黃敬群教授之空位偵測研究 自動智慧停車塲智慧再升級！

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所謂智慧型運輸系統(Intelligent Transportation System , ITS)，是指利用先進之電子、通信、電腦、控制及感測等技術，於各種運輸系統 (尤指陸上運輸)，透過即時資訊傳輸，以增進安全、效率與服務，改善交通問題。台灣地狹人稠，高度集中發展的都市化區域，因為「停車一位難求」而衍生的違規停放、交通壅塞、空污加劇等亂象，使得「智慧停車」相關解決方案，成為智慧運輸系統中最為熱門的應用。

一般可將智慧停車管理系統分為閘門管制、（車位）在席偵測、收費／支付及後端管理四大塊，近年來最多的應用以在席偵測技術的選擇為主；而以停車格在席偵測技術而言，一般以「影像辨識法」、「偵測器法」兩種為主要大宗。影像辨識方面，通常有路口高架攝影機與地面架設攝影機立柱兩種方案，但後者會遇到「架設成本高」、「地權問題」（若是將智慧立柱安裝在地面上需要確認土地是否為私人產權），以及對於「隱私問題」的相關顧慮等挑戰。至於採用偵測器方式蒐集資料，也存在著「需與勞務業者配合才能辨識車主身份」、「仰賴電信公司通訊架構成熟度」，以及「偵測器對於環境的耐受度與天線設計的通訊品質」等問題，因此，高位攝影機在席偵測方法逐漸受到廠商的青睞，也成為政府近期試辦的主流智慧停車服務。

本校資工系黃敬群教授長期進行智慧停車空位偵測相關研究，其運用 AI 與視訊演算法所研發的影像辨識服務，不但克服了白天、夜晚、陰天、下雨天、大太陽等諸多戶外場景狀況，更讓單一攝影機就能拍攝涵蓋停車場 60~70 個停車位，不但解決了傳統影像辨識設置成本極高（每個停車格皆需設立智慧車柱）的問題，大幅提高服務系統的經濟價值，架設於高位的攝影機也不會產生地權問題；而由於攝影設備只針對車輛區塊區拍攝，不會照到人或環境，留存影像也僅有車輛跟車牌，所以也不會造成侵犯隱私問題的疑慮。

黃敬群教授將研究成果與專業停車場管理廠商「歐特儀」股份有限公司進行合作，研發出擁有強大後端運算能力的「高位攝影開單系統」，只要在路燈上架設高位攝影機，系統透過影像串流方式，從偵測拍照、即時 AI 演算、到辨識車牌或干擾物、甚至開單、離場、系統異常、影像存留等，全部都可以自動化作業。

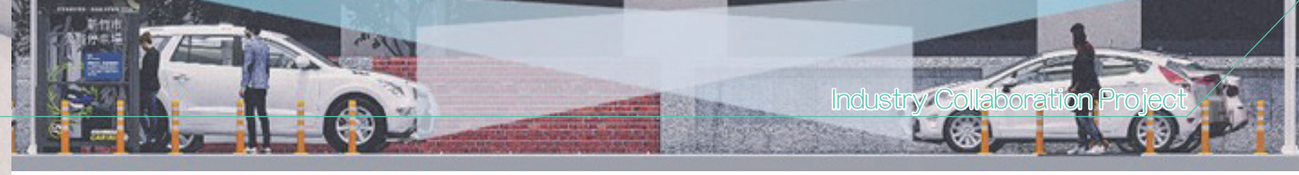
此高位攝影開單系統，今年分別與和台北市政府、新竹市政府合作進行「高位攝影智慧化開單服務」與「影像智慧停車柱」的試辦應用，不但成為台北市試辦的第三種路邊停車智慧開單服務，「影像智慧停車柱」也成為新竹市公有停車場首創的自動智慧停車服務。

