idea scales with different engineering challenges

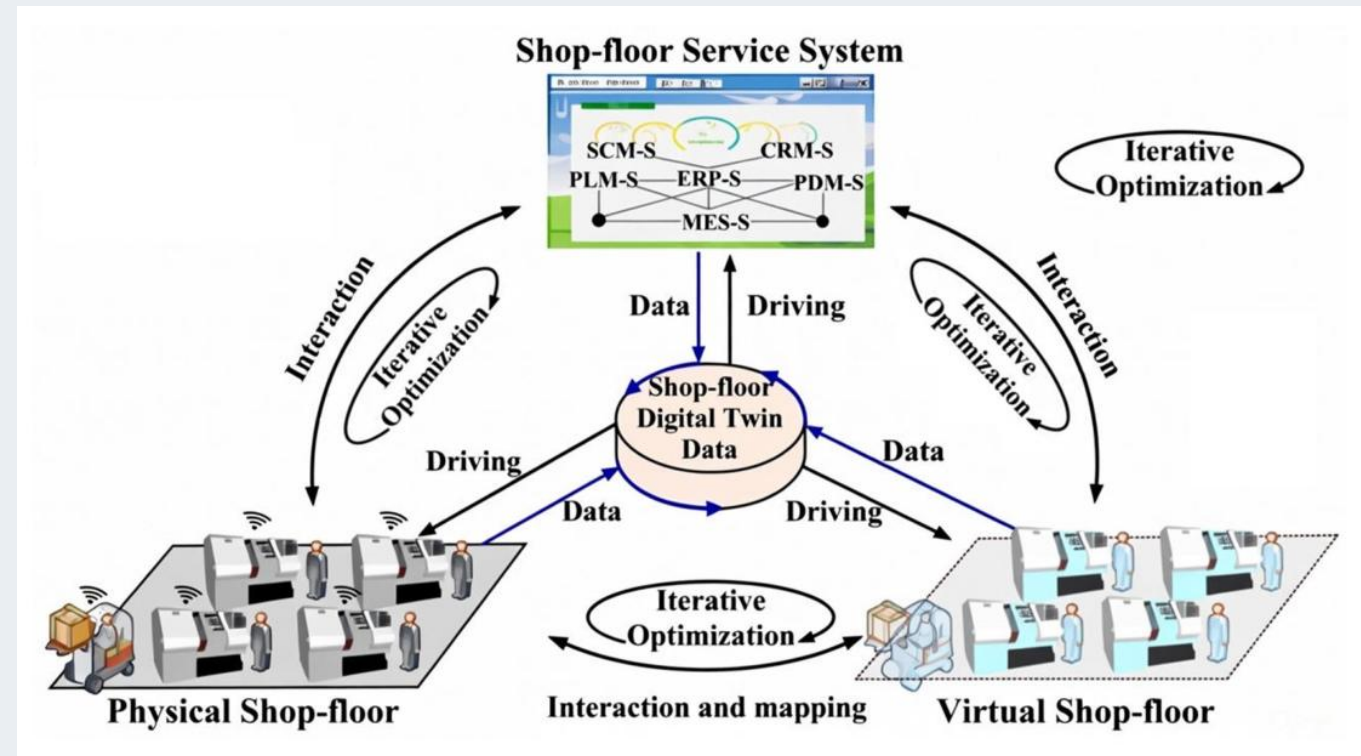


Figure: reproduced from [R2], Fig. 4.

Sources: [R2]. Figure: reproduced from [R2], Fig. 4.

Machine-level DTs: monitoring and prediction

- Machine twins represent individual manufacturing assets
- Continuous monitoring supports condition awareness
- Prediction can estimate degradation or remaining life
- Edge computing supports fast local fault detection
- Useful applications include CNC machines and rotating equipment

