EBOOK:
OPTIMIZING CONTROL ROOMS WITH ARTIFICIAL INTELLIGENCE

MOTILDE

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INTRODUCTION

In control rooms, operators are frequently faced with high-pressure situations that require intense multitasking, critical decision-making, and stress management. These demands are compounded by organizational challenges such as shift rotations, operator interactions, and the extensive training needed to master tools and decision-making protocols. The high level of expertise required to ensure smooth operations only adds to the complexity.

To ease cognitive load, boost operational efficiency, and reduce reliance on individual expertise, new tools are emerging within control environments. These solutions aim to streamline training processes, simplify technology adoption, and deliver significant performance and cost optimization.

The combination of big data management and artificial intelligence provides a powerful response to the growing challenges faced by control rooms. These innovations not only support operators in their critical tasks but also enable smarter, more proactive process supervision.

This guide examines the current challenges in control room operations, outlines the AI-driven solutions available, and offers a roadmap for integrating these technologies into your environment.

Discover how AI can transform your operations and elevate your process oversight.

CHALLENGES OF CONTROL AND SUPERVISION

When we talk about "control rooms," we inevitably talk about the people who operate them. Operators are at the heart of every decision and bear the full weight of operational challenges.

The demanding nature of control room environments makes training a critical factor in ensuring smooth operations. To make informed decisions, detect anomalies at their onset, respond effectively, and supervise a wide range of processes, operators often require years of training before becoming fully autonomous. Artificial intelligence can play a pivotal role here: by supporting decision-making, helping identify anomalies, or preparing recommended actions for validation, AI enhances operator efficiency, accuracy, and independence—while significantly reducing the time needed to become proficient.

At the same time, some control operations rely heavily—or even entirely—on the expertise of a small number of seasoned professionals. But what happens when these key experts are unavailable? This dependency on a few individuals remains a significant risk for many control rooms today. Here too, AI provides a valuable answer.

It can:

- Assist less experienced operators with complex decisions
- Automate critical tasks
- Enable smarter, more adaptive supervision processes

By leveraging these technologies, organizations can **reduce their vulnerability to human expertise gaps** and **improve the continuity** and **reliability** of operations.

ARTIFICIAL INTELLIGENCE: REAL-WORLD IMPACT

The question you're probably asking is: "**But how, exactly**?" How can artificial intelligence deliver real, measurable value in control rooms and supervision contexts?

To answer that, let's take a look at a few real-world examples that show how AI can be applied effectively in day-to-day operations. While not exhaustive, these cases offer a clear view of how AI can become a practical, high-impact asset in complex settings.

REAL-TIME ANALYSIS: CATCHING WHAT HUMANS MIGHT MISS

AI-powered tools integrated with CCTV (Closed-Circuit Television) systems offer a wide range of capabilities—especially when it comes to anomaly detection. For example, they can identify risky behaviors such as not wearing helmets or gloves, improper lifting posture, slips or falls, and unauthorized access to restricted areas. They can also flag obstructions, like misplaced objects blocking key pathways.

When combined with additional sensors—thermal, infrared, humidity, gas detection, and more—these systems can go even further, detecting leaks, explosion risks, and other safety threats before they escalate.

AI's analytical capabilities aren't limited to video data. They extend to virtually any type of input, making them especially valuable in industrial settings where massive volumes of data are constantly being generated. By consolidating and analyzing that data in real time, **AI provides critical insights into past, ongoing, and emerging processes.**

REDUCING OPERATOR COGNITIVE LOAD: THE NEXT-GEN ASSISTANT

In high-stakes environments like control rooms, operators are constantly bombarded with information they must process quickly—while managing alerts and coordinating with team members in real time.
AI can significantly ease this cognitive burden through several key functions:

Detection and prioritization: AI identifies critical information and intelligently routes data, streamlining communication between operators and focusing attention where it matters most.

Smart reporting: It generates concise, high-level logs that highlight essential details for shift handovers or later reviews, ensuring continuity and clarity.

