未來科技

深度強化式學習技術應用於自駕模型賽車

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自 2016 年人工智慧圍棋軟體 AlphaGo 展現驚人學習力與精湛棋藝，擊敗韓國棋王李世乭後，在各大媒體宣傳報導下，人工智慧一詞登上網路熱搜，成為家喻戶曉的科技產業新趨勢；也同時象徵著深度強化式學習（Deep Reinforcement Learning）的應用在未來，將徹底改變人類社會「食衣住行育樂」等各面向既定模式的趨勢。本院吳毅成教授與其所率領的團隊，以「應用於自駕模型賽車之深度強化式學習技術」獲得 2021 未來科技獎殊榮，便是深度強化式學習具體應用的實踐與突破。

深度強化式學習為獲獎展品的核心技術，近年來不單被廣泛用於棋類、電腦遊戲開發，需要精準控制的物件夾取、無人機操作等任務範圍也可發現其應用蹤跡。吳毅成教授與團隊希望將過去團隊在棋類及電腦遊戲上成功的技術與經驗，擴展應用範圍到「自駕模型賽車」。受限於真實世界中蒐集資料的困難度與可行性，團隊選擇先在模擬環境中進行訓練，再於真實世界中籌備測試。然而，考量到模擬環境並無法將光線、背景各項因素完美複製，進而可能產生誤差，導致應用效果不佳，設計團隊發展出一套基於影像的虛實轉移技術（sim-to-real transfer），搭配上深度強化式學習，提升神經網路模型在真實環境中的表現。

有關於此技術應用之科學突破性，吳毅成教授與團隊以 PPO 作為核心演算法，提出 teacher model 與 student model 的架構，並將其應用在自駕模型賽車上，首開運用此概念來解決虛實環境差異的先例。透過訓練「老師模型」來學習最佳路徑，再藉由老師模型與隨機化（randomization）訓練「學生模型」，使其適應真實與模擬環境中的差異，提升在真實環境中的行駛速度及穩定性，同時有效減少模型轉移所產生的附帶成本。相較於使用光達（LiDAR）作為主要感測器的多數自駕模型賽車，設計團隊選擇高性價比的相機作為感測器，更適合大規模部署的同時，不被有牆壁構造的賽道所限制。

團隊不單將應用成果發表於國際頂尖會議 IROS 2020 的 Workshop，同時多次於 AWS DeepRacer 自駕模型賽車競賽中脫穎而出，取得亮眼成績，甚至打破官方最快完賽的時間紀錄，佐證此技術之應用突破性與可行性。團隊獲獎學生也受邀前往北京青少年無人車俱樂部、逢甲大學、新加坡星展銀行等單位進行演講，分享開發構想與經驗。目前團隊已與雷虎科技合作，研究如何使用自駕技術以提升模型賽車比賽的精彩度。例如應用自駕技術於國際模型賽車聯合會主辦的世界無線電遙控汽車錦標賽上，藉由人類與機器的競賽，增進觀賞性。

就產業應用性角度來看，設計團隊其許可將技術應用於固定環境的機器人巡邏程式，如工廠內的無人搬運車，使用一般相機搭配開發技術，取代價格昂貴的光達和舖設導引線的繁瑣程序，達到低成本、快速部署、高效率的目的。此外，自駕技術也可以應用於探勘高風險環境，減少手動控制的失誤機率和人員訓練成本，在避免救難人員承擔安全風險的同時，提高搜救效率及範圍。可以肯定，在不久的將來，吳毅成教授與團隊所開發之深度強化式學習技術，將透過其泛用性和高度發展性，改變並造福人類社會。

Future Technology:

Autonomous Miniature Car Racing Based on Deep Reinforcement Learning

Since AlphaGo, the artificial intelligence Go software with incredible learning ability and impressive chess skills, defeated South Korean Go master Lee Sedol in 2016, artificial intelligence has become a top trending topic on the Internet and a well-known new trend transforming technology industry. Moreover, AlphaGo symbolizes the trend that the applications of Deep Reinforcement Learning will completely revolutionize the established patterns in human society in terms of "food, clothing, housing, transportation, education and entertainment" in the future. Dr. I-Chen Wu, professor of College of Computer Science at NYCU, and his team received the 2021 Future Technology Award for “Deep Reinforcement Learning for Autonomous Miniature Car Racing'', which illustrates the breakthrough and achievement of deep reinforcement learning.

Deep reinforcement learning is the core technology of the award-winning exhibit. In recent years, it has been widely used not only in chess-like games and video games, but also in control tasks such as object grasping and quadrotor flying. Professor I-Chen Wu and his team hope to extend their great success and experience from chess-like games and video games to autonomous miniature car racing. Because of the difficulty and infeasibility of collecting data from the real world, the team decided to conduct training in a simulated environment first, and then deployed the model into the real world. However, since the simulated environment will not perfectly replicate the light and background factors, which may cause the simulator-trained model to perform poorly in the real world, the team developed an image-based sim-to-real transfer technology to integrate with deep reinforcement learning to improve the performance of neural network models in real environments.

Regarding the scientific breakthrough of this applied technology, Professor I-Chen Wu and his team used PPO as the core algorithm and proposed the technique comprising “teacher model” and “student model”. They applied this technique to autonomous miniature car racing, which was the precedent of a new methodology to reduce the gap between virtual and real environments. First, they train a teacher model to move along a near optimal path and then use this model to teach the student model the correct actions along with randomization. The technique bridges the sim-to-real gap, improving the driving speed and robustness of the simulator-trained student model in the real world. Unlike the most autonomous miniature racing cars that use LiDAR sensors, the team chose a cost-effective camera as a sensor, which afforded large-scale deployments and overcame the obstacle of track walls.

The team not only presented the results in the workshop of IROS 2020, the top international conference, but also stood out from the AWS DeepRacer competition multiple times and achieved outstanding results. Moreover, the team even broke the official record for fastest completion time. All these achievements have proved the breakthrough and feasibility of the technology in the application. The team’s award-winning members were also invited to give speeches at Beijing Youth Unmanned Vehicle Club, Feng Chia University, Singapore DBS Bank to share their ideas and experiences on development. The team, at present, is working with Thunder Tiger Corp to increase the racing excitement of model cars by utilizing autonomous-driving technology. For example, using autonomous miniature racing cars in The IFMAR World Championship hosted by the International Federation of Model Auto Racing (IFMAR) will make the competition more attractive through the race between humans and artificial intelligence agents.

From the perspective of industrial application, the team expects to apply the technology to robot patrol programs in specific environments, such as unmanned trucks in factories. They use common cameras with their technology to replace expensive LiDAR and tedious procedures for laying guide wires to achieve low cost, rapid deployment, and high efficiency. In addition, when applied to exploration in high-risk environments, autonomous-driving technology can reduce personnel training cost and the probability of manual errors, as well as maximize the search efficiency and broaden the search scope while avoiding risks in rescue operations. We all believe that the deep reinforcement learning technology developed by Professor I-Chen Wu’s team will make a difference and benefit human society through its versatility and high extensibility in the near future.