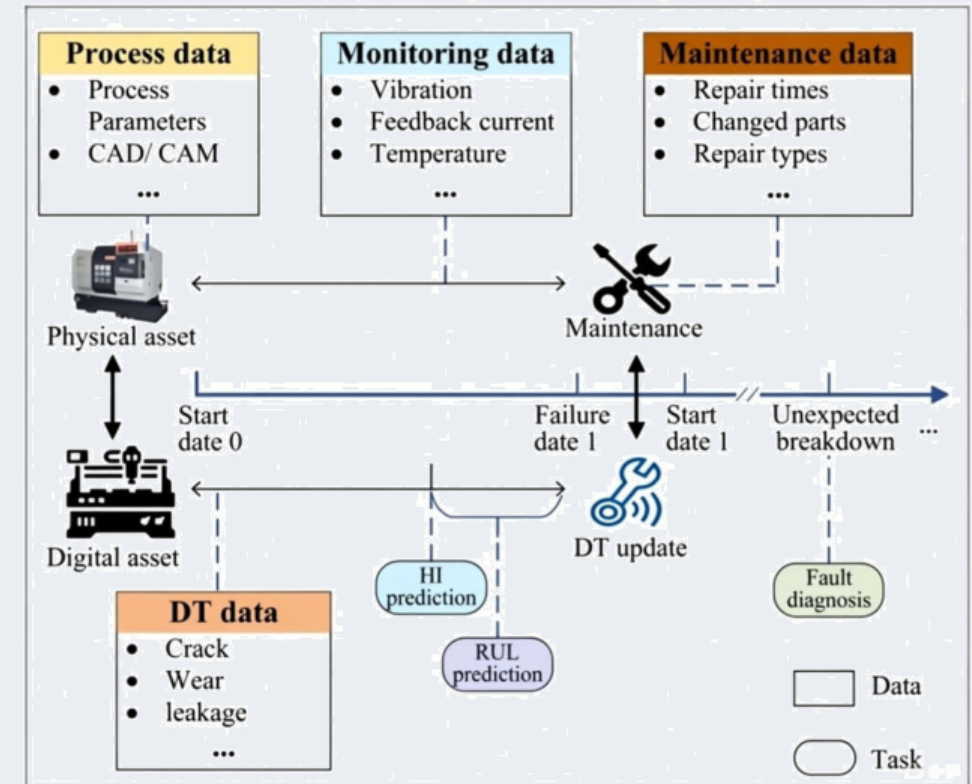


Figure: reproduced from [R2], Fig. 2.

Sources: [R2], [R3]. Figure: reproduced from [R2], Fig. 2.

Cell-level DTs and human-robot collaboration

- Cell twins coordinate machines, robots, and workstations
- Simulation helps test tasks before physical deployment
- Human-robot collaboration requires safety and awareness
- AI can support dynamic task allocation
- Virtual commissioning reduces deployment risk

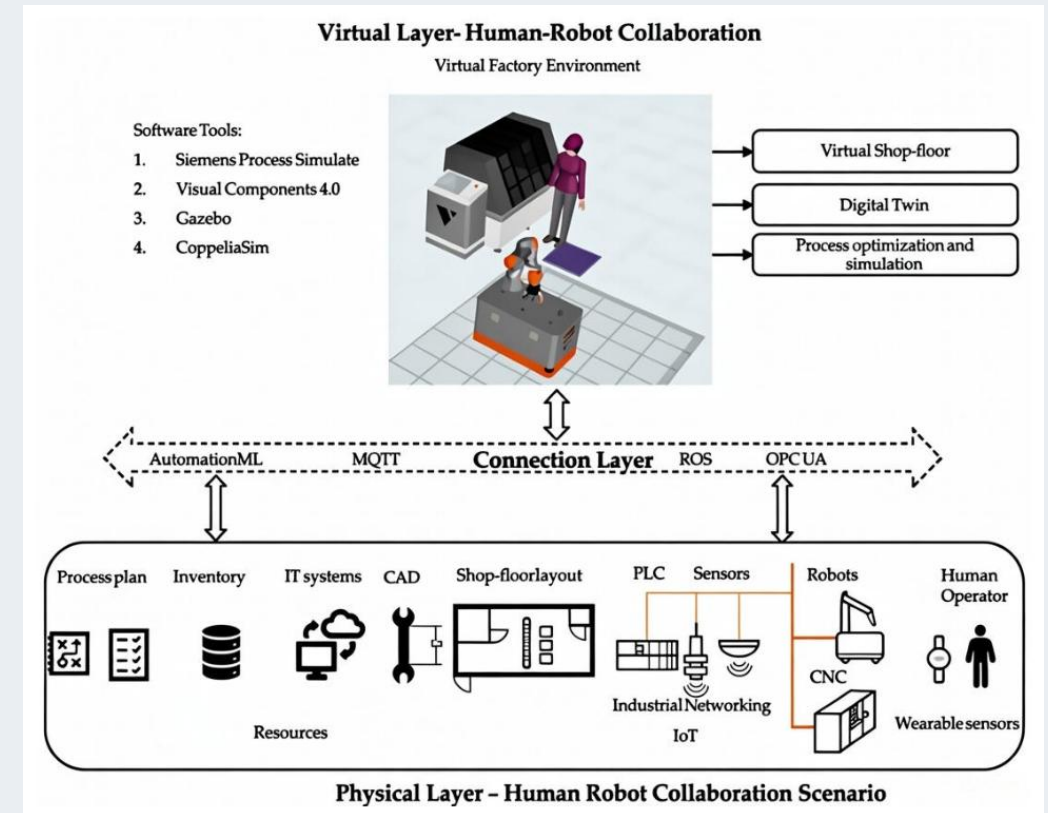
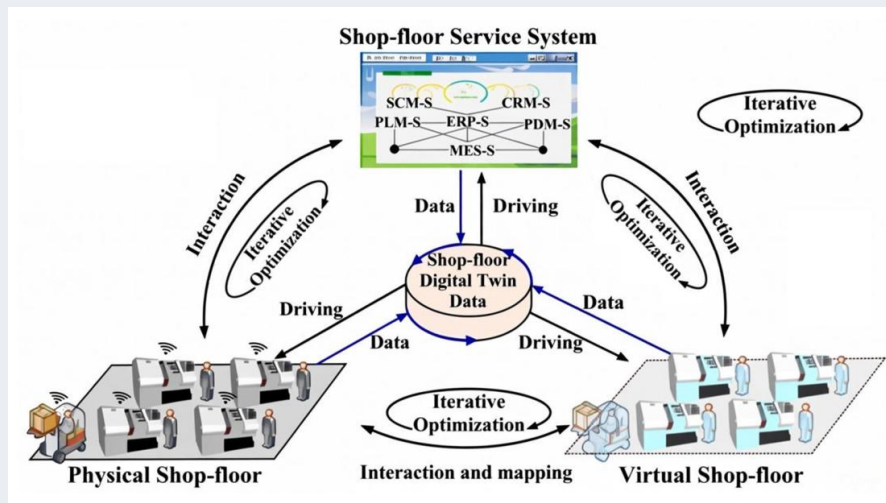