Enhanced interfaces: AI enables the development of more intuitive and responsive interfaces, improving the overall user experience in control rooms.

Alarm management: It helps reduce alert fatigue by simplifying alarm handling, filtering out noise, and lowering stress during peak load situations.

AI doesn’t replace the operator—it empowers them to focus on what truly requires human judgment.

DECISION SUPPORT: THE RIGHT INFORMATION, AT THE RIGHT TIME, FOR THE RIGHT PERSON

In addition to reducing cognitive load, AI can significantly assist operators in their decision-making process—especially in situations that require quick action and involve large amounts of complex data. Expert systems and fuzzy logic help simulate decision-making and provide operators with precise, context-driven recommendations, or even fully automate certain actions.

This improves incident prioritization, reduces false alarms, speeds up decision-making processes, and ultimately lessens the need for deep human expertise when dealing with complex situations.

AI also enables fast "*what-if*" scenario analysis, allowing operators to visualize the potential outcomes of their actions before taking them. This feature is particularly valuable for less experienced operators or in high-pressure, unfamiliar situations.

OPTIMIZED MAINTENANCE: PREVENTION AND PREDICTION

AI excels at predictive analytics. By analyzing data from equipment, it can forecast failures and enable predictive maintenance. Unlike reactive maintenance (fixing issues after they occur) or preventive maintenance (routine upkeep), predictive maintenance targets specific interventions, cutting both costs and downtime.

In cybersecurity, a similar approach detects vulnerabilities, or intrusion attempts **before they cause damage**. More broadly, AI can help identify potential issues across various industries before they escalate.

OPTIMIZING CONTROL ROOM OPERATIONS

AI can also improve the internal operations of control rooms:

- **Organizational improvements:** Monitoring individual performance to optimize shift scheduling and deliver targeted training.
- **Automation:** Streamlining operations by automating repetitive tasks or using virtual assistants.
- **Voice commands and summaries:** AI-driven natural language processing (NLP) can simplify complex reports and enable voice commands to make operations more efficient.

These enhancements boost overall team performance and eliminate organizational bottlenecks.

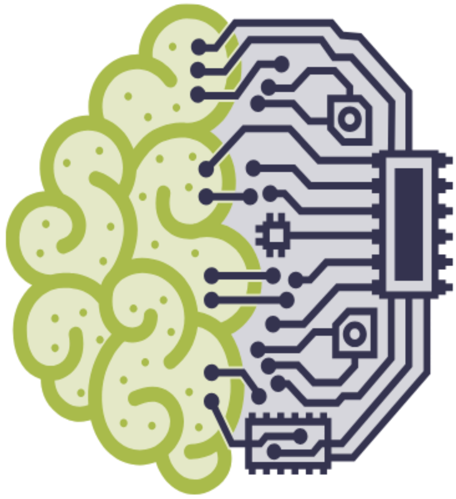
AI doesn’t just add value—it transforms control rooms into smarter, more agile operational hubs.

Adopting these technologies leads to better operations management, cost savings, and continuous performance improvements in increasingly complex environments.

REQUIREMENTS AND SETUP

To be fully leveraged, artificial intelligence (AI) requires a supply of data that is high-quality and often large in quantity.

Before we delve into how some AI tools work, we would like to give you an overview of the types of data found in control and supervision environments, as well as the key principles for their proper use.



TYPES OF DATA IN A CONTROL ROOM

Control rooms are environments where a wide variety of data converges to be monitored, analyzed, and manipulated.

This data can be grouped into three main categories, which must be processed simultaneously and in an optimized way to ensure effective management.

PROCESS DATA

This refers to information originating from the processes being supervised or controlled.

- Physical sources: sensors, cameras, detectors, using various protocols (IoT, SCADA).
- Non-material sources: software, web pages, virtual machines.

This data forms the core of operations and is often very extensive and diverse.

The protocols used to handle this data are highly varied, and their processing can be done through SCADA (Supervisory Control And Data Acquisition) systems or the IIoT. We've written a blog post exploring these two data management systems.

