台電工程月刊879期(11月)目錄

人工智慧在電業之應用　專輯
Special Issue：Applications of Artificial Intelligence in Electric Utilities

人工智慧應用於電力設備預測性維護發展情勢分析

Analysis of Artificial Intelligence Applications in Electrical Equipment Predictive Maintenance

李政崇* 簡士恩* 林彥廷* 曹昭陽*
Li, Cheng-Chung Chien, Shih-En Lin, Yen-Ting Tsao, Chao-Yang

摘 要

隨著科技日新月異，過去許多人類無法預知的事，如今已變成可能；拜人工智慧和大數據分析等相關技術不斷精進之賜，電力設備健康狀態的預測已成為可行，且已廣泛應用在電力產業當中各個領域。本文調查整理了人工智慧在發電、輸電和配電設備預測性維護的應用，在國際上已可找到大量相關文獻，例如在發電業包含水、火力、核能電廠電力設備的預測診斷，風力發電、太陽光電設備運轉維護之應用以及電廠的生命週期管理；在輸配電業則包含輸電線檢測、變壓器及斷路器等變電設備狀態診斷以及電力設備資產管理等應用。透過這次調查可以確認機器學習技術在電力設備預測性維護上有巨大的應用潛力，希望本文能引起電業同好與專家學者的興趣，共同為落實人工智慧應用於電力設備預測性維護而努力。

Abstract

Accompanied with the rapid development of science and technology, things previously unpredictable are now probable. Thanks to the continuous improvement of artificial intelligence (AI), big data analysis, etc., the health condition prediction of power equipment is now feasible and has been widely used in various fields of power industries. This study summarizes the AI applications regarding predictive maintenance of electrical equipment, and a large number of international documents for reference have been surveyed, namely AI applications in predictive diagnosis of hydraulic, thermal power, and nuclear power plant equipment; operation and maintenance of wind and photovoltaic farms; life cycle management of power plants; as well as AI applications in electricity transmission and distribution, such as fault diagnosis of substation equipment, i.e., transformers and circuit breakers, and asset management of power equipment. Based on the survey, we believe that machine learning technology has great potential when applied in the predictive maintenance of power equipment. Hopefully, this paper may excite the interest of experts and scholars and have them work together in the aforesaid fields.

關鍵詞(Key Words)：人工智慧 (Artificial Intelligence)、機器學習(Machine Learning)、深度學習(Deep Learning)、預測性維護 (Predictive Maintenance)、再生能源(Renewable Energy)。

---

*台灣電力公司綜合研究所

應用人工智慧於風力發電預測之研究

Research on Applying Artificial Intelligence to Wind Power Forecasting

吳元康* Wu, Yuan-Kang
吳昇鴻* Wu, Sheng-Hong
黃崢亮* Huang, Cheng-Liang
洪景山** Hon, Jing-Shan
張惠玲** Chang, Hui-Ling

摘　要

本文的主旨在於提出風力發電決定性與機率預測的模型以及程序。預測的領前時間分別考慮一小時與一日前。研究的重點包含數值天氣預報產品的應用、資料前處理技術，以及採用人工智慧的預測模型。在預測模型資料輸入的部分，本研究同時應用三種不同數值天氣預報模式輸出的預報風速，以及風場歷史發電量。數值天氣預報由台灣中央氣象局所提供，包括區域模式決定性預報、即時預報系統、系集預報系統。本研究並利用實際測風塔的風速量測值與數值天氣預報的風速預測值進行比對，以此挑選出誤差最小的時間組合。在資料前處理的程序中，本研究將模式預報風速內插至風機高度，並使用 PCA 與 EMD 進行風速特徵擷取。在預測模型方面，本研究分別使用類神經網路與極限梯度提升決策樹進行風力預測，並根據誤差指標進行預測性能的評估。最後本研究使用台灣實際的風場進行發電預測。研究結果顯示所提出的方法可以有效提升預測的精確度，且證明訓練模型、數值天氣預報、以及資料前處理的重要性。

