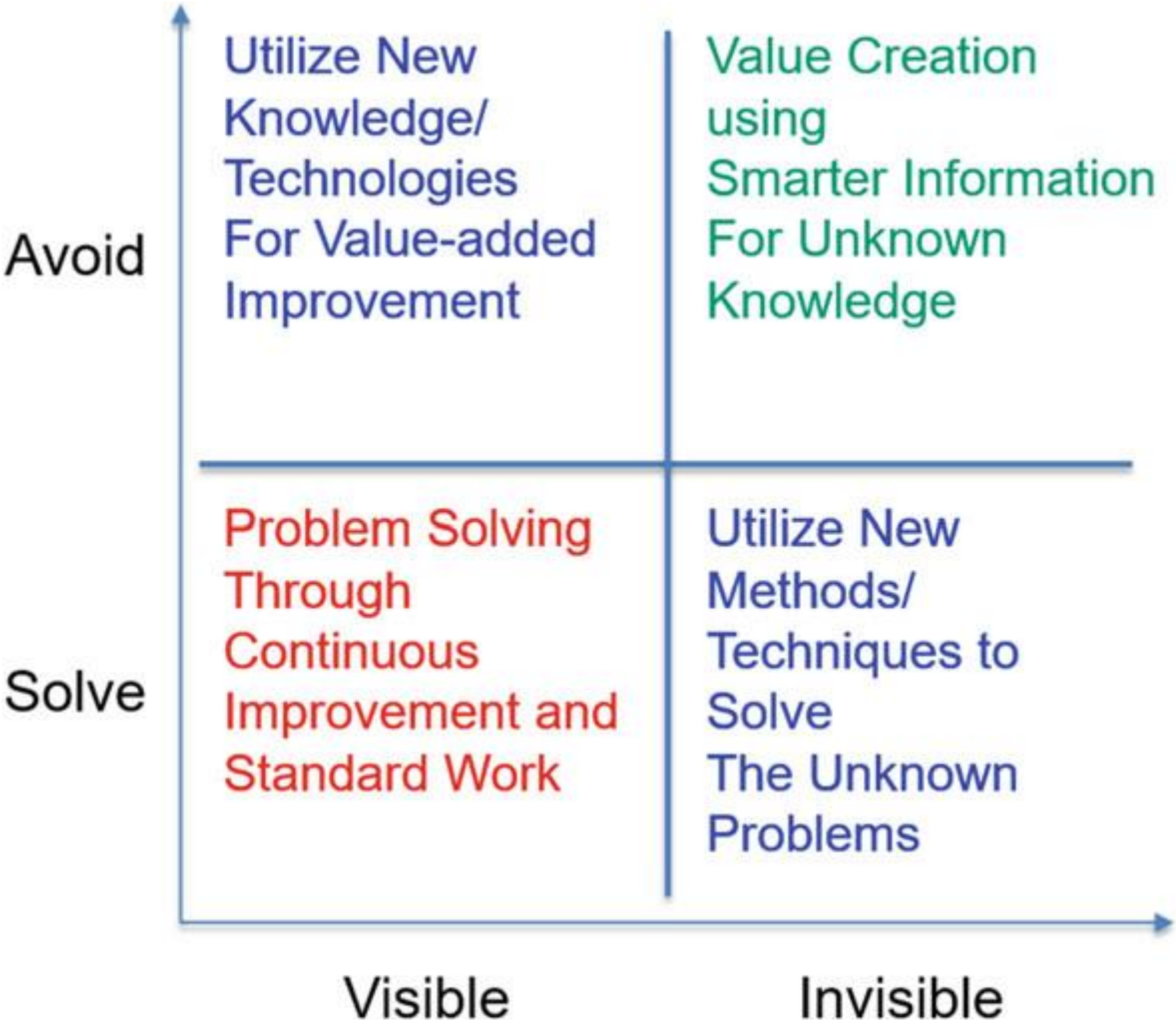
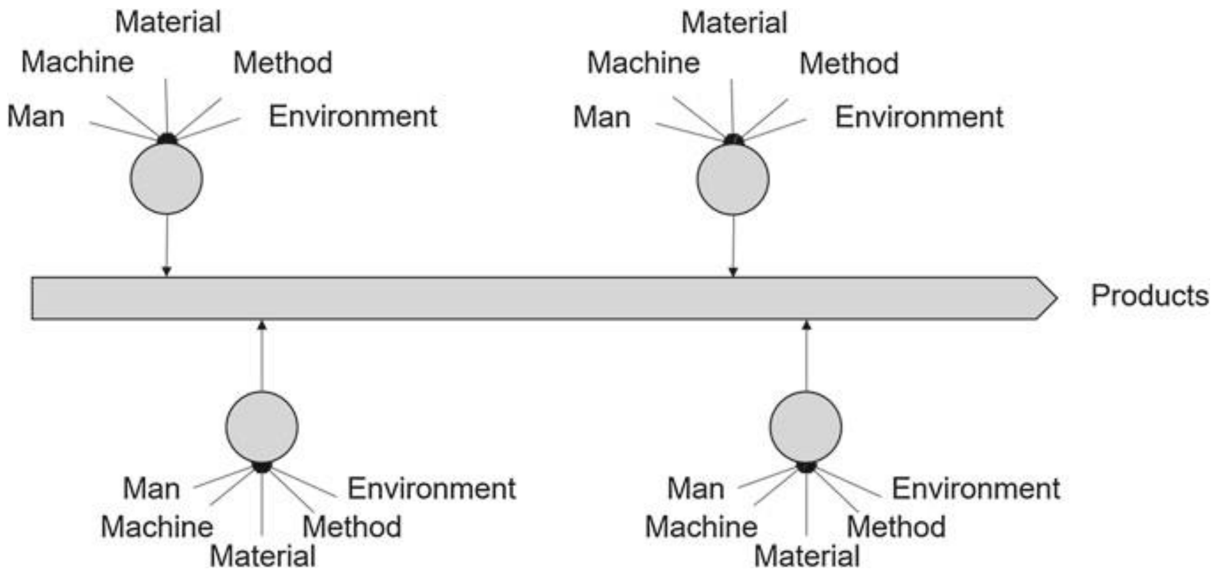
The Purpose and Value of Industrial AI



