# Research on the Operation and Optimisation of Smart Power Plant System Based on Artificial Intelligence

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**Abstract.** This thesis constructs an intelligent power big data algorithm selection and evaluation system by investigating the evaluation and selection methods of supervised machine learning algorithms related to power big data. Based on the big data background of artificial intelligence, in order to make the system more suitable for the needs of power big data analysis, this paper needs to carry out an artificial pre-assessment of the mainstream machine learning algorithms to determine the key machine learning algorithms for power big data, and for this reason, it is necessary to construct a machine learning algorithm index system. The process of constructing the indicator system is to select a number of interrelated statistical indicators to form the indicator system. The principles that should be followed in selecting the indicators are the principle of purpose, the principle of comprehensiveness, the principle of feasibility, the principle of stability, the principle of coordination and the principle of integration. The principle of coordination and the principle of integration.

**Keywords:** Artificial Intelligence; System Optimisation; Smart Power Plants; Data Processing; Data Updating

## 1 Introduction

The construction of a new power system is a key initiative to achieve the goal of "carbon peaking and carbon neutrality" [1]. However, with the increasing proportion of renewable energy power generation and a large number of emerging load access, the power system presents problems such as reduced inertia, source-load mismatch, and increased peak-valley difference, and the safe and stable operation of the power grid is facing serious challenges [2]. Artificial intelligence technology has been booming in recent years, with strong perceptual reasoning ability, intelligent decision-making ability and massive data analysis ability, which helps the new power system to achieve accurate modelling, efficient analysis and intelligent control, and is a key supporting technology for the development of the power system to digitalisation, networking and intelligentisation. How to provide decision support for the perception regulation and control of the new power system through a new generation of artificial intelligence and information and communication technology, and realise the synergistic control and optimal configuration between the elements of the power system deserve extensive attention and in-depth research [3].

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## 2 Technologies related to intelligent power plant management system

### 2.1 Spring cloud

Martin Fowler described the concept of microservices and published a paper on microservices, which shed light on the definition of microservices [4]. Nowadays, people are familiar with relatively large and complex architectures, usually because of the functional business, the amount of data derived from the dramatic increase. After much of this evolution, traditional architectures are gradually being phased out, and microservices have been widely used in recent years as the best choice for current software architectures. With the increasing complexity of software applications and the constant replacement of Internet technologies, many problems have been exposed that traditional application architecture can no longer cope with. Therefore, the introduction of architectural systems with microservice architecture becomes necessary to ensure the scalability and stability of the system structure [5]. [6].

### 2.2 Precision and recall

**Table 1:** Project Value

| | Projected value 0 | Projected value 1 |
|---|---|---|
| Real value 0 | 9978(TN) | 12 (FP) |
| Real value 1 | 2 (FN) | 8(TP) |

Accuracy:

$$precision = \frac{TP}{TP + FP} \tag{1}$$

As show in equal 1: i.e., the accuracy is :8/(8+12)=40%

As shown in table 1. Accuracy is a measure of the number of correct predictions as a percentage of all positive predictions.

In a word: the proportion of predictions with a value of 1 that are correct.

Why do we call it precision? In biased data, we usually focus on features that have a value of 1, such as "disease" or "risk". On average, out of 100 predictions that result in a disease, 40 are correct. This means that the precision rate is how accurate the prediction is for the event we are focusing on.

recall rate:

$$pecall = \frac{TP}{TP + FP} \tag{2}$$

i.e.: the precision rate is 8/(8+2)=80 per cent.

Recall is: the number of correct predictions out of all the data with a true value of 1.

### 2.3 Service Registration and discovery

Service registration is when a service process registers the address where it is located with the service centre, such as its own host and port number, which contains the protocol, relevant authentication information, etc. Service discovery refers to the access of a service by a client process by sending a request to a registry and obtaining the location information of the service and then accessing the service based on the information obtained [7].

Explanation of the principle of service registration and discovery: The service provider registers its information to the service registry at startup, including the name, IP address, port number, and health status of the service. And when consumers invoke a service, they need to query the service registry for information about the corresponding service before they can access it. Through the service registry, consumers can obtain information about the service provider's data, such as the service's IP address and port number, thus enabling access to the service provider [8]. As show in Figure 1.