IT INFRASTRUCTURE DATA

This data relates to the **status of the IT equipment** that supports the transmission of process information. This could include data about the operational status of an IT device (functioning, slow, stopped) or its usage characteristics, such as memory usage, current throughput, or available bandwidth.

It's thanks to the proper handling of this data that alerts are managed effectively in the control room. If an alert occurs, the first step is to verify that the source of the alert is functioning correctly, thus distinguishing whether the problem originates from the process or the infrastructure itself.

This data also helps in identifying the source of a failure: if information is missing, we can determine if the fault lies with the sensor, the switch, or even just the display.

Therefore, the effective use of this data ensures service continuity and rapid fault detection, as well as optimizing information transmission by identifying bottlenecks and underutilized processing capacities within the IT infrastructure equipment.

ENVIRONMENTAL OR SITUATIONAL DATA

Finally, less obvious but often crucial, environmental or situational data encompasses all the information that enables operators to make decisions based on additional pieces of information that can come from very **diverse origins**.

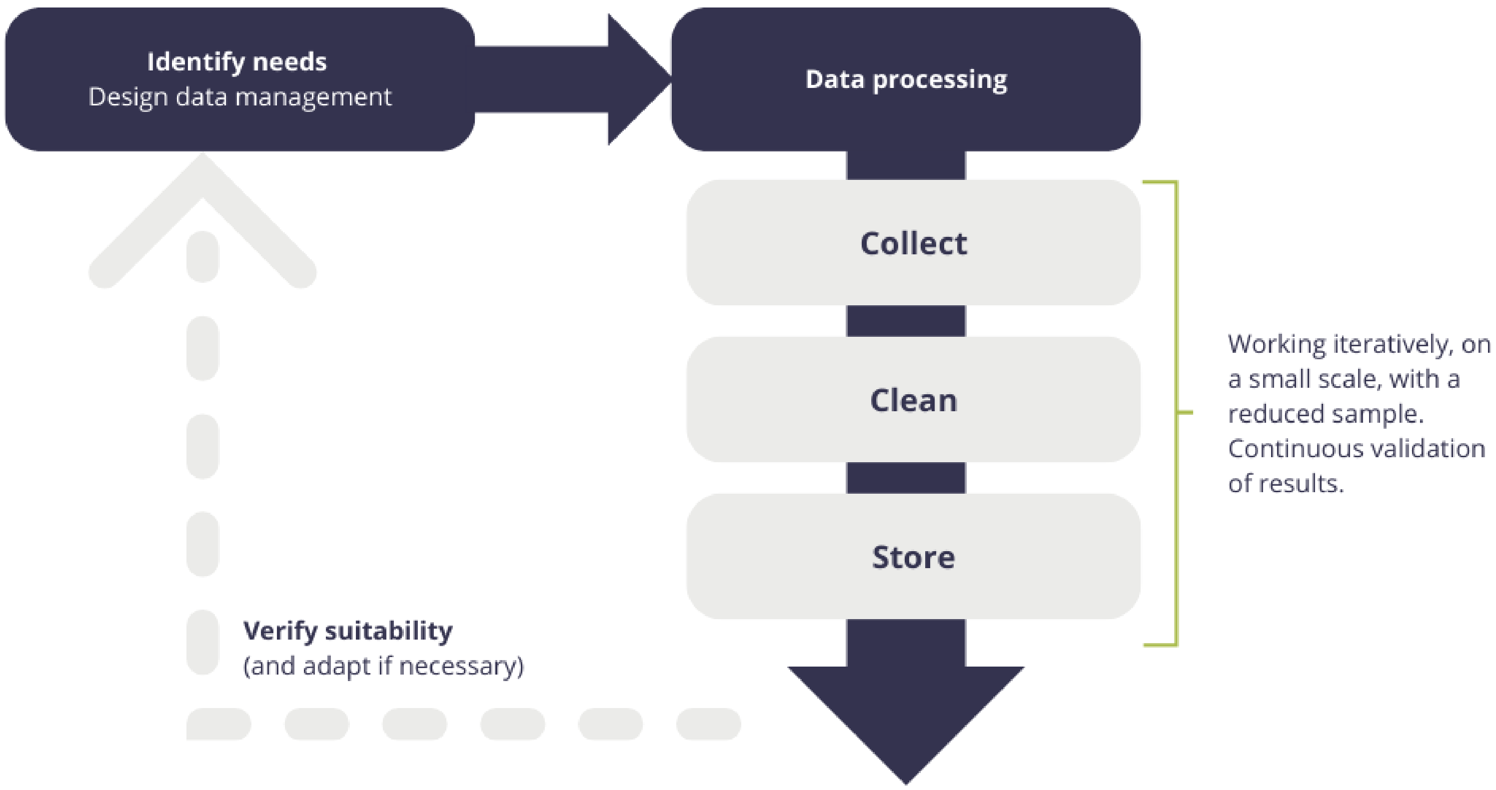
This includes information that can come from the operator's environment: the outside weather, the temperature in the control room, noise or the number of people in the room, lighting levels, etc.But it also includes data about the current situation during operations: the absence of an operator or the presence of a supervisor, a particular political situation, knowledge of specific information from colleagues or service providers, an emergency situation, etc.