Abstract

In this research, we propose a model and the procedures of deterministic and probabilistic forecasts, e.g., hour-ahead and day-ahead, for wind power generation. The contents of this research include numerical weather prediction, data pre-processing technique, and forecasting models using artificial intelligence methods. Regarding the inputs of the model, we had considered three kinds of NWP wind speeds, generated by the Central Weather Bureau based on three atmospheric models, namely WRFD, RWRF and WEPS, and historical wind power generation. The measured wind-speed, out of an anemometer tower, were used to compare with the NWP wind speeds to help us select the least error time combination. Regarding data pre-processing, NWP wind-speed correction based on the height of wind turbines and PCA and EMD for exacting wind-speed feature had been tested. As for the forecast model, we used artificial neural network and XGBoost to predict the generation of wind power, and a number of error indexes had been used to evaluate the performance of the forecasts. The empirical data from an windfarm in Taiwan verifies the accuracy of the method we applied in this research. What worth mentioning, the importance of model selection, numerical weather prediction, and data pre-processing is self-evident.

關鍵詞(KeyWords)：風力發電(Wind Power)、預測(Forecasting)、數值天氣預報(Numerical Weather Prediction)、資料前處理(Data Preprocessing)、人工智慧(Artificial Intelligence)、類神經網路(Artificial Neural Network)。

---

*國立中正大學電機系
**交通部中央氣象局

應用改良式模糊模型進行太陽光電發電量推估

Application of Modified Fuzzy Model on Photovoltaic Power Generation

吳元康* 賴怡惠*

Wu, Yuan-Kang Lai, Yi-Hui

摘 要

近年來台灣太陽光電發電量大幅增加，不過大部分的太陽光電設施，特別是小規模的案場，並未有相關的監控與即時量測裝置，而這些隱形的發電量將造成系統調度上的極大挑戰。因此，必須要有合適的方法來進行太陽光電發電量的推估。本文的主要目的便是提出改良式模糊模型進行太陽光電發電量推估，其中包含案場的分群處理、代表性案場的挑選、以及既有模糊模型的改良等。首先，本研究使用 K-近鄰演算法填補某些遺失資料的數據處理，接著分別應用兩種集群演算法對太陽光電案場進行分群，再來藉由單一案場的發電量與該集群內總發電量的相關性選擇代表性案場。最後，本研究應用改良式的模糊模型進行太陽光電發電量推估。本研究採用台灣實際太陽光電案場的資料進行推估、驗證、以及比較。研究結果顯示，本研究所提出的方法可以在少數已知案場資訊的前提下，獲得 7% 左右的平均發電量估測誤差，證明所提出方法的高效率以及實用性。

Abstract

In recent years, the photovoltaic (PV) power generation in Taiwan has increased significantly. However, most PV facilities, especially small-scale sites, have not yet installed monitoring and real-time measurement devices. Unmonitored generation may pose huge challenges on the scheduling/dispatching of power system. It is necessary for us to adopt suitable methods to deal with the problems. The main purpose of this paper is to propose an improved fuzzy model to estimate PV generation. The contents of research include 1) clustering processing of PV sites, 2) selecting representative PV sites, and 3) improving the existing fuzzy model. First, this research used K-nearest neighbor (KNN) algorithm to deal with the imputation of the missing data, and applied two algorithms for PV sites clustering. The generation of single PV site was then used to compare with the cluster's total generation to pick out representative PV sites. Finally, we used an improved fuzzy model to estimate PV generation. An averaged estimation error of 7% had been achieved in this research, demonstrating the efficacy and practicality of the proposed method

關鍵詞(Key Words)：太陽光電(Solar Photovoltaic)、隱形發電量(Invisible Power Generation)、代表性太陽光電案場(Representative PV Sites)、發電量推估(Power Estimation)、模糊系統(Fuzzy Systems)。

---

*國立中正大學電機系

人工智慧應用於水庫水位預測與水力發電領前模擬-以德基水庫為例

Application of Artificial Intelligence to Reservoir Water Level Forecasting and Look-ahead Simulation of Hydroelectric Power Generation - Using Techi Reservoir as an Example

周儷芬* Chou, Li-Fen
曹顥瀚** Tsao, Hao-Han
張志榮* Chang, Chih-Jung
林哲宇* Lin, Jhe-Yu
曹昭陽* Tsao, Chao-Yang
呂藝光** Leu, Yih-Guang