Figure: reproduced from [R2], Fig. 3.

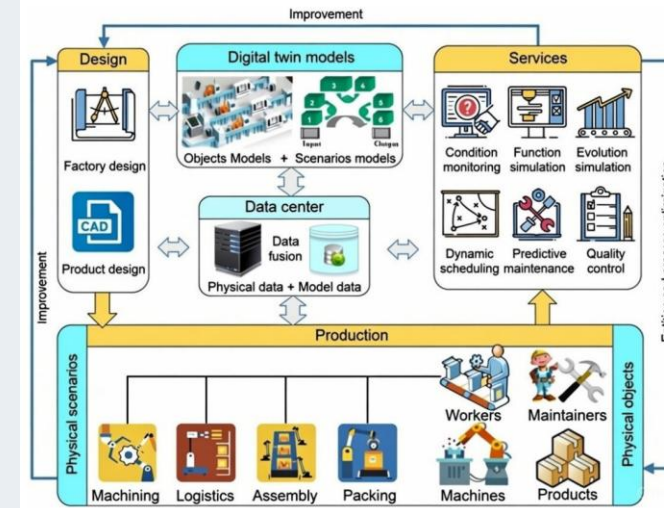
Sources: [R2]. Figure: reproduced from [R2], Fig. 3.

Shop-floor and enterprise digital twins

- Shop-floor twins integrate machines, cells, and operators
- Enterprise twins connect design, production, and service
- System-level twins support scheduling and lifecycle decisions
- Cloud and edge intelligence can work together
- Interoperability becomes a central engineering requirement



Shop-floor DT: [R2], Fig. 4.



Enterprise DT: [R2], Fig. 5.

Sources: [R2]. Figures: reproduced from [R2], Figs. 4 and 5.

Smart manufacturing as a connected ecosystem



- Sensors provide measurements from the physical plant
- PLCs and controllers provide local automation logic
- Networks, SCADA, and historians provide data visibility
- AI converts data into predictions and recommendations
- Digital twins integrate models, data, and decisions

The human role in AI-driven automation

- Human expertise defines meaningful industrial problems
- Operators provide context for abnormal events
- Engineers validate models before operational use
- Maintenance teams turn predictions into action
- Human-in-the-loop systems support trust and accountability

