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INTELLIGENT CONTROL SYSTEM-AN OVERVIEW

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Abstract

The intelligent control system combines control theory and artificial intelligence, which is AI technology. In this paper, we will go over how intelligent control systems work and why they are used. We will also discuss its critical importance in the field of technology, as well as its advantages and disadvantages. The use of a control device to make the controlled object run automatically or keep the state unchanged without the participation of people is referred to as automatic control. In order to solve the current methods that require human intelligence, the guiding ideology of intelligent control is based on people's ways of thinking and ability to solve problems. Control system intellectualization issues are observed. The need for intellectualization of a diverse range of systems and control methods is supported. The hierarchy of intellectual control levels is observed, and various artificial intelligence methods are compared.

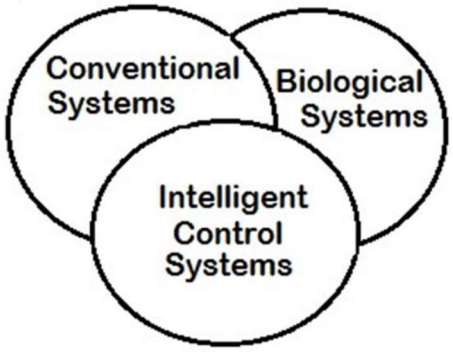
Keywords: Intelligent Control System, Fuzzy Logic, Classical Control, Intelligent Control, Artificial Intelligence, Soft Computing, Hard Computing, Soft Computing Tools.

Introduction

Artificial Intelligence (AI)

The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings is defined as AI.

The definition of intelligent systems is a function of expectations and the state of current knowledge: perhaps today's "intelligent systems" are tomorrow's "classical systems."



Artificial intelligence (AI) emerged and developed concurrently with the theory of automatic control, beginning around the 1950s, with the first major applications in computing and information science, and later in automatic control1. The first commercial and industrial applications of AI can be traced back to the 1980s2. AI has reached a certain level of stability and maturity during this time.

Artificial intelligence is quickly becoming a critical component of computer science and research. It is in high demand in the market, with significant applications in computing and information science. Artificial intelligence has reached a tipping point in recent years and is gaining traction in the field of computer science. As the market becomes more reliant on computers, artificial intelligence has carved out a niche for itself, and its application is helping to run the market because it is very efficient in processing and data security. It has a high level of implementation on logic gates and other technology that is completely reliant on computer systems. A general information process or machine learning mode is used to combine hardware and software in an intellectual control system.

The sharp increase in computer technology's capabilities, including hardware implementation of logical and other AI means, is an important factor that can lead to a rethinking of today's achievements and new ups of AI theory and practice. [1-3]

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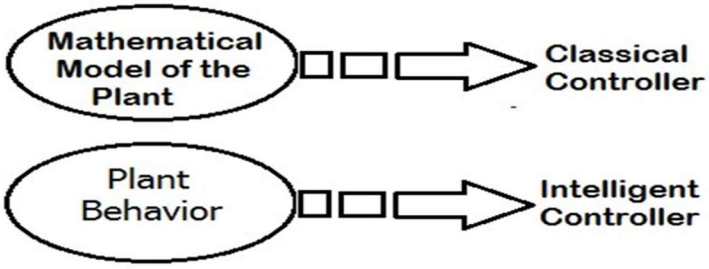
The term "intellectual control system" refers to any combination of hardware and software linked by a general information process, capable of synthesising the control goal and finding rational ways to achieve the control goal (in the presence of motivation and knowledge, including information about the environment and its internal status)1,3. Human-machine interaction now enables the capacity to synthesise the control goal, and autonomous control systems capable only of finding rational ways to achieve the control goal are referred to as "intelligent control systems."

Currently, the science and practise of control are very interested in the integration of traditional automatic control methods with AI methods, as well as AI applications in the field of control for complex weakly formalised objects and processes. Especially when the information, system status, control criteria, and control goals change over time and become hazy and sometimes contradictory. [4-5]

Distinguishing between Classical and Intelligent Control: [6-10]

- The mathematical approach is used in developing a classical control system, the designer must mathematically model the plant.
- The designer of an intelligent control does not need to know the model of the plant to be controlled; only the plant's behavior is required. The plant may be too complex to model in many cases.



Classical and Intelligent Control

- For traditional control, the designer must model the plant, and thus the intelligence (or knowledge) is his. The designer's intelligence has been shifted.
- For intelligent control, the software abstractly models the plant and thus retains the intelligence (or knowledge). The software is now in charge of intelligence.