Although seemingly less tangible, this data often has the most significant impact on how events are managed in the control room.

Therefore, just like process and infrastructure data, it must be fully processed to ensure that control operations are as effective as possible.

DATA PROCESSING

Regardless of the type of data we're dealing with, it is always necessary to process it beforehand so that we can then utilize it effectively. This is because AI models require clean data to be efficient. Data management and processing follow a classic process that we will detail in this section. Although several procedures exist, they almost all follow the same pattern.



IDENTIFYING THE NEEDS

Before starting to process the data, it's essential to define the scope of this processing, and this will depend on the specific project.

A huge amount of data might be available, so it is necessary to **target the data that is relevant to the objective at hand**.

It is also important to define each data source we plan to interact with, as well as the type of data involved.

Additionally, it is necessary to define the collection frequency, the analysis frequency, the total amount of data to be managed, and so on.

Only once the data management project is properly framed can we begin processing the data.

DATA COLLECTION

The first step, and a crucial one, is the extraction, or collection, of all the data we want to utilize. The goal is to obtain the necessary data at the desired frequency from each targeted source.
To do this, we need to open the correct communication channel with each data source and use the appropriate protocols (such as Modbus or OPC-UA for certain automated systems, MQTT for IoT devices, etc.).
It's at this stage that we differentiate between data we want to collect in real-time (streaming) and data we collect periodically by storing it (batch). Sometimes, a preliminary processing step is performed directly during data collection, verifying that the formats comply with expectations and that the data flow can continue without interruption or processing errors. Edge computing involves processing data close to the source, before storage, in contrast to cloud computing, which constitutes post-storage processing.

DATA STORAGE

The step that comes after collecting data in a typical data flow is storing it. Here, we differentiate between **edge computing** – which is pre-processing data close to where it originates – and **cloud computing**, where data is processed in the cloud.

Designing the architecture for how data flows is a whole area of expertise in itself. Decisions specific to the client's situation need to be made based on the security and performance levels they want. The different kinds of storage that can come out of this – like a data lake, data warehouse, or database – and where they're located, whether in the cloud or on-premise, each have their own unique features and benefits.

Processing data in real-time also needs a special setup that will vary depending on the project.