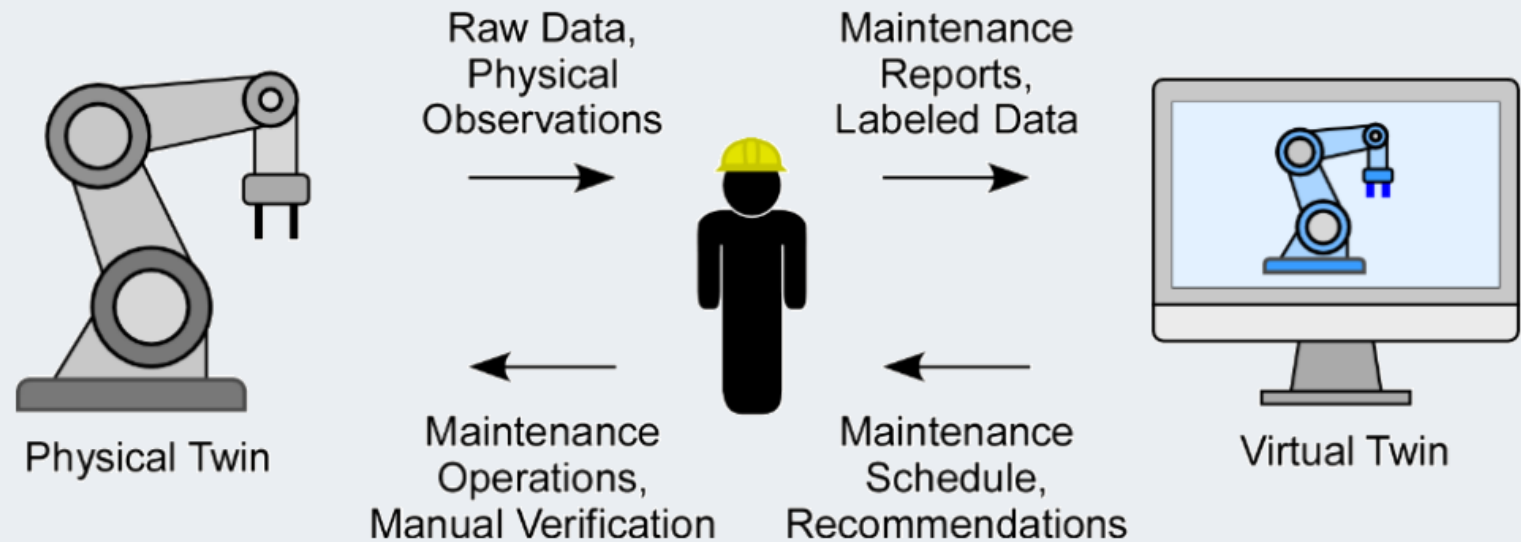
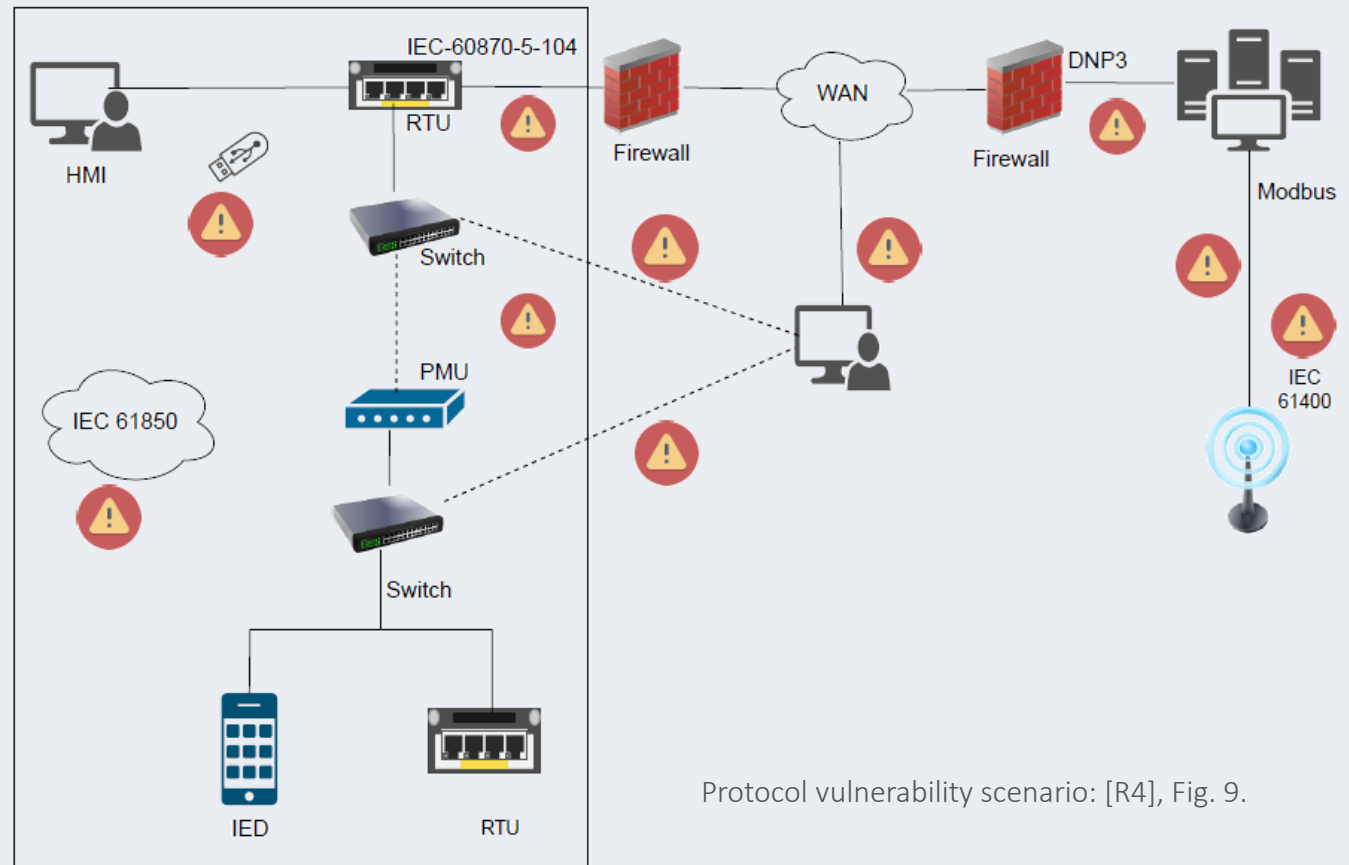


