

# CAIRS NEWSLETTER

APRIL 2023 ISSUE 8

Signal Processing using AI to ensure the  
Reliability of Sensors and Integrity of Data  
運用人工智能處理信號以確保  
傳感器的可靠性和數據的完整性



## Dr Daniel P.K. Lun 倫栢江博士

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PhD, CEng, FIET, MHKIE, SMIEEE

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香港工程師學會會員, 電機電子工程師學會高級會員

## A Conversation with Dr Daniel Lun 與倫栢江博士的對話

Centre for Advances in Reliability and Safety (CAIRS) is working with the industry through leveraging innovative artificial intelligence technology on different research projects that focus on product reliability and system safety to predict failures and nip them in the bud. In this issue, we invited Dr Daniel Lun, Associate Professor and Associate Head, Department of Electronic and Information Engineering at The Hong Kong Polytechnic University who leads our research program, "Integrity of Sensor Data", to share his experiences. Dr Lun has published more than 170 international journals and conference papers. His research interests include signal and image enhancement, computational imaging, and deep neural networks.

產品可靠性暨安全研發中心 (CAIRS) 利用人工智能等先進技術與業界開展多項不同的研究項目, 重點是對產品的可靠性和系統安全進行研究, 務求準確預測故障發生, 防患於未然。今期, 我們邀請了協助研究有關“傳感器數據的完整性項目”的香港理工大學電子及資訊工程學系副主任及副教授倫栢江博士與大家分享他的經驗。倫博士發表了170多篇國際期刊和會議論文。他的研究領域包括信號和圖像增強、計算成像和深度神經網絡等技術。



## A Conversation with Dr Daniel Lun 與倫栢江博士的對話

### 1 What is your current research interest? 您目前的研究興趣是什麼？

My research focus is signal enhancement, which has been an important research area over the last few decades due to its widespread application in different fields of study. Due to the imperfection of the working environment and the limitation of the technology, signals obtained by current signal sensing methods are far from perfect. By enhancing the signals acquired, researchers can better understand the underlying features and patterns of their data, leading to more accurate and meaningful results. Currently, my research interests include photographic and microscopic image enhancement, speech enhancement for headsets and hearing aids, data enhancement for indoor positioning systems, signal enhancement for improving system reliability and safety, etc. Different machine-learning approaches are adopted to realize these research works.

我的研究重點是信號增強，由於信號增強在不同研究領域中廣泛應用，在過去數十年來它一直是一個重要的研究課題。因工作環境的不完善和技術的限制，目前的信號傳感方法所獲得的信號遠非完美。通過增強獲取的信號，研究人員可以更好地理解其數據的潛在特徵和模式，從而獲得更準確和有意義的結果。現時我的研究興趣包括攝影和顯微圖像增強、耳機和助聽器的語音增強、室內定位系統的數據增強、提高系統可靠性和安全性的信號增強等。並採用不同的機器學習方法來實現這些研究工作。



## A Conversation with Dr Daniel Lun 與倫栢江博士的對話

## 2 Would you share your opinion on how signal and image processing using AI technologies can help with the reliability and safety of systems?

請分享一下你對於使用人工智能技術進行信號和圖像處理如何幫助提高系統的可靠性和安全性的看法？

Signal and image enhancement using AI technologies are essential to the reliability and safety of systems. It is particularly the case for the current smart systems which try to use the acquired signal and image directly in decision-making without human intervention. Wrong decisions will be made if the acquired signal and image are of low quality and thus affect the reliability and safety of systems. These low-quality signals and images can be the results of the degradation of the sensing systems. It can also be due to the limitation of the sensing technology. In both cases, signal and image enhancement can uplift the quality of the acquired signals and images and facilitate their deployment in smart systems.

使用人工智能技術增強信號和圖像對於系統的可靠性和安全性至關重要。對於當前的智能系統來說尤其如此，它們試圖在沒有人為干預的情況下直接在決策中使用獲取的信號和圖像。如果獲取的信號和圖像質量欠佳，則會做出錯誤的決策，從而影響系統的可靠性和安全性。這些低質量的信號和圖像可能是傳感系統退化的結果。這也可能是由於傳感技術的限制。在這兩種情況下，信號和圖像增強都可以提升所採集信號和圖像的質量，並促進它們在智能系統中的部署。