DATA CLEANSING

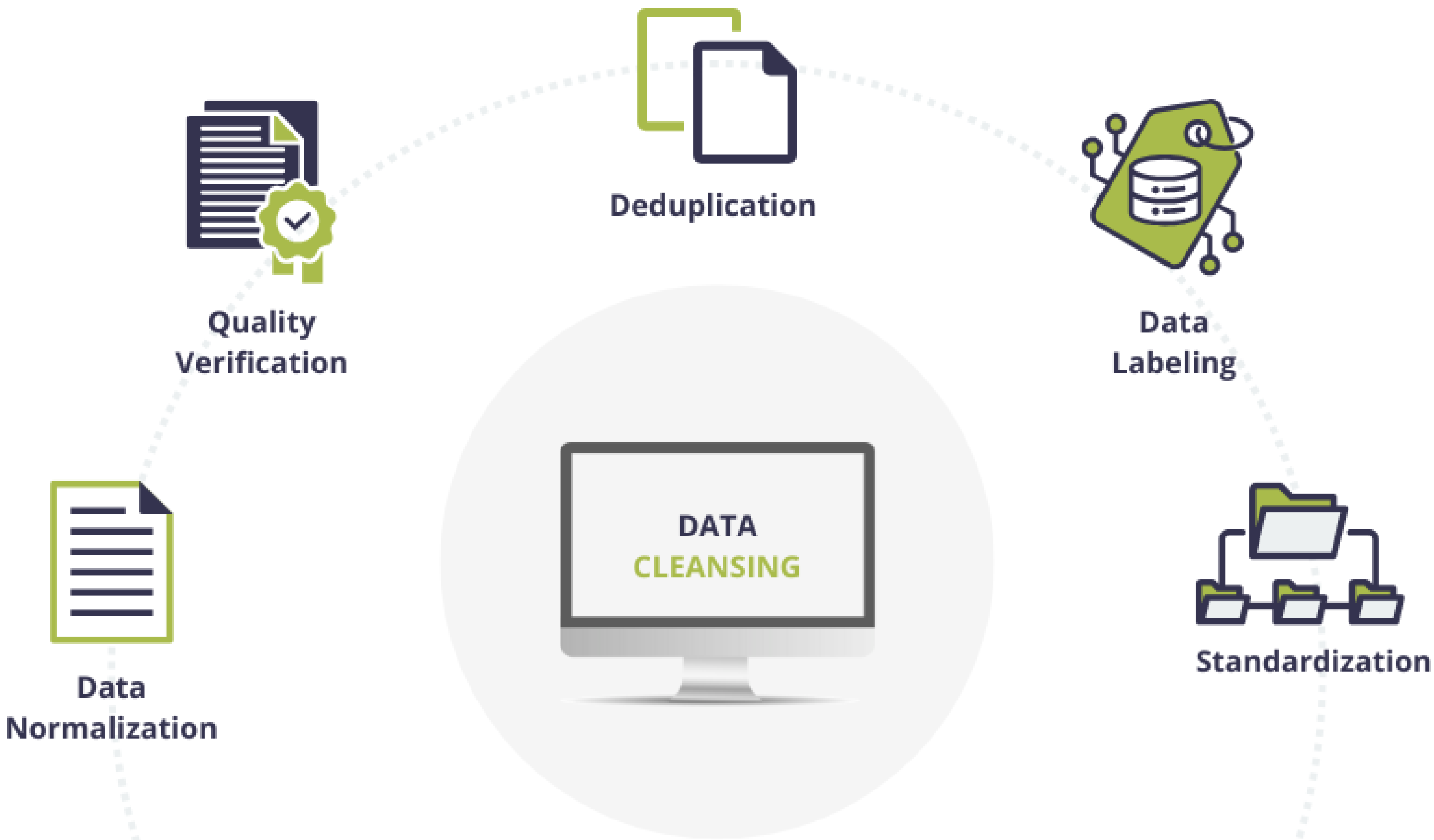
Data cleansing is likely the data management step that makes all the difference between a project with significant added value and one that yields few operational results. Depending on the storage method used, this step can also be carried out before the previous one if the chosen model has prerequisites for the data that needs to be stored.

Whether performed before or after storage, data cleansing is the step that **transforms raw data into usable data**.

Like a sieve that removes lumps from flour before you can bake with it, data cleansing involves applying filters to make the data workable.

This can involve making corrections to address acquisition flaws, such as detecting abnormal values or replacing missing ones.