Classical Control Methodology

Solve the control problem by doing the following steps

- Develop a model of the plant to be controlled.
- Design a controller using the mathematical model.
- Study plant performance using the mathematical model of the closed loop system.
- Implement the controller and evaluate the performance of the closed loop system (again, possibly leading to redesign).

Methods for Classical Control

Open-Loop Control System

A signal is sent to a plant to cause it to move to a specific location. There is no connection or feedback from the plant to ensure that it moved to the desired position.

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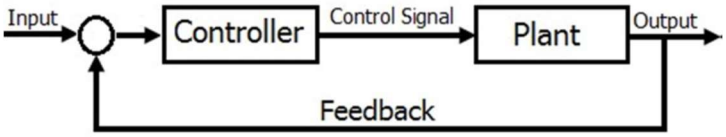
Methods for Classical Control
Closed-Loop Control System

The controller generates a control signal to the plant based on the difference between the desired and actual positions. The plant provides feedback to ensure that it reached the desired position.



Methods for Intelligent Control
No System Modeling

- The designer only has to input the appropriate stimuli to the intelligent control and evaluate it on its output.
- The intelligent control itself develops a model of the system to be controlled.
- Humans can perform complex tasks without knowing exactly how they do them.
- The types of intelligent control include: fuzzy logic, artificial neural networks, genetic programming, and others.

Definition of intelligent systems

Intelligence is a mental quality that consists of the abilities to;

- learn from experience,
- adapt to new situations,
- understand and handle abstract concepts, and
- use knowledge to manipulate one's environment.

Definition of intelligent systems:

- Over the last four decades, researchers have proposed numerous model-based control strategies that include modelling, analysis, simulation, implementation, and verification.
- According to Zadeh, this decade is the era of intelligent systems.
  "I believe that system analysis and control should embrace soft computing and priorities the development of methods that can deal with imprecision, uncertainty, and partial truth."
- Intelligent control is intended to seek control methods that provide intelligence and autonomy in control decisions, allowing for improved system performance.

Soft computing & Hard computing

- In hard computing, the prime objectives of the computations are precision and certainty.
- In soft computing, the precision and certainty carry a cost.
- As a result, it is reasonable to consider integrating computation, reasoning, and decision making in order to provide a framework for balancing precision and uncertainty.
- The primary consortium partners are fuzzy logic, neural network computing, generic algorithms, and probabilistic reasoning, as well as their integration.
- Intelligent systems underlie what is called "soft computing."
- Intelligent control has different tools for emulating the biological behavior that could solve problems as human beings do. The main tools for IC are;
  - Fuzzy logic systems are based on the experience of a human operator, expressed in a linguistic form (IF–THEN rules).
  - Artificial neural networks mimic the learning process of biological neural networks, allowing the network to learn different patterns using a supervised or unsupervised training method.

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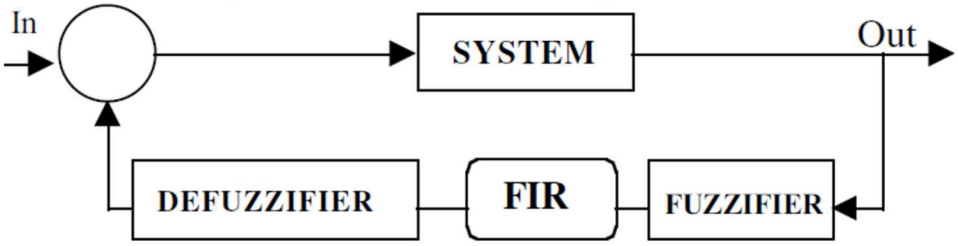
- Evolutionary methods are based on evolutionary processes such as natural evolution. These are essentially optimization procedures.
- Predictive methods are mathematical methods that provide information about the future system behavior.