Visible and invisible problems in industrial systems



Invisible problems in manufacturing systems

There are still many hidden problems that cannot be managed, mainly reflected in:

• The process factors cannot be measured, and the state of the machine can be unknown. This includes deterioration of equipment performance, deviation of process parameters, and inconsistency of incoming materials.

• The relationship between process factors (x) is not clear, which may cause all of x to be within the control limits while the quality of the process still deviates.

• The relationship between the variations of process factors and the quality of intermediate processes cannot be accurately and quantitatively assessed.

The first purpose of Industrial AI is to make the hidden problems in an industrial system explicit, then to avoid those problems by managing them while they remain hidden. The core technologies include:

1. Measuring process factors that cannot be automatically measured, such as equipment conditions and fault prediction through machine vision, pattern recognition, advanced sensing, and other technologies.

2. Modeling the relationship between process factors and process quality:Multivariate process anomaly detection, virtual metrology, deep learning, neural networks, association rule mining, and other technologies.

3. Dynamic optimization of optimal process parameter settings enables the enhancement of the system resilience and automatically compensates for errors including:

optimization algorithms, dynamic error compensation, intelligent control systems, and other technologies.

The second goal of Industrial AI is to accumulate, inherit, and apply knowledge on a large scale.

Human knowledge generation can no longer meet the requirements of the production system. Humans are reaching the peak efficiency of operation and collaboration. Restricted by human experience and knowledge, a large part of the value of production systems has been inhibited by the limitations of human decision making. This is mainly reflected in three bottlenecks: the speed of knowledge acquisition, the maximum ability capacity, and the scale of applications. The management of knowledge through Industrial AI needs to achieve the following two goals to surpass this:

1. Enhance the productivity of knowledge as the core factor of production and make the production, utilization, and transmission of knowledge more efficient at large-scale.

2. Reoptimize the value chain relationship of production organizational factors so that each link in the entire industrial chain can provide services to end-users in an efficient and collaborative manner, focused on providing value.