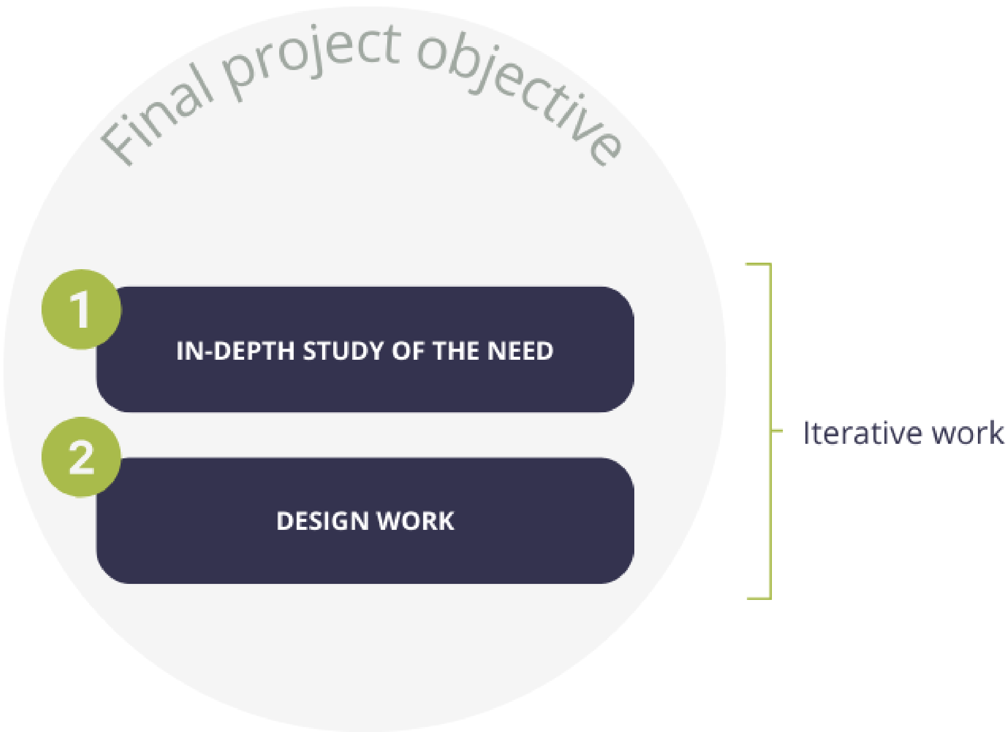
There may also be more specific treatments related to future processing needs, such as normalization, segmentation, or enrichment through data labeling.



KEYS TO SUCCESSFUL MANAGEMENT

Adhering to a few fundamental principles in data management will lead to a higher success rate for your Artificial Intelligence projects.

Firstly, it's crucial to keep in mind that a thorough **and in-depth study of the needs** is necessary before embarking on such a project. You need to know what data is accessible and determine which data is useful and where you want to start.
Next, a **design phase** must take place. You need to think about the data architecture, define the flows that will circulate, and the methods for collection, storage, and cleaning.
A good practice is to work iteratively. Start with small-scale data collection to verify that the designed flows are working correctly and to observe the initial results.
This allows you to validate each step of the data management process and build a concrete and verified solution.



Finally, following the previous steps and throughout the iterations, it's essential to **never lose sight of the project's ultimate goal**. It's important to continually question whether the solution being built will provide the answer and if it aligns with the initial need.

By following these tips, you'll ensure quality data management, which is an indispensable prerequisite for any AI project in control rooms.

SOME AI AND DATA MANAGEMENT TOOLS - AND THEIR MAIN FUNCTIONS

Here's a quick look at some of the tools we often see in data management or artificial intelligence projects in control room settings.