根據台北市停管處表示，從 7 月 17 日到 9 月 30 日，在台北市中正區潮州街（羅斯福路 1 段至杭州南路 2 段）16 格路邊停車停車格試辦第 3 種智慧停車服務：「高位攝影智慧化開單服務」，此項設備具影像辨識及車輛感測功能，除了可偵測車輛入停、提供即時停車格位資訊之外，還能自動開單，民眾不會收到停車費開單，只要在車輛駛離停車位 10 分鐘之後，就能透過手機於智慧支付平台查繳，或至四大超商多媒體機列印繳費單櫃檯繳費、綁定銀行、電信業者代扣繳等方式繳費，實現真正的無人化、無紙化智慧停車與開單服務。目前經北市府評估成效良好，將陸續擴大到 160 格。

相對於台北市於「路邊停車格」試辦智慧停車服務，新竹市交通處此次是選擇在東區區公所停車場，啟用「影像智慧停車柱」服務。

新竹市自 2019 年起便積極建置智慧停車系統，陸續在 9 處公有停車場，以代幣與自動柵欄建置無人自動化的車輛進出管理系統；為使服務更升級，此次啟用全市首創的的影像智慧停車柱，利用車牌辨識技術，結合自動停車收費系統，停車場無柵欄也無需取代幣，車輛進出無需停留，離場前到收費亭按壓車牌號碼繳費後即可離場，或可於期限內至超商或以第三方支付繳納，讓使用者輕鬆停車、簡單繳費、快速離場，停車省時、方便性升級！

戶外情境相當複雜，除了天候外，大型車遮蔽、用路人行為等，都影響了電腦視覺與深度學習辨識技術的正確性，黃敬群教授的空位偵測研究應用，與廠商攜手合作，攻克戶外場域干擾問題，透過前背景的渲染專利，讓系統的可靠度達商轉的條件，讓智慧停車服務技術邁入了全新的里程碑，停車與繳費能正式進入完全無人化與無紙化的智慧服務，也期待此次於台北市與新竹市的試辦能成為智為城市重要一環，並持續累積有用的數據資料，進一步推升未來智慧停車科技的相關研究工作！



Smart Parking System Based on

Professor Ching-Chun Huang's Vacancy Detection Research

The term "Intelligent Transportation System (ITS)" denotes the utilization of cutting-edge technologies, encompassing electronics, communication, computers, control systems, and sensors, across different transportation networks, with a particular focus on land transportation. This seamless integration of advanced technology empowers the enhancement of safety, efficiency, and service quality through real-time data transmission to tackle multifaceted traffic challenges. In Taiwan, the nation's constrained geographical landscape and high population density have given rise to issues such as unauthorized parking, traffic congestion, and increased air pollution due to the scarcity of parking spaces. Consequently, solutions for "smart parking" have emerged as one of the most widely embraced applications within the field of intelligent transportation systems.

In general, smart parking management systems typically consist of four main components: gate control, parking space detection, payment processing, and backend management. In recent years, the primary focus has been on advancing parking space detection technology. When it comes to detecting parking space occupancy, two primary methods are commonly employed: "image recognition" and "sensor-based" techniques. Regarding image recognition, there are typically two options: overhead cameras at intersections and ground-mounted camera pillars. However, the latter approach faces challenges such as costly installation, property rights issues (particularly when securing the necessary land ownership verifications for ground-based smart pillars), and privacy concerns. On the other hand, the utilization of sensor-based methods for data collection gives rise to a set of complexities in terms of 'coordination with service providers to identify vehicle owner,' 'dependence on the maturity of telecommunications infrastructure provided by telecom companies,' and 'the sensor durability in various environmental conditions and the quality of antenna design for communication.' As a result, high-position cameras for parking space detection have garnered increasing favor among manufacturers and have emerged as the primary choice in recent government trials of smart parking services.