摘　要

水力發電具有潔淨、快速啟停供電的特性，相較於風電、太陽光電的間歇性，其可在電力系統中扮演確保供電安全的角色。然而台灣位於西北太平洋海域之樞紐位置，每年依季節分別受到梅雨、颱風及中緯度鋒面影響，水資源有明顯豐枯差異；近年極端天氣頻傳更面臨短延時強降雨的衝擊，為滿足多用途標的需求，水庫作業面臨嚴峻挑戰。為提高水庫發電用水的使用率，本文針對德基水庫設計了一套 48 小時入流量與水位預測系統；該系統整合了區間二型模糊分類器與類神經網路的多層複合模型，對降雨的樣態進行分類與訓練；然而豐枯兩種雨量情境，使得降雨量資料的落差匯入同一模型時，導致預測準確度降低以及訓練時間的延長。為此本文先透過區間二型模糊分類器對降雨情形分類，再針對該樣態情境進行預測模型訓練以提升預測的準確度。此外，本系統設計一發電調度模擬功能，以預測趨勢為基準，分析不同放水條件下的水位變化，期能提供運轉人員對未來 2 日的機組排程規劃有明確的趨勢掌握，對水庫操作有更高的應用價值。

Abstract

Unlike intermittent renewable energies such as wind and solar, hydropower can ramp up and down quickly to adapt to ever-changing energy demands. To put it differently, hydropower may very well function as load following or peaking units. In recent years, due to climate change, we witness more and more extreme weather events, which also lead to the need for flood control. To fulfil the requirements for reservoirs and improve their operation effectiveness, we developed a 48-hours ahead reservoir water level and inflow forecasting system, based on type-2 neural fuzzy classifiers and neural networks with multi-stage architecture, to simulate power generation dispatching modes according to the forecast results of reservoir water levels, at the same time, enhance the application value of reservoir operations.

關鍵詞 (Key Words)：水庫水位預測(Reservoir Water Level Forecasting)、類神經網路(Artificial Neural Network)、降雨量(Rainfall)、數值氣象預報(Numerical Weather Predictions)。

---

*台灣電力公司綜合研究所
**國立臺灣師範大學

融入 AI 技術導引智慧變電所規劃設計及 AutoLISP 程式建構自動繪圖系統於 IEC 61850 監控架構之研究

A Study on Applying AI Technology to the Planning of Smart Substation and the Development of Automated Design System Using AutoLISP to Comply with IEC61850 Supervisory Control Architecture

呂世彬*
Lu, Shih-Pin

張喜翔*
Chang, Hsi-Hsiang

林正義*
Lin, Cheng-Yi

張耀元*
Chang, Yao-Yuan

陳應廣*
Chen, Ying-Kuang

摘　要

本研究係為配合政府推行智慧電網相關規劃，將變電所導入 IEC61850 監控架構來實現智慧變電所之應用，本公司陸續啟動再生能源加強電力網、區域電網、變電所整所改建計畫及南區一期等變電工程，並採用 IEC61850 監控架構，尤其再生能源由目前 4.9%，至 2025 年提升到 20%，因此本公司將建置友善併網環境來加速綠能發展，而規劃興建升壓站及開閉所之開關設備及擴充變壓器等工程，並趕辦再生能源業者併網期限內完成。考量規劃設計時間緊迫及人力無法及時補充，為了達成工程如質如期加入系統，因此導入人工智慧深度學習之演算法，藉由該演算法協助推算出最佳規劃配置，再利用 Visual Basic 軟體開發人機介面視窗系統，分別結合深度學習演算法及 AutoCAD 繪圖軟體，再透過 AutoCAD 內建程式 AutoLISP 取代人工繪製之方式，進而開發自動繪圖系統。

爰此，對智慧變電所工程規劃設計提出一種新的創新方法，改革傳統作法，改善規劃作業及縮短設計時間，有效提升圖面準確性。

Abstract

To cope with the government policy of implementing smart grid and to realize the relevant applications of smart substations, Taiwan Power Company (TPC) has successively initiated power grid reinforcement program, while introducing IEC 61850 monitoring framework at the same time. To help achieve the policy goal 20% renewable energy (RE) generation in 2025, 4.9% nowadays, TPC needs to construct a friendly interconnection environment, i.e. more substations, switchgear stations and transformers, to necessitate the development of RE. Restricted by tight schedule and short manpower, we decided to apply artificial intelligence (AI) deep learning (DL) algorithm to calculate the optimal planning configuration, and use Visual Basic software to develop human machine interface. We then combined the DL algorithm and AutoCAD drawing software and applied AutoLISP, which is a built-in program of AutoCAD, to develop an automatic drawing system to replace manual drawing. In this study, we put forward an innovative method helpful to improve the current planning operation, shorten the time in need for design, and elevate the accuracy of drawing.

