以 5G 與智慧無人機建構之海岸巡防與環境永續調查系統

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近年來，伴隨科技高速發展，用於生產、服務、消費端等各項技術革新的同時，環境保育與永續發展意識亦逐步抬頭，人們開始認知到與環境共存的重要性。有鑑於此，本院資工系的莊仁輝教授與智慧計算與科技研究所的謝君偉教授，將無人載具、5G 通訊兩大新興技術做結合，共同開發出一款「以 5G 與智慧無人機建構之海岸巡防與環境永續調查系統」，希望藉由無人機的高機動性與 5G 通訊的高速低延遲特性，為我國現有與未來的永續發展規劃盡一分份心力。

綜觀當代，無人機技術的應用並不少見，其所能提供的寬廣視野與靈活性被廣泛運用於生活中，自私人拍攝、娛樂用途，至公私部門勘救災、資料蒐集、環境監測等各領域，皆可見無人機技術現蹤。然而，無人機對於「極小物件」的拍攝與分析存在一定的難度，如此技術瓶頸持續困擾學界與業界多年。莊仁輝教授與謝君偉教授所開發系統之技術核心，主要利用深度學習技術，使極小物件「即時偵測」化為可行，同時保留對大尺寸物件的分析能力，解決前述關鍵問題的同時，突破技術應用限制。

該技術目前已發表於影像處理領域的最頂級期 刊 IEEE transactions on Image Processing，Impact factor = 10.865 （2021, Nov.），其所提出平行特徵金塔（parallel pyramid）的概念，不單解決了物件尺度差異帶來的偵測問題，同時具有很強的通用性，可直接架構於不同的偵測器，例如直接掛放於 YOLO v4 與 YOLO v7 上，立即改善極小物件偵測的效能，達到比原系統更高的辨識準確率。以此技術為基礎，研發團隊不單開發出海洋廢棄物影像即時辨識系統、海面油汙偵測與分析系統，另一方面，更與台電、緯創、義隆電子、新竹市警察局等公私部門合作開發白海豚調查系統、公安巡檢系統與交通流量分析系統，希望能對環境保育、永續發展有所貢獻。

此外，團隊更與中華電信 5G 團隊長期合作，將該技術結合 5G 無線通訊，實現「即時回傳分析結果」的可能，相較過去「先錄影事後分析」的監測模式，5G 通訊的即時性有效的避免「違規事件發生後無法及時控管」的問題。不僅如此，除去前述所提及海洋保育、車流減碳等領域的技術應用，目前團隊也提出了數項該技術的潛在產業應用性，其中包括與智慧農業結合，不單能做到農作物產量統計，還能協助颱風過後的災損評估、人員搜救。除了空拍影像領域外，極小物件的偵測技術也能應用於智慧醫療領域，執行如大腸癌、肝癌、腎腫瘤之偵測與分析，滿足精密醫療需求，造福社會大眾。

開發團隊除了將「以 5G 與智慧無人機建構之海岸巡防與環境永續調查系統」所應用之技術發表於國際頂級期刊，亦報名參加 2022 未來科技獎，並從中脫穎而出，獲得產學研各界專家所組成之評審團肯定具備「科學突破性」與「產業應用性」，未來將有機會實踐技術應用於各大領域。再次恭喜獲獎的莊仁輝教授、謝君偉教授開發團隊！

Coastal Patrol and Sustainable Environmental Investigation System Constructed by 5G and Intelligent Unmanned Aerial Vehicles (UAVs)

In recent years, there has been a rapid development of technology leading to significant innovations in production, service, consumer sector, and more. Consequently, a growing concern for environmental conservation and sustainable development has emerged, which has resulted in an increasing awareness among people about the importance of coexisting with the environment. Therefore, Professor Jen-Hui Chuang from the Department of Computer Science and Professor Jun-Wei Hsieh from the Institute of Computational Intelligence have combined two emerging technologies, unmanned vehicles and 5G communication, to jointly develop a "Coastal Patrol and Sustainable Environmental Investigation System Constructed with 5G and Intelligent Unmanned Aerial Vehicles." By utilizing the advanced mobility of unmanned aerial vehicles and the high-speed, low-latency properties of 5G communication, the system aims to make a meaningful contribution to both the present and future sustainable development strategies of our country.

Currently, the application of drone technology is widespread and its capability to offer a wide range of views and versatility is extensively utilized in various aspects of daily life. The presence of drones can be observed in numerous fields from personal photography and entertainment to public and private sectors like disaster relief, data collection, and environmental monitoring, among others. However, both academia and industry have been struggling for many years with the technological difficulties associated with detecting and analyzing "extremely small objects" on drones. Professor Chuang and Professor Hsieh developed a system that primarily utilized deep learning technology to enable the feasible "real-time detection" of extremely small objects while retaining the ability to analyze large-sized objects. By addressing the critical problem, the technology overcomes limitations of its applications.

The technology has been published in the top-tier journal of the image processing field, IEEE Transactions on Image Processing, with an impact factor of 11.041 (Nov. 2021). The proposed parallel pyramid feature extraction not only addresses the issue of detecting objects with varying sizes, but also has high versatility, as it can be easily incorporated into various detectors. For instance, it can be implemented directly onto YOLO v4 and YOLO v7, leading to an immediate enhancement in the detection of extremely small objects, and achieving higher recognition accuracy compared to the original system. The accuracy of this PRB-Net outperforms YOLO v7. The research team has applied this technology to a real-time image recognition system for marine debris and another one for detecting and analyzing oil spills in offshore areas. In addition, they have partnered with public and private organizations, including Taiwan Power Company, Wistron Corporation, ELAN Microelectronics Corp, and the Hsinchu City Police Bureau, to develop systems for white dolphin investigation, public safety patrols, and traffic flow analysis with the aim of making a meaningful contribution to environmental conservation and sustainable development.

In addition, the team has established a long-term collaboration with Chunghwa Telecom's 5G team to integrate the technology with 5G wireless communication, enabling the possibility of real-time analytics and reporting. Compared to the traditional monitoring mode of "recording first and analyzing later", low-latency 5G communication effectively reduces the response time after violations occur. Furthermore, in addition to the aforementioned applications in marine conservation and carbon reduction in transportation, the team also identified several potential industrial applications, such as integration with smart agriculture, for this technology. This could not only generate crop yield statistics, but also aid in post-typhoon damage assessment and personnel search and rescue. Apart from its use in aerial imaging, the detection technology for ultra-small objects has potential applications in the field of smart healthcare. It can be utilized to detect and analyze conditions such as colorectal cancer, liver cancer, and kidney tumors, addressing the needs of precision medicine and benefiting the general public.

The development team not only published the technology applied to the "Coastal patrol and sustainable environmental investigation system constructed by 5G and intelligent unmanned aerial vehicles (UAVs)" in renowned international journals, but also participated in the 2022 Future Technology Awards and received recognition for its "scientific breakthrough" and "industrial applicability" from the judging panel composed of experts from academia and industry. The potential of this technology to be applied in various domains in the future is significant. Congratulations once again to Professor Jen-Hui Chuang, Professor Jun-Wei Hsieh, and the entire development team for their award-winning achievement!