So, what is knowledge? How should knowledge be modeled and managed? We believe that knowledge within an industrial system is the relationship and operations of objects, environments, and tasks. It is an abstract expression of comparability, relevance, and purpose, and can be summarized by the three R's:

• Resources: Knowledge and experience are built on the basis of sample data from observation and results. Data sources can be historical data, sensor data, or human experience data, all of which can combine in a logical way to form a knowledge model. Resources are also the basis of comparability.

• Relationships: Based on the analysis of comparison and correlation, relationships between the visible and the invisible can be found. For example, there are hundreds of sensors generating data in semiconductor fabrication, and historical alarm information and Bayesian networks can be used to establish relationship maps between them. If, perhaps, these hundreds of sensors had strong correlations with a group of five particular sensors—these five sensors could then manage the status represented by the sensor data as a whole. Another example is how, during the operation of engines developed by GE, a relationship between air pressure, air density, combustion temperature, and speed can be established and used to reduce fuel efficiency by optimization.

• Reference: There are two aspects of reference: one is the reference of comparison,the other is the reference of execution. This can also be divided into active reference and passive reference. Reference is also the basis of memory; if a result is used as the point of reference, the purpose is then to find the root cause of its occurrence.

If a process is used as the point of reference, then the purpose is to find ways to avoid problems. There is a saying in Chinese: "Using glass as a mirror, you can fix up your clothes. Using history as a mirror, you can learn the cycle of a dynasty. Using people as a mirror, you can understand right from wrong." This ancient proverb summarizes the three dimensions of reference: How sensor data reflects a system (using a normal, glass mirror that reflects reality), how historical data reflects the interaction of data (using history as amirror to learn patterns), and how people understand and interpret the data (using people as a mirror to understand the real effects of things). Industrial AI can achieve a significant improvement in the management of the above three R's. It can acquire and manage data from richer sources, model more complex relationships, and provide reference and comparability in broader dimensions.

In the final analysis, it is a process of optimizing real time decision-making of management and control activities, and efficient execution of employees being able to assess the state of the processes.

There are three challenges in Industrial Intelligence including “state assessment,” “decision-making optimization,” and “collaborative implementation.” These terms represent the greatest challenges in achieving the above capabilities.

1. State assessment: In order to understand the real-time state of individuals and the environment and how they relate to activities, many of which are not measurable, it is necessary to use modeling to predict the measurable parameters, and more importantly, to accurately evaluate and predict how individuals interact.

2. Decision-making optimization: Decision-making optimization should be based on an accurate and complete understanding of the state, precise analysis, and deduction of the impact of various possible decisions. Full consideration of the

3 Definition and Meaning of Industrial AI trade-offs among multiple objectives must be considered in order to maximize the value of the overall objective.

3. Collaborative implementation: In the process of collaborative implementation, we should consider the hierarchical relationships, timescale, and correlation between decision-making and implementation, and have a pre-determined amount of fault-tolerance.

Knowledge does not exist by itself—it needs to be communicated through a medium. The medium determines the efficiency of knowledge generation, transmission, and application. An example is how, in Japan’s manufacturing culture, knowledge is mostly based on using human experience and management systems as the carrier, and is expressed through the training of people and constant improvement of the culture of inheriting knowledge. In German manufacturing culture, knowledge is mostly inherited by focusing on superior production equipment and integrated manufacturing systems, which solidify knowledge into control instructions and logic. With the help of Industrial AI, knowledge can be applied and inherited through data and models, and can help people acquire new knowledge more quickly by constantly finding new relationships and rules from data generated during machine operation.

Future industrial systems will face more uncertainties and changeable environments and systems (environment uncertainty, system uncertainty and task uncertainty). Therefore, smart industrial systems need four basic concepts:

1. Environment-oriented intelligence, which perceives and predicts changes and uncertainties in the environment.

2. State-oriented intelligence, which evaluates and predicts the changes of its own state and the factors influencing risk and performance.

3. Cluster-oriented intelligence, which includes cooperation and collaboration with other individuals and the environment, and helps others learn new knowledge and experience using the activities of individuals.

4. Task-oriented intelligence, which is the transition from “if-then” to “what-if.” This requires not only achieving goals, but also includes the knowledge of predicting and managing adverse outcomes.