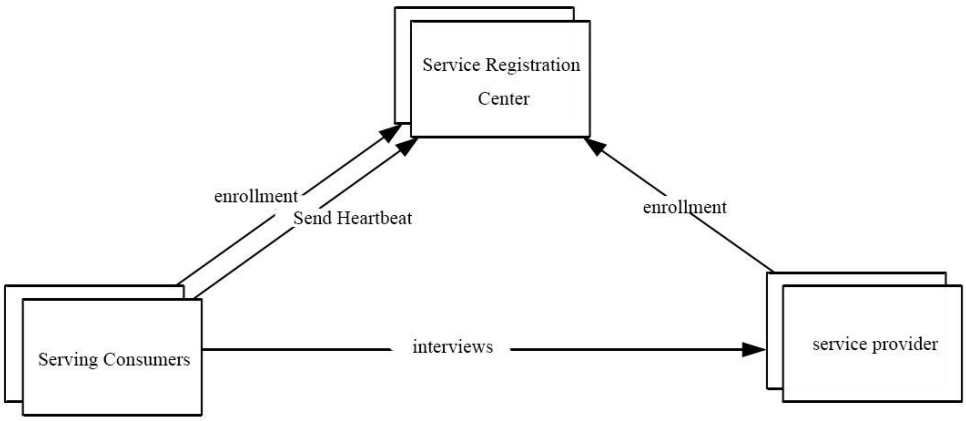


**Figure 1:** Service Registration and Discovery Schematic.

### 2.4 Load balancing

Load Balancing (Load Balancing) is a technology that distributes business traffic to multiple servers to achieve load balancing across servers and improve overall system performance and reliability. Under the load balancing architecture, multiple servers form a server cluster Figure 1:, and a load balancer receives client requests uniformly and distributes them to different servers for processing according to certain load balancing algorithms. The implementation of load balancing can extend the bandwidth and throughput of servers, improve the scalability and flexibility of the system, and thus better meet the demands of highly concurrent access and large-scale business processing [9].

Explanation of the principle of load balancing: When the access volume of instance A is too large, the system can use load balancing as an aid to average the access to instance A through the corresponding forwarding policy, and then distribute the access volume to instance B and instance C, so as to achieve the sharing of the access volume load, avoiding the abnormal operation of the system module due to the excessive access volume of an instance [10]. As show in Figure 2.

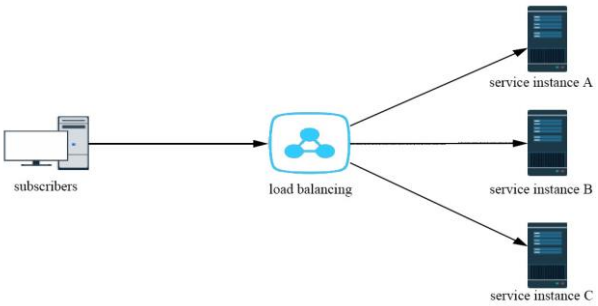


**Figure 2**: Load Balancing Schematic.

### 2.5 Link tracing

Explanation of the principle of link tracing: a link is uniquely identified by a Trace Id, Span identifies that a request message was issued, and each Span is associated by a parent id. Trace: a span-based collection, represented as a call link with an identifier, and the identifier is unique. span: i.e., the tracking information of a request, which contains information such as the start time, elapsed time, request header, and request parameters of this request. In the node, the tracking of the link is achieved by displaying the corresponding information during the link access.

### 2.6 API gateway

In microservices architecture, multiple independent microservices are obtained by splitting large services. Usually each microservice will provide service interface in the form of Restful API. However, in terms of front-end page design, we complete the display of requests sent by different microservices through a single page. Therefore, we need a unified entry point for API invocation [11]. API Gateway in this scenario acts as the gateway to multiple services, the unified entrance to the system, API Gateway encapsulates the internal complex structure of the system, while it may also have other API management, invocation of common functions, such as authentication, flow restriction, flow control and other functions.

Explanation of the principle of the API gateway: the API gateway serves as the entrance to the system, providing a unified interface to the client and shielding the details and complexity of the back-end microservices, as shown in Figure 3.

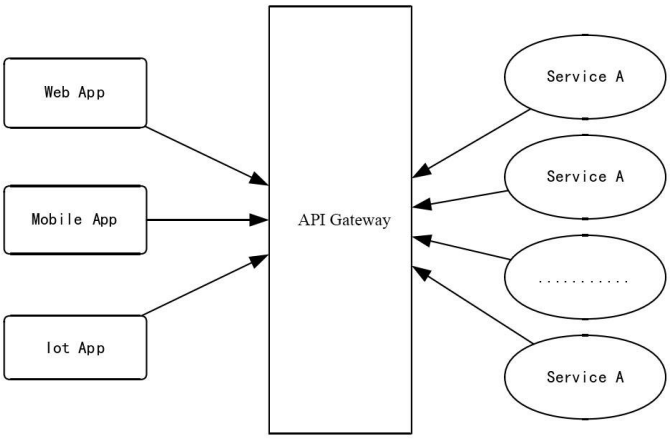


**Figure 3:** Gateway Schematic.

### 2.7 Spring Cloud core components

There are a number of different implementations based on the Spring Cloud specification. These include Spring Cloud Netflix, Spring Cloud Alibaba implementation, the former is in the maintenance phase, the latter strong momentum in the ongoing development. As shown in table 2 &3.