Soft computing Tools

- Soft computing tools are commonly used to enhance AI and incorporate human expert knowledge in computing processes.
- Their applications include the design of intelligent autonomous systems (controllers) and dealing with unknown parameters.
- Soft computing can:
  - learn from experience,
  - universalize into domains where direct experience is absent,
  - By using parallel computer architectures that simulate biological processes, we can perform mapping from inputs to outputs faster than serial analytical representations.
- Intelligent control techniques that mimic biological system characteristics provide opportunities for developing control products with new capabilities.
- **Neural Networks**
  - For many decades, engineers and scientists have aimed to create a machine with simple elements similar to those found in the human brain.
  - Artificial neural networks (ANNs) are made up of many simple elements that simulate different brain activities and operate in parallel. The connections between these elements heavily influence network function. Because of the nature of their nonlinear mappings of input to output data sets, neural networks can be trained to perform complex functions.
  - Recently, the NN has been applied successfully to many fields of Engineering.
- **Fuzzy Logic**
  - Zadehin 1965 published the first paper on fuzzy set theory. He was implicitly advancing the concept of human approximate reasoning to make effective decisions based on available imprecise linguistic information in this paper.
  - Mamdani completed the first implementation of Zadeh's idea in 1975, demonstrating the viability of fuzzy logic control for a small model steam engine.
  - As a result of this pioneering work, many consumer products and other high-tech applications based on fuzzy technology have been developed.

  FL serves as a foundation for both information and knowledge-based systems. Knowledge-based methodology is much more similar to human thinking and natural language than traditional logic. The FL controller employs fuzzy logic to convert the expert-based linguistic control strategy into an automatic control strategy.



- **Evolutionary Computation**
  Evolution concept, genetic programming, and genetic algorithms are three approaches to evolutionary optimisation algorithms. These algorithms share similar evolutionary concepts but differ in their approach to parameter representation.
- **Genetic Algorithm (GA)** is an evolutionary algorithm that has demonstrated good performance in noisy, nonlinear, and uncertain processes. GAs are useful tools for solving problems of extreme complexity.
- **Genetic Programming (GP)** is a nonlinear symbolic optimisation. By applying fitness-based selection and genetic operators to a population of parse trees from a given programming language, the GP paradigm computationally simulates Darwinian evolution. It differs from traditional GAs primarily in its representation scheme.
- **Hybrid Systems**
  - In the design and implementation of IC systems, fuzzy logic, neural networks, and evolutionary computations are complementary methodologies.

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- Each approach has advantages and disadvantages. Several integrations of these methodologies have been proposed to capitalise on their benefits while minimising their drawbacks.

1. Neuro-fuzzy systems: provide the fuzzy systems with automatic tuning systems using NN as a tool.
2. Fuzzy neural network: retains NN functions while fuzzifying some of their elements. Fuzzy logic, for example, can be used to determine the learning steps of a NN structure.
3. Fuzzy-neural hybrid systems: utilize both fuzzy logic and neural networks in a system to perform separate tasks for decouple subsystems.
4. The GP-Fuzzy System evolves in response to selective pressure caused by their relative success in implementing the desired behavior.

Design of Intelligent Control Systems

- The study of intelligent control systems requires;
  - defining some important expressions that clarify these systems,
  - understanding the desired application goals, and also
  - understanding different tools of soft computing.
- Intelligent control systems are built using a variety of software development platforms. The LabVIEW is one of the most important software platforms used by researchers for developing engineering applications. It can be connected to various hardware systems and run standalone programmes to simulate the controller's performance (validating the controller by simulation then implementing it). Furthermore, LabVIEW is a graphical programme that is simple to learn.

Advantages Of Intelligent Control Systems [11-14]

- Many benchmarking performance results revealed that intelligent control systems outperform traditional control methods overall. The intelligent control system with neural network and fuzzy controller performed well in terms of accuracy and temperature modification.
- It has a mean indoor temperature that is closer to optimal, resulting in a smaller standard deviation and lower temperature fluctuation, as well as maximum and minimum temperatures that are closer to optimal for utilising total energy usage for traditional methods.
- One advantage of using neural networks is their ability to solve real-world problems by learning non-linear models and complex relationships to identify gaps. It also predicts data of any unknown information by concluding variables available to them and generalising data based on the inputs it receives to produce desired outputs. ANN does not execute on any input variable constraint. It can learn hidden data with high volatility and non-constant change. It is critical for forecasting financial time series such as stock prices. It can store information about the entire network, unlike traditional programming, which is stored in a database. ANN is capable of working. with incomplete information to provide the data and the performance is depending on the missing information. ANN is trained to provide the best data possible. It can also provide data based on incomplete information.

Conclusion

Intelligent control is growing in popularity and taking up valuable market space. It is in high demand in the market by both individuals and governments due to its practical importance. There are few research papers on intelligent control systems, but this paper contains all of the information about intelligent control that will be useful in the future.

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