關鍵詞(Key words)：智慧電網(Smart Grid)、再生能源(Renewable Resources)、人工智慧(Artificial Intelligence)、深度學習(Deep Learning)。

---

*台灣電力公司輸供電事業部輸變電工程處南區施工處

無人機智慧巡檢結合輸電設備維護管理系統於事故查修作業之應用

Application of Unmanned Aerial Vehicle Intelligent Inspection Combined with Transmission Facility Maintenance and Management System in Line Accident Inspection and Repair

洪永輝*
Hong, Young-Huei

林世孺*
Lin, Shyh-Ru

徐益逢*
Shiu, Yi-Feng

李志賢*
Lee, Chih-Shyan

王聖評*
Wang, Sheng-Ping

洪永翰*
Hong, Yong-Han

摘　要

本文主要介紹台電公司推動智慧電網政策，在電網管理面所採行之精進作法，一為優化既有之輸電設備維護管理系統，導入整合型閃電落雷偵測及故障測距系統，將事故訊息結合地理圖資準確定位顯示於圖台系統上，以利維修人員快速找出事故地點，縮短停電時間，有效提升巡檢效率。二為發展智慧巡檢系統，運用無人機結合人工智慧科技即時影像辨識系統，進行鐵塔礙子及附屬配件異常檢測及分析可能風險，充分掌握設備運轉狀況，有助於達成穩定供電的目標。

Abstract

This article mainly introduces Taipower’s smart grid policy and advanced practices in grid management. One of the practices is to optimize the existing Transmission Facility Maintenance and Management System(TFMMS), which was developed by the Institute for Information Industry(III), meanwhile integrating with the Total Lightning Detection System (TLDS) and the fault location estimation system, to allow accurate integration of accident information and geographic map data. The data will then be displayed on a map platform system to facilitate the maintenance personnel to promptly locate the accident sites. In this way, the power outage time is shortened, and the inspection efficiency improved. The second is to develop a smart inspection system, using drones together with artificial intelligence real-time image recognition system, to detect abnormalities in transmission tower insulators and accessories and to analyze the possible risks, so that we can fully comprehend the operating condition of equipment and conjointly ensure stable power supply.

關鍵詞(Key Words)：無人機 (Unmanned Aerial Vehicle)、智慧巡檢(Intelligent Inspection)、人工智慧(Artificial Intelligence)、GIS 圖台(GIS Map)。

---

*台灣電力公司輸供電事業部供電處

應用 AI 技術於斷路器動作時間分析及預防保養

The Analysis for Implementing AI Technology in Circuit Breaker Operation Time and Condition-based Maintenance

蕭仰哲* 簡兆麟**
Hsiao, Yang-Che Chien, Chao-Lin
張庭碩** 劉昌維*** 劉奕均**
Chang, Ting-Shou Liu, Chang-Wei Liu, Yi-Chun

摘 要

民國 103 年供電處委託資訊處建置斷路器動作時間線上量測系統，利用該系統比對斷路器動作時間與點檢紀錄的動作時間，判別斷路器操作是否正常。惟每一斷路器於變電所內接線方式皆有差異，導致回傳至斷路器動作時間線上量測系統之數值與實際動作時間值有些許時間延遲產生之誤差，進而造成系統將功能正常之斷路器誤判。

為有效解決此一痛點，加強系統判斷之準確性並有效提升預防保養作為，本篇文章即介紹應用人工智慧(Artificial Intelligence, AI)技術於斷路器動作時間分析，此一作為將有效降低斷路器動作時間之誤判，並能夠提升預測之準確率，使變電設備逐步邁向狀態基準維護(Condition-based Maintenance, CBM)；有鑑於公司同仁對於人工智慧技術相對陌生，本文亦以淺顯易懂方式介紹人工智慧概念，避免同仁對此技術有所誤解，對於機器學習與類神經網路有興趣的同仁，可自行上網搜尋文中所提及之演算法，相關資訊也可提供資產管理及風險管控之決策參考。