Figure: reproduced from [R2], Fig. 6.

Sources: [R1], [R2]. Figure: reproduced from [R2], Fig. 6.

Cybersecurity risks in connected industrial systems

- More connectivity can expand the attack surface
- SCADA, DCS, and PLCs are critical industrial assets
- Some protocols lack encryption or authentication
- Attacks can affect safety, availability, and operations
- Cybersecurity must be part of automation design



Sources: [R4]. Figures/table reproduced from [R4], Fig. 9 and Table 2.

AI/ML for industrial cybersecurity

- ML can support anomaly detection in ICS traffic
- Threat intelligence can improve situational awareness
- Predictive techniques can support maintenance and defense
- ML is not a replacement for security controls
- Defense requires layered technical and governance measures

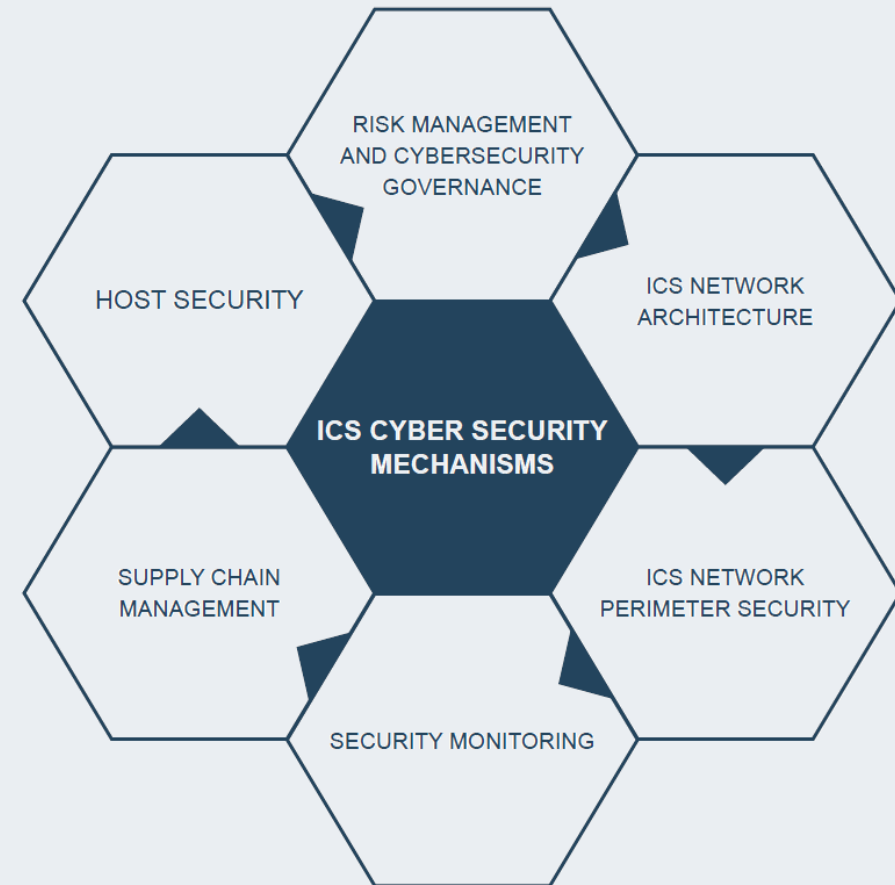


Figure: reproduced from [R4], Fig. 13.

Sources: [R4]. Figure: reproduced from [R4], Fig. 13.