Professor Ching-Chun Huang, from the Department of Computer Science at NYCU, has conducted extensive research on smart parking space detection. Through the use of AI and video algorithms, he has developed an image recognition service that not only effectively addresses various outdoor conditions—such as daytime, nighttime, overcast weather, rainy conditions, and bright sunlight—but also allows a single camera to efficiently cover 60 to 70 parking spaces within a parking lot. This innovation addresses the challenge of the usually high costs linked to conventional image recognition setups, which demand the installation of smart pillars for each parking space. This significantly enhances the economic value of the entire service system. Additionally, the use of high-position cameras addresses concerns about property rights. These cameras specifically focus on the vehicle area without capturing individuals or the surrounding environment. As a result, the saved images include only vehicles and license plates, thereby alleviating concerns about privacy infringements.

Professor Huang is partnering with the professional parking management company 'Altob Inc.' to bring forth an advanced 'high-position camera-based ticketing system' featuring robust backend computing capabilities. By simple deployment of high-position cameras mounted on lampposts, this system will employ a video streaming approach to automate operations, such as detecting photography, real-time AI algorithms, license plate recognition, interference detection, ticket generation, exit management, handling system anomalies, and image storage.

The high-position photography ticketing system has collaborated with both the Taipei City Government and the Hsinchu City Government this year to conduct trial runs for the 'high-position photography smart ticketing services' and 'image smart parking pillars.' It emerged as the third type of smart on-street parking ticketing service in Taipei City's trial, while it also pioneered automated smart parking services in public parking lots in Hsinchu City.

The Taipei City Parking Management Office conducted a trial of the third type of smart parking service, known as the "high-position photography smart ticketing service," from July 17 to September 30. The trial took place on the 16 on-street parking spaces along Chaozhou St. in Zhongzheng Dist., Taipei City, spanning from Sec. 1, Roosevelt Rd., to Sec. 2, Hangzhou S. Rd. The innovative system is equipped with image recognition and vehicle sensing functions. In addition to detecting vehicle entry and providing real-time parking space information, it also has the capability to automatically issue tickets. Instead of receiving parking fee tickets, users can check payment options for parking fees on their mobile phones within 10 minutes after the vehicle leaves the parking space. These options include paying via their mobile phones on the smart payment platform, printing payment slips at multimedia kiosks in major convenience stores and making payments in-store, linking payments with banks, or enabling auto-debit of telecom service providers. This advancement signifies a genuinely unmanned and paperless smart parking and ticketing service. The current success, as evaluated by the Taipei City government, will lead to a gradual expansion to cover 160 parking spaces.

Compared to Taipei City's trial of smart parking service for "on-street parking spaces," Hsinchu City Government Department of Transportation has opted to introduce the "Smart Parking Pillars" service at the Hsinchu Eastern District Office parking lot.

Starting from 2019, Hsinchu City has actively established a smart parking system. An unmanned automated system for managing vehicle entry and exit has been implemented, utilizing tokens and automatic barriers, in nine public parking lots. To further elevate the service, the city has introduced a groundbreaking image smart parking pillar. By incorporating license plate recognition technology and integrating an automated parking fee system, the parking lots no longer rely on barriers or token usage. Vehicles can smoothly enter and exit without the need to come to a halt, and users can easily input their license plate number at the payment kiosk before departing. Alternatively, payments can be swiftly settled at convenience stores or through third-party payment platforms within the specified timeframe. This work flow streamlines the parking process, simplifies payment, and facilitates a quick exit, ultimately saving users time and significantly enhancing convenience!

The outdoor setting poses numerous challenges, including factors such as weather, large vehicles blocking the view, and pedestrian behavior, all of which impact the precision of computer vision and deep learning recognition technology. Professor Huang's collaborative research on parking space detection, in partnership with manufacturers, has successfully addressed interference issues in outdoor environments. Leveraging patented technology, the system's reliability now meets commercial standards, marking a significant advancement in smart parking service technology. This application facilitates the formal transition of parking and payment processes into fully automated and paperless smart services. With the anticipation that the trials in Taipei and Hsinchu will play pivotal roles in smart cities, we look forward to accumulating valuable data and contributing to the ongoing progress of research in smart parking technologies in the future!