**Table 2:** Spring Cloud Netflix subassemblies.

| Netflix component name | intent |
|---|---|
| Eureka | Service Registration Center |
| Zuul | API Service Gateway |
| Feign | Declarative Service Calls |
| Ribbon | Client load balancing |
| Hystrix | Client-side Fault Tolerance Protection |

**Table 3:** Spring Cloud Alibaba subassemblies.

| Alibaba Component Name | intent |
|---|---|
| Sentinel | Client-side Fault Tolerance Protection |
| Nacos | Service Registration Center |
| OpenFeign | service call |
| Gateway | API Service Gateway |

Under the Spring Cloud specification, the components can be interconnected, and a relatively full-featured microservice architecture can be realized. So far Spring Cloud Netflix is in the maintenance phase, where the related functional components are not active in their development and maintenance status. In order to reduce the difficulty of maintenance for developers and

improve the quality of development, this paper uses Alibaba's open source microservices framework.

## 3 MQTT communication protocol

The MQTT protocol is designed in such a way that it follows the three principles of simplicity, scalability and reliability. Simplicity lies in the fact that it uses a concise form that allows a message object to be published on different platforms, operating systems and devices. Scalable means that the MQTT protocol has a set of adaptive communication protocols and network topologies; reliable means that the MQTT protocol uses a reliable message queue instead of sending data through the server like other message queues. The message data will be routed to other middleware based on user-set rules to achieve data interoperability between the device side and the server side. As show in Figure 4.

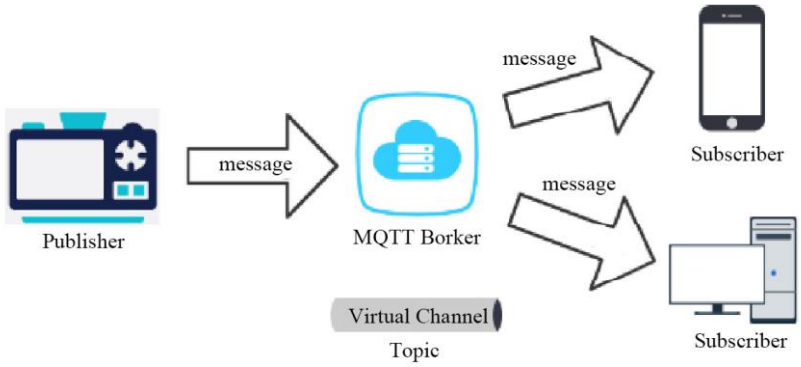


**Figure 4:** MQTT communication protocol.

HTTP is used to transfer data between web applications.REST API is a web service based on the HTTP protocol that defines a set of rules for transferring data over the network. In the application system, the terminal device collects the data and transmits it to the back-end server for processing. By opening the API data interface, third-party applications can communicate with the back-end server through HTTP requests to acquire and use the processed data.

### 3.1 API interface related technology

Smart Power Plant Management System is designed by separating the front-end and back-end. The back-end server provides API interface for the front-end, and the front-end page completes the function response according to the data interface. This design scheme allows the back-end system does not have to participate in the design of the front-end page, focusing on the realization of logical business. And Restful style data interface docking form will have more application prospects. Included is support for single page applications, browser requests and third party SDK access requests.

The API interface request is shown in Figure 5:

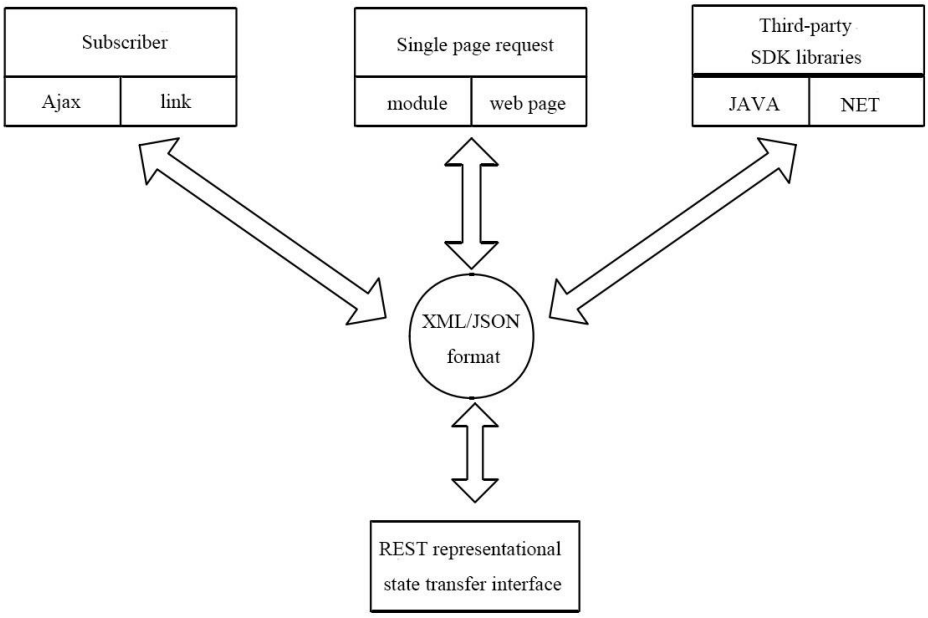


**Figure 5:** API request.

## 4 Bayesian optimization

Bayesian optimization is a typical representative of data-driven optimization methods. The objective to be optimized is to find the parameter variable X such that the objective function is maximized:

$$arg \max_{x \in A} f(x) \tag{3}$$

Where X is a d-dimensional decision variable, A is the set of possible values of x and the set members are more easily available, such as algorithm configuration, parameter configuration, drug prescription, etc., and f(x) is an implicit function for evaluating the goodness of the decision variable, e.g., judging the model effect, the efficacy of the drug, etc. Since the structure of f (x) is not directly observable and is expensive to obtain, it is also referred to as a black box. Bayesian optimization is an important approach to black-box search and often results in optimal solutions using minimal cost. Bayesian optimization is based on Bayes' theorem:

$$P(f \backslash D) = \frac{p(D|f)p(f)}{p(D)} \tag{4}$$

where f is the unknown objective function, D is the set of observed data points $p(D|f)$ is the likelihood distribution of the observations y, $p(f)$ is the prior distribution of f, which is the probability model assumed prior to the start of the Bayesian optimization, and subsequently the prior distribution is corrected by observing the set of D, and $P(f/D)$ denotes the confidence level of the corrected hypothesized model, which is generally increased with more observed data.

Bayesian optimization involves two important concepts, the probabilistic agent model and the acquisition function. The probabilistic agent model is the probabilistic prior distribution $p(f)$ and the modified likelihood distribution $p(f/D)$ in the above Bayesian formulation, which is used as a proxy for the unknown objective function and is progressively corrected by obtaining feedback from observations, and is categorized into parametric and nonparametric models. Parametric models, including Bernoulli models, linear models, etc., have a fixed number of parameters and are not suitable for optimization problems with particularly large decision spaces. The nonparametric model is represented by a Gaussian process, which constructs a multivariate Gaussian distribution based on an existing training set.

The acquisition function is a function related to the posterior probability distribution, and the Bayesian optimization algorithm selects the X to be observed next by maximizing the acquisition function. The selection of the collection function is related to the selection of the probabilistic agent model, and the commonly used collection functions include the collection function based on the boosting strategy, the collection function of the confidence boundary strategy, and the collection function based on the information strategy.

Bayesian optimization starts by selecting a point in the middle of the decision space for observation and obtaining the observation value, followed by initialization of the probabilistic agent model and setting the number of iterations. After the initialization is completed, the main framework of the Bayesian optimization method is entered, which can be summarized as three main steps: generation means finding the next observation point by optimizing the collection function, observation means using the observation point obtained in the previous step to input the black-box function to obtain the output to get the observation value, and updating means using the newest observation point for learning and updating the approximation distribution to the objective function. The collection function ensures that the algorithm chooses the observation points carefully every time, assuming that the collection function chooses the global minimum every time, when the number of iterations is large enough and the algorithm explores enough points in the space, the algorithm will theoretically be sure to converge to the optimal solution, which is one of the advantages of the Bayesian optimization method.

## 5 Conclusion

Although some of China's power generation enterprises in the field of intelligent power plant has carried out relevant exploration and attempts, but from the current construction and application of the domestic intelligent power plant, its application is more focused on the level of intelligent information integration display, energy saving, quality and efficiency is not strong, deviating from the original intention of the intelligent production, at the same time, the planning and implementation of many projects is often a simple pile up of the local information technology system, automation system, the lack of a close link between the various systems, and it is difficult to solve the problems in the implementation of the intelligent power plant in a holistic and systematic manner. Therefore, this paper will start from the connotation of smart power plant, apply the concept of digital twin, put forward the overall framework of smart power plant, and focus on the system deployment mode of smart power plant by combining the application reality of smart power plant and the characteristics of information technology. The concept of smart power plants was not supported by concrete projects at the time of its

introduction, but was only an aspiration and a requirement for future development prospects. In recent years, many scholars have carried out in-depth research, but also many power generation enterprises have carried out specific practical exploration, although there is currently no real sense of intelligent power plant specific landing, but also gradually enriched and perfected the connotation of the intelligent power plant, the industry consensus on the construction of the intelligent power plant goal has been initially formed. This paper is based on the existing big data artificial intelligence status quo on the construction of the power plant technical level analysis and at the same time on the current situation of the industry as well as the industry's development to analyze and study the new breakthroughs in the research has a certain padding.

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