Abstract

In 2014, the Department of Power Supply entrusted the Department of Information Management to build a real time circuit breaker (CB)operation measurement system- to compare the CB operation time and the time recorded by inspections to determine whether the operation of CB is normal. However, different substation CB wiring methods usually result in a difference caused by deferred time (the measuring system and the actual operation)and then cause CB misjudgments. This paper introduces the applications of artificial intelligence technology on the analysis of CB operation time- to increase the accuracy of the measuring system and realize preventive maintenance. The method may effectively reduce misjudgments of CB operation time, help improve the accuracy of prediction, and lead the transformer equipment step by step towards Condition-based Maintenance(CBM). This paper aims to introduce the concept of artificial intelligence (AI)in an easy-to-understand way to assist the others colleagues to understand AI technology- those interested in machine learning and neural networks may online search for the algorithms mentioned in this paper. The information in this paper can also serve as reference for the topics of asset management and risk management and control.

關鍵詞 (Key Words)：人工智慧(Artificial Intelligence)、大數據分析(Big Data Analysis)、狀態基準維護(Condition-based Maintenance)、斷路器動作時間(Circuit Breaker Operation Time)、機器學習(Machine Learning)、XGBOOST。

---

*台灣電力公司輸供電事業部嘉南供電區營運處
**台灣電力公司輸供電事業部供電處
***台灣電力公司輸供電事業部高屏供電區營運處

應用局部放電圖譜與卷積神經網路於地下電纜絕緣狀態檢測之研究

Study on Insulation Status Assessment for Power Cable Joints Based on Partial Discharges Patterns and Convolutional Neural Network

張建國* Chang, Chien-Kuo
張軒豪* Chang, Hsuan-Hao
吳佑軒* Wu, You-Xuan
吳瑞南* Wu, Ruay-Nan

摘要

高壓地下電纜的維護及狀態監控成為近年來的研究重點，而在地下電纜事故中，又以直線接頭和終端接頭等附件最容易發生故障。本文將針對 13 組配電級 25 kV 地下電纜直線接頭的完整劣化試驗數據，提出以相位解析圖譜(PRPD)與脈衝序列圖譜(PSA)的不同型態，並利用卷積神經網路來建立絕緣狀態的自動判讀模型。最後，搭配專家經驗建立一套可判斷絕緣狀態屬於未知、注意與危險的決策規則。結果顯示由兩種不同型態圖譜所建立的決策規則，皆可在絕緣破壞前，提出危險的警告，亦即能夠為維護人員提供可靠與簡單的參考依據。值得注意的是，脈衝序列分析圖譜可應用在無法量測電壓的場所下，且成效和傳統常用的相位解析圖譜相似，有助於在地下電纜等場所使用。

Abstract

The maintenance and monitoring of high-voltage underground cables have become a research trend in recent years. For underground cable accidents, accessories such as cable joints and cable terminations are most likely the causes of insulation failure. In this study, based on 13 sets of complete degradation test data of 25 kV distribution-level underground cable joints, various types of phase-resolved partial discharge pattern (PRPD) data and pulse sequence analysis pattern (PSA) are proposed to establish the automatic assessment model of insulation status by convolution neural network. A decision rule available to interpret the insulation states, unknown, attention, or risky stage, has been established with the help of expert experience. The results of this study show that both types of the decision rule developed in this study are competent to provide before the event warning and may serve as reliable reference for maintenance personnel. It is noteworthy that we may apply the pulse sequence analysis pattern to places where voltage cannot be measured, and achieve similar performance, when comparing with the commonly used phase-resolved analysis pattern, which is useful for underground cables among others.

關鍵詞(Key Words)：局部放電(Partial Discharge)、電纜接頭(Cable Joint)、局部放電相位解析(Phase-Resolved Partial Discharge)、脈衝序列分析(Pulse Sequence Analysis)、卷積神經網路(Convolutional Neural Network)、圖像識別(Pattern Recognition)、絕緣狀態評估(Insulation Status Assessment)。

---

*國立臺灣科技大學電機工程系

人工智慧 AI 應用於電力變壓器運轉維護策略之研究

A Research on Applying Artificial Intelligence to the O&M Strategies of Power Transformers

陳謀臣* Chen, Mo-Chen
陳昌國** Chen, Chang-Kuo
鄭駿騰*** Cheng, Chun-Tang
簡士恩**** Chien, Shih-En
劉家銘***** Liu, Chia-Ming
李宜軒***** Li, Yi-Hsuan