Safety, reliability, and trust

- Industrial systems must remain safe under abnormal conditions
- Model predictions require validation and monitoring
- Explainability supports trust in safety-critical contexts
- Fallback modes should be defined before deployment
- Network segmentation reduces consequences of compromise

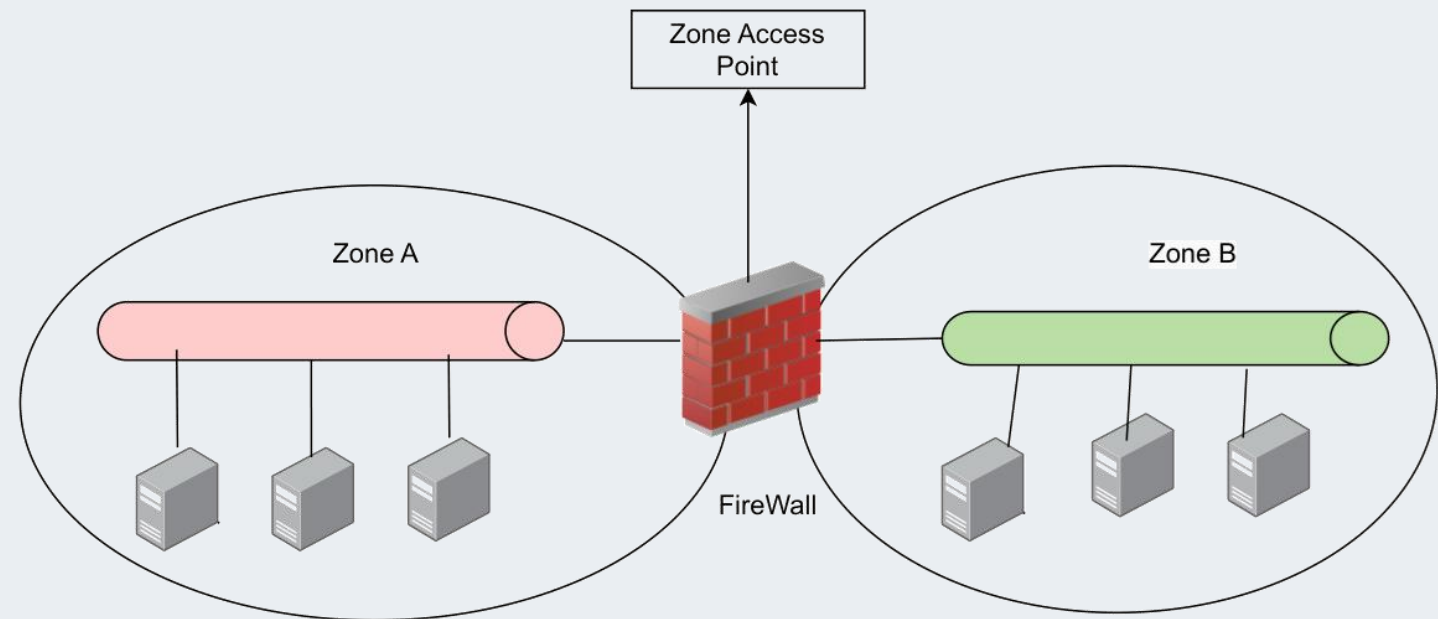


Figure: reproduced from [R4], Fig. 14.

Sources: [R1], [R2], [R3], [R4]. Figure: reproduced from [R4], Fig. 14.

Implementation challenges: where projects fail

- Data quality may be insufficient or inconsistent
- Models may not generalize across operating conditions
- Real-time deployment can exceed hardware limits
- Interoperability problems can block integration
- Organizational adoption requires trust and workflow fit