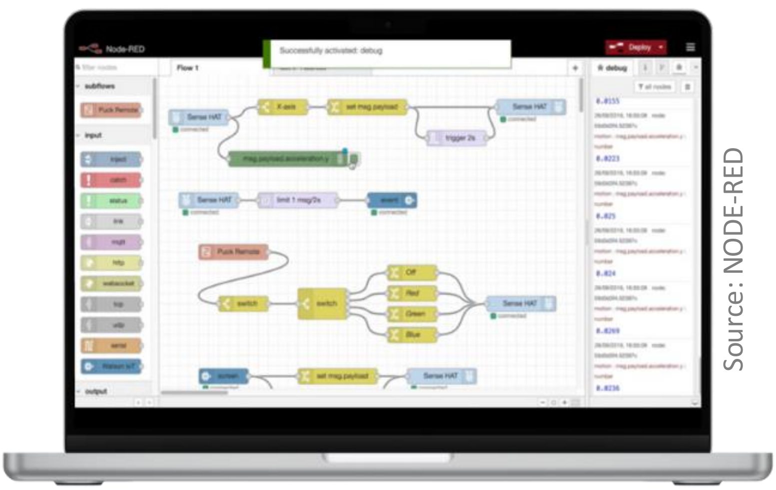
IIOT - INDUSTRIAL INTERNET OF THINGS

You've probably heard of the IoT (Internet of Things), well, the IIoT (Industrial IoT) is simply when it's used in industrial applications. It relies on lots of connected devices and smart sensors that can collect a huge amount of data in industrial environments.

Using communication that usually goes through the Cloud, and thanks to its modern communication methods (like MQTT and AMQP), it allows for both collecting a massive amount of data and sending it quickly.
If you want to know more about this, our blog post that compares SCADA and IIoT should be helpful.

NODE-RED

Node-RED is a tool for managing events. It's an open-source platform that uses a "low-code" approach, meaning you don't need a lot of coding knowledge to use it. With its visual interface, you can set up how data flows and connect different devices, sensors, and APIs (Application Programming Interfaces). You basically pick what data comes in and where it goes out, and you can add functions to process that data along the way. This makes it easier to build the underlying structure for managing your data. You'll need to get the hang of it to use it well, but it lets you design how your data is handled without having to write a bunch of code. For more complex tasks or larger systems, you can still fine-tune it by adding your own scripts.



Source: NODE-RED

MACHINE LEARNING

Machine Learning is a part of artificial intelligence where models are trained to learn and improve on their own using a large amount of existing data to perform a task. This could be something like spotting unusual activity, categorizing different situations, or **predicting when something might go wrong**. This can help reduce downtime, make better use of resources, and improve **safety** in industrial plants.

To set up a Machine Learning solution, the first step is to choose a model that fits the type and scale of the problem you're trying to solve. Then, using a large amount of data that has already been collected and cleaned, you train the model so it learns on its own. It will repeatedly adjust its settings during this training process until it reaches a satisfactory level of success. After that comes the testing phase, then deployment (putting the model into use), and finally, maintaining the models over time.

For example, in an industrial setting, trained models can use past data to figure out the likelihood of future breakdowns based on current production data. This means maintenance can be specifically targeted at those machines, which is what we mean by predictive maintenance.

VIDEO ANALYSIS

With the need to automatically process data and the ever-increasing amount of it, real-time analysis has become one of the most widespread areas of AI. One of its applications in control rooms is real-time video analysis.

Using image recognition or anomaly detection models, you can apply an "AI Filter" to videos to: detect intrusions, identify vehicles, check if safety regulations are being followed, spot leaks, monitor speeds, verify the presence of objects or people, and much more.