摘　要

本研究旨在發展一套具人工智慧 AI 解決方案之電力變壓器運轉維護策略，以 IEEE 與 IEC 標準、皮爾森關聯性(Pearson Correlation)分析、以及近鄰演算法(k-Nearest Neighbor, kNN)等技術為基礎，開發各式線上工程計算模組與人工智慧 AI 分析模型，對電力變壓器進行線上熱源監測(Thermal Monitoring)，提供潛在異常之早期預警，輔助定檢及定期油中氣體/特性等之檢測。另外，電力變壓器所有相關之工程計算與分析方法，可以結合電力變壓器各組件之重要程度比例，定義綜合分析之健康指標(Health Index, HI)，評估電力變壓器之整體健康狀況，供領域專家共同判斷可能發生之潛在故障及類型。期能協助現場維護工作由時間基準維護(Time-based Maintenance)轉向狀態基準維護(Condition-based Maintenance)，達到運轉維護優化之目標。

Abstract

This research aims to develop a set of operation and maintenance (O&M) strategies for power transformers (PT) with the application of Artificial Intelligence (AI). On the basis of IEEE and IEC standards, Pearson Correlation analysis, and k-Nearest Neighbor (kNN) techniques, we developed various online engineering calculation modules and AI analysis models for PT online thermal monitoring, to provide early warning against potential abnormalities and to assist regular and Dissolved Gas Analysis (DGA) inspections. In addition, PT related engineering calculations, together with analysis models and importance ranking for different PT components, may be used to define Health Index (HI) for the purpose of comprehensive PT health analysis, to serve as reference for the experts to determine the causes/types of potential failures. It is expected that the results of this research will assist and turn on-site maintenance works from Time-based Maintenance into Condition-based Maintenance to achieve optimal O&M results.

關鍵詞 (Key Words)：人工智慧(Artificial Intelligence, AI)、近鄰演算法(k-Nearest Neighbor, kNN)、熱源監測(Thermal Monitoring)、健康指標(Health Index)、狀態基準維護(Condition-based Maintenance)。

---

*永信能源科技股份有公司
**行政院原子能委員會核能研究所
***台灣電力公司水火力發電事業部再生能源處
****台灣電力公司綜合研究所
*****台灣電力公司輸供電事業部供電處

運用人工智慧建模辨識異常用電-以高壓 AMI 為例

Identifying Abnormal Electricity Activities with Artificial Intelligence Modelling Methods - Taking High-tension AMI as an Example

朱漢農* Chu, Han-Nung
陳秉洋** Chen, Ping-Yang
郭維軒** Kuo, Wei-Hsuan
林順傑** Lin, Shun-Chieh
卓明遠*** Cho, Ming-Yuan
楊新全* Yang, Xin-Quan

摘　要

配電系統的損失主要分為技術性損失及非技術性損失。以非技術性損失的方面來觀察，用戶違規用電所造成的損失佔有很高的比例。現行對於異常用電之稽查，仍需靠具有豐富經驗及專業知識的資深電務同仁判讀。為提升違規用電自查之成案率、減少電費短收，本研究以智慧型電表資訊建構具有類神經網路模型(Artificial Neural Network, ANN)與高斯混合模型(Gaussian Mixture Model, GMM)的複合偵測系統，利用人工智慧(Artificial Intelligence, AI)自我學習之特性自動判斷嫌疑度，做為業務單位用電稽查作業排程之優先順序參考準則，有效集中稽查人力資源於高違規用電嫌疑之用戶群。

Abstract

Electricity loss of distribution systems consist of technical and non-technical causes. Regarding non-technical loss, theft is one of the key causes. The current detection system for abnormal consumption, to a considerable extent, depends on the experience and expertise of inspection personnel. To improve the efficiency of abnormal consumption detection, this research utilizes AMI data to construct a neural network and Gaussian mixture model based artificial intelligence system. The said system may automatically compute and interpret the degrees of suspicion to decide the priority for on-site inspections.