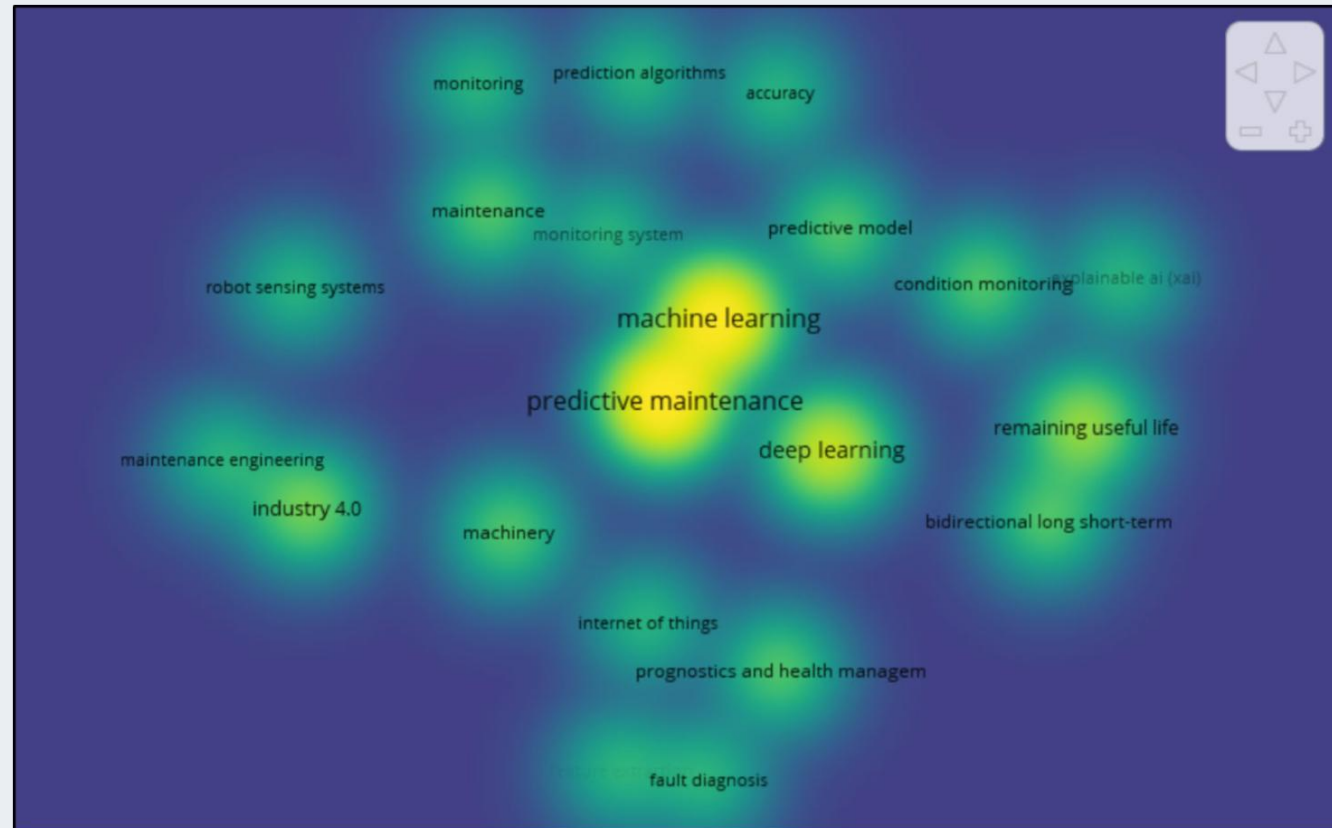


Figure: reproduced from [R3], Fig. 8.

Sources: [R1], [R2], [R3]. Figure: reproduced from [R3], Fig. 8. Verify reuse permissions before public release.

Data, interoperability, and integration barriers



- Industrial data often sits in separated systems
- Metadata is needed to interpret sensor values correctly
- Protocol differences can limit system integration
- Digital twins need synchronized physical-virtual alignment
- Successful projects require engineering and IT/OT collaboration

Figure: reproduced from [R3], Fig. 9.

Sources: [R2], [R3], [R4]. Figure: reproduced from [R3], Fig. 9. Verify reuse permissions before public release.

Future trends in industrial automation



- Self-learning and adaptive automation systems
- Explainable AI for trustworthy industrial decisions
- Federated learning for distributed industrial data
- Edge-compatible digital twins for low-latency use
- Hybrid and physics-informed AI for robustness

Sources: [R1], [R2], [R3].

Skills needed by future automation engineers



- Instrumentation and measurement fundamentals
- PLC programming and industrial control logic
- Process control, SCADA, DCS, and communications
- Data analytics, machine learning, and digital twins
- Safety, cybersecurity, project work, and professional practice

Sources: [R1], [R2], [R3], [R4], [R5].

How this connects to industrial automation education



- Modern automation requires both classical and digital skills
- Classical foundations: sensors, PLCs, control, and SCADA
- Professional practice links technology to real projects
- Digital capabilities: data analytics, ML, and digital twins
- The EIT program reflects these connected skill areas

Image: MIA program structure at EIT [R5].

Closing message: from sensors to digital twins



- Industrial automation begins with reliable measurement and control
- Connectivity turns local signals into plant-wide visibility
- AI converts data into prediction and decision support
- Digital twins connect models, systems, and real operations
- The future engineer integrates automation, data, safety, and people

Sources: [R1]-[R5].