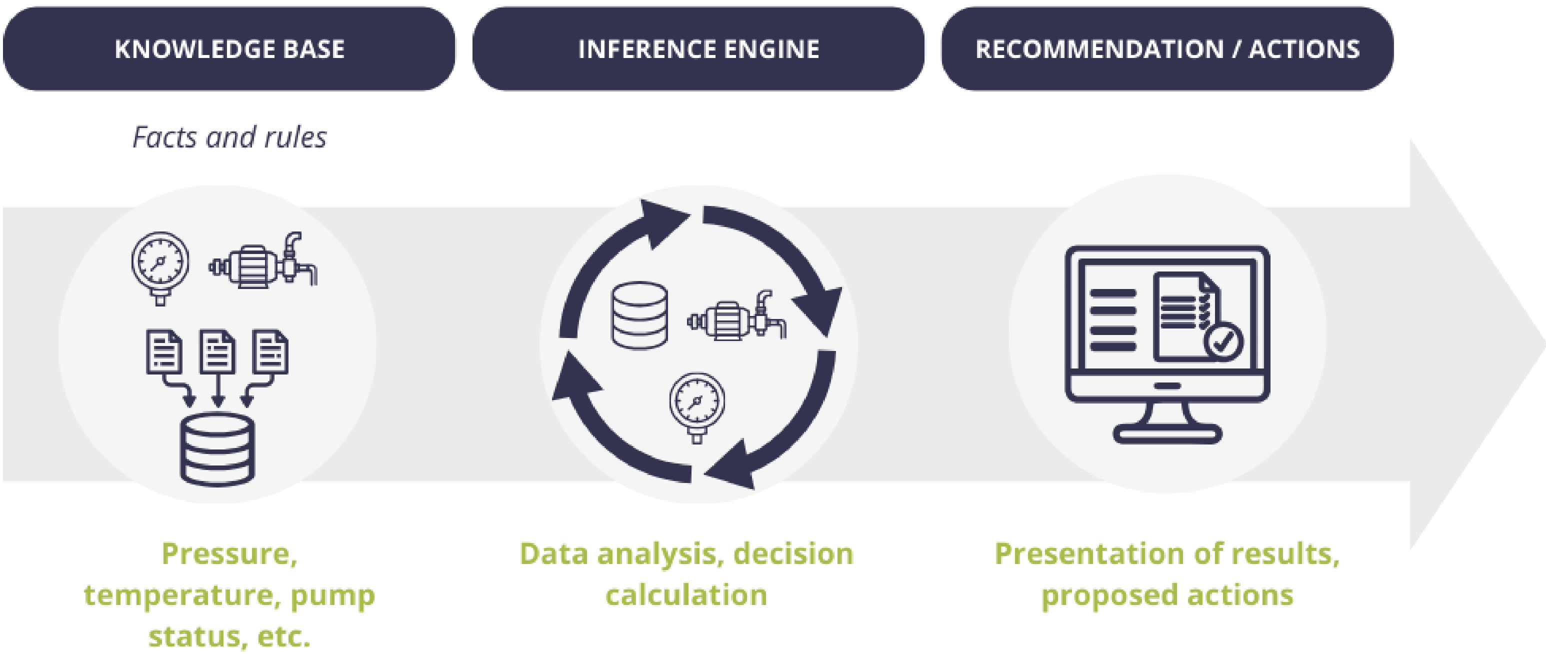
As you can see, the possibilities are almost endless and mainly depend on what you need.

EXPERT SYSTEMS

Expert systems are particularly useful for making decisions in complex environments. They can generate recommendations for actions based on a library of rules and factual data, along with an "*if-then*" style reasoning engine.

The power of these systems comes from their speed of calculation combined with the ability to consider a huge number of factors. When setting up an expert system project, the first important step is to define the facts that the system will use to generate its recommendations.
It's also crucial to design rules that are logical and meet the project's needs, and to formulate them properly and intelligently so that the system is as effective as possible.

Finally, the last step is to integrate these systems within the control environment and into the data processing chain. For example, they can be integrated with SCADA systems and even automate certain actions in response to events that occur.
Fuzzy logic systems work on a similar principle and are very much like expert systems, except that the rules governing them are less black and white and can generate more nuanced recommendations. Both types of systems are key tools in helping operators make decisions quickly and effectively, while taking a large number of factors into account.



You now have a foundational understanding of the potential applications of data management and AI in optimizing processes and enhancing decision-making within a control environment.

Should you require further information or wish to discuss your specific requirements in greater detail, we encourage you to contact our specialists in control room solutions.

REQUEST A CUSTOMIZED STUDY OF YOUR PROJECT

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