關鍵詞(Key Words)：先進讀表基礎建設(Advanced Metering Infrastructure, AMI)、人工智慧(Artificial Intelligence, AI)、違規用電(Electricity Theft)、類神經網路(Artificial Neural Network, ANN)、高斯混合模型(Gaussian Mixture Model, GMM)。

*台灣電力公司綜合研究所
**工業技術研究院南分院
***國立高雄科技大學電機工程系

結合機器學習與時間序列模型預測短期負載

Short-term Load Forecasting Based on Machine Learning and Time Series Analysis

何尚謙* 吳鎮安* 張正彥*
Ho, Shang-Chien Wu, Chen-An Chang, Cheng-Yen

摘 要

基於高壓以上用戶已全面布建智慧型電表，為增進資料價值，台電已透過高壓用戶服務入口網站提供用戶各項加值服務。其中，負載預測功能運用 AMI 及氣溫資料，提供個別用戶查詢未來 2 日用電預測。為精進負載預測功能，本文運用該預測自迴歸模型(Autoregressive Model)之短期負載預測初步結果，接續使用機器學習與集成學習，新增月份、平日與否、時間帶等特徵變數，以優化預測模型，並透過平均絕對百分誤差(MAPE)比較預測結果，提供未來入口網負載預測功能精進之參考。

Abstract

Since high-voltage customers have been fully deployed with AMI, Taipower is utilizing the High-voltage Customer Service Portal to provide customers with value-added services. One of the services is load forecasting (LF), which combines AMI and temperature data to offer customers load predictions of the coming two days. To improve the functions of LF, we use autoregressive model to obtain initial results for short-term load forecasts and construct machine learning models, creating some new characteristic variables (month, weekend/weekdays, time-of-use), to optimize the models. Finally, we use MAPE to compare the forecast results of the machine learning model and the autoregressive model. We look forward that the results of this study may serve as reference for the portal to optimize its load forecasting functions.

關鍵詞 (Key Words)：機器學習 (Machine Learning)、集成學習(Ensemble Learning)、負載預測(Load Forecasting)、時間序列(Time Series)、資料探勘(Data Mining)。

*台灣電力公司配售電事業部業務處

人工智慧應用於電業環保化學的探討

On the Application of Artificial Intelligence to the Environmental Protection and Chemistry of the Electric Industry

曹志明*
Tsao, Chih-Ming

摘 要

基於智慧化和生態化的目標，本研究試著從電業環保化學相關業務的需求出發，探討大數據及人工智慧技術應用的可行性。研究架構係以問題、資料分類及應用技術作為探討主軸，有關資料分析與視覺化問題，研究過程自行研發 autoML 網頁界面(http://app.ezbear.net/)，應用 Python 語言的資料分析及繪圖功能來完成；有關廢水處理加藥劑量的預測問題，則應用機器學習的迴歸和分類技術來解決，實作上則使用 autoML 網頁界面，透過點選和設定即可完成機器學習的相關運算和結果顯示；有關觀測空氣品質 PM2.5 此類時間序列資料的預測問題，以長短期記憶模型進行處理和預測；水中硼濃度分析和微藻濃度分析等圖像分類問題，以卷積神經網路的深度學習架構進行分類處理；有關水下智慧型生態監測系統的物種數量偵測問題，以深度學習的物件偵測技術記錄各物種長期的變化趨勢。

Abstract

In pursuit of intelligence and ecology, this research explores the feasibility of applying big data and artificial intelligence (AI) technologies, focusing on the confronting problems, data classification and applicative technologies, to help electric utilities align with the requirement of environmental protection and their needs in chemistry related businesses. We implemented an autoML web page (http://app.ezbear.net/) and used the data analysis and drawing functions of Python language to solve the problems of data analysis and visualization, whereas the problems of predicting the reagent dosage for waste water treatment, the regression and classification functions of machine learning. In practice, autoML web interface had been developed to carry out the relevant calculations and the visualization of the calculation results, through the functions of button clicking and parameter setting of the said web page. As for time series prediction of air quality /PM2.5, we used long-term and short-term memory models to process the relevant data and make predictions. In addition, the problems of image classification, e.g., the analysis of boron concentration in the water and the analysis of microalgae concentration, were classified by deep learning architecture of convolutional neural network. Lastly, the intelligent underwater ecological monitoring system, we applied object detection technology to record the quantities of marine species for the purpose of long-term trend analysis.

關鍵詞(Key Words)：人工智慧(Artificial Intelligence)、機器學習(Machine learning)，深度學習(Deep Learning)，模型(Model)，訓練(Training)。

---

*台灣電力公司綜合研究所