References

- [R1] M. A. Rahman, M. F. Shahrir, K. Iqbal, and A. A. Abushaiba, “Enabling Intelligent Industrial Automation: A Review of Machine Learning Applications with Digital Twin and Edge AI Integration,” *Automation*, vol. 6, no. 3, Art. no. 37, 2025, doi: 10.3390/automation6030037.
- [R2] P. Nguyen, M. Kim, E. Nichols, and H.-S. Yoon, “AI-Driven Digital Twins for Manufacturing: A Review Across Hierarchical Manufacturing System Levels,” *Sensors*, vol. 26, no. 1, Art. no. 124, 2026, doi: 10.3390/s26010124.
- [R3] A. H. Alaoui, A. Meddaoui, and M. Hain, “AI-driven predictive maintenance for Industry 4.0: A systematic review of models, methods, and challenges,” *International Journal of Advanced Manufacturing Technology*, vol. 143, pp. 4861–4876, 2026, doi: 10.1007/s00170-026-17531-w.
- [R4] M. Nankya, R. Chataut, and R. Akl, “Securing Industrial Control Systems: Components, Cyber Threats, and Machine Learning-Driven Defense Strategies,” *Sensors*, vol. 23, no. 21, Art. no. 8840, 2023, doi: 10.3390/s23218840.

Primary evidence base: [R1]-[R4].



Thank You!

EIT – Virtual Open Week 2026



Our Virtual Open Week is our biggest live online event yet, featuring a range of sessions across the week of **Monday, 12 October 2026**.

Register for the sessions that interest you to discover more about **who we are, what we do, and why we do it**.

Plus, enter our competition for your chance to WIN!

Win A Professional Certificate of your choice valued at up to **AU\$1,581!***

Choose a certificate that aligns with your goals, build in-demand skills, and take the next step towards your future.

How to enter:

Register → Attend live → Complete the survey → You're in the draw!

Will you be our winner?

*Terms & Conditions apply. Prize value varies depending on location and selected Professional Certificate. For full conditions visit: <https://www.eit.edu.au/event/eit-virtual-open-week-2026/>

EIT
Engineering Institute of Technology

5 Days

Expert Insights | Real-World Learning | Future-Focused Engineering.

Plus live demos, student stories & industry insights.

Virtual Open Week 2026
12-16 October 2026 | Join us live

Register Now

CRICOS Provider Number: 03567C | Higher Education Provider Number: 14008 | RTO Provider Number: 51971

Upcoming Courses



Please note: courses listed below are subject to their own regulatory requirements—refer to the relevant website for further information.

Engineering Institute of Technology (EIT) <i>Australian Accredited Qualifications & Short Courses</i>		Start Date
52886WA Advanced Diploma of Industrial Automation Engineering		06 October 2026
Professional Certificate of Competency in Digital Twins and Simulation Monitoring		13 October 2026
Professional Certificate of Competency in Control Valve Sizing, Selection and Maintenance		13 October 2026
Graduate Certificate in Industrial Automation Engineering		4 January 2027
Graduate Certificate in Industrial Automation and Machine Learning		4 January 2027
Master of Engineering (Industrial Automation)		4 January 2027
Master of Engineering – Applied Research (Industrial Automation)		4 January 2027
Bachelor of Science (Industrial Automation Engineering)		8 February 2027
Professional Certificate of Competency in Instrumentation, Automation & Process Control		16 March 2027

Upcoming Courses



Please note: courses listed below are offered by separate institutions in the UK and South Africa, each subject to their own regulatory requirements - refer to the relevant website for location-specific details.

Engineering College of Technology (ECT) <i>UK qualifications</i>		Start Date
Bachelor of Engineering (Honours) in Industrial Automation		8 February 2027
Bachelor of Engineering (Honours) in Electrical Engineering		8 February 2027
Master of Science (Power System Analysis and Renewable Integration)		28 September 2026
Master of Science (Industrial Automation and Instrumentation Control)		28 September 2026

Engineering College of Science and Technology (ECST) <i>South African accredited qualification & ECSA-endorsed</i>		Start Date
Bachelor of Engineering Technology in Mechanical Engineering		24 February 2027
Bachelor of Engineering Technology in Electrical Engineering		1 March 2027

Contact Us:



Website
www.eit.edu.au



Head Office
6 & 8 Thelma Street, West Perth,
Perth, WA 6005



Phone
Inside Australia: 1300 138 522
Outside Australia: +61 8 9321 1702



Email
webinars@eit.edu.au



Courses
<https://www.eit.edu.au/schedule/>



Website
www.ect.ac.uk



Head Office
Whittle Way, Stevenage SG1 2FS,
United Kingdom



Phone
Inside UK: 0208 335 4014
Outside UK: +44 208 335 401



Programmes
<https://www.ect.ac.uk/programmes/>



Website
[www. ecst.ac.za](http://www.ecst.ac.za)



Head Office
Unit 3, Elevation Gardens,
Elevation Close, Water fall
Office Park, Midrand, 1686



Phone
Within South Africa: 010 823 4497
Outside South Africa: +27 11 823 4497



Programmes
[www.ecst.ac.za/course-
types/bachelor-of-engineering/](http://www.ecst.ac.za/course-types/bachelor-of-engineering/)