## A Conversation with Dr Daniel Lun 與倫栢江博士的對話

### 3 What is the challenge in applying AI or deep learning techniques to the assurance of data integrity?

#### 將人工智能或深度學習技術應用於保證數據完整性的挑戰是什麼？

The use of AI or deep learning techniques for the assurance of data integrity faces several challenges. One challenge is related to model explainability - It is often difficult to understand and interpret the results of the AI algorithms used for assuring data integrity, making it hard to explain how the conclusions are reached. It is particularly the case for medical applications where a higher standard of explainability is required to ensure the resulting data truly reflect the condition of the patients but are not arbitrarily generated by the AI model. Another challenge is related to biases in the data - If the data used for training the machine learning models are biased, the results of the model will also be biased, which can lead to incorrect conclusions. Constructing an unbiased dataset for AI model training is easier to say than done. Most well-tested systems will generate correct data when they operate normally. There are only some rare occasions when anomalous data can be obtained from these systems. It is tedious and time-consuming to collect sufficient anomalous data for constructing an unbiased dataset. To mitigate the problem, synthesized training data are often used but it then leads to the generalization problem of the resulting model. Finally, the integration of AI and physics is also an interesting problem - For many data generation processes, the physics behind them is well-known. Rather than using a black-box approach as in the current AI methods, the integration of physics in the AI model design would help reduce the training time and enhance the accuracy of the final results. How to strike a good balance between human intelligence and machine intelligence in the design process is still a challenge.

使用人工智能或深度學習技術來確保數據完整性面臨多項挑戰。其中一個挑戰與模型的可解釋性有關——通常用於確保數據完整性的人工智能算法結果都很難理解和解釋，以致很難解釋如何得出有關結論。醫療應用尤其如此，需要更高標準的可解釋性，以確保產生的數據真實反映專利狀況，而不是由人工智能模型任意產生。另一個挑戰與數據中的偏差有關——如果用於訓練機器學習模型的數據存在偏差，那麼模型的結果也會有偏差，這可能會導致錯誤的結論。為人工智能模型訓練無偏數據集構建說來容易實踐難。大多數經過良好測試的系統在正常運行時都會生成正確的數據。只有在極少數情況下才能從這些系統中獲取異常數據。收集足夠的異常數據以構建無偏數據集既繁瑣又耗時。為了緩解這個問題，通常使用合成訓練數據，但這會導致生成模型的泛化問題。最後，人工智能和物理學的融合也是一個有趣的問題——對於很多數據生成過程，其背後的物理學是眾所周知的。與當前人工智能方法中使用黑盒方法不同，將物理學集成到人工智能模型設計中將有助減少訓練時間並提高最終結果的準確性。如何在設計過程中很好地平衡人類智能和機器智能仍然是一個挑戰。



## A Conversation with Dr Daniel Lun 與倫栢江博士的對話

### 4 Would you share with us an interesting AI-related project? 可否與我們分享一個人工智能相關的有趣項目嗎？

As mentioned above, the integration of physics in the model design is an important direction of the current AI research. Our research team recently applied the physics-driven approach to the deep neural network design for a long-established challenging problem called phase retrieval and achieved a significantly improved result. Phase retrieval (PR) intends to reconstruct a complex-valued signal only from its Fourier intensity measurements. It is a key problem in crystallography, optical imaging, astronomical imaging, diffraction imaging, holographic imaging, etc. For example, in microscopic imaging, phase retrieval allows the acquisition of the phase images of biological cells so that researchers can visualize the detailed changes in the cell texture that cannot be seen in normal magnitude images. However, traditional optimization-based phase retrieval approaches are often time-consuming while the quality of the result is not guaranteed. Besides, some approaches require capturing many image frames in sequence to enhance the estimation accuracy. It introduces motion blur in dynamic applications with moving samples. Recently, AI-based PR approaches using different deep neural network methods were developed. However, since the problem is severely ill-posed, the accuracy of these approaches is usually very low. To solve the problem, our team developed a physics-driven deep learning-based PR method. It requires only a single Fourier intensity measurement for each PR reconstruction and can operate in real-time. To improve the accuracy, we allow the Fourier intensity measurement not only to inform the training but also the inferencing processes of the AI model so as to guide it to give the right solution. The method was tested on a microscopic imaging platform and achieved significantly improved performance over state-of-the-art approaches. Although the work was just completed, we have received inquiries from overseas research teams for collaboration on this topic. I believe the result of this work will bring a strong impact on the field of study and related industry.

如前所述，將物理學融入模型設計是當前人工智能研究的一個重要方向。我們的研究團隊最近將物理驅動的方法應用於深度神經網絡設計，以解決一個長期存在的挑戰性問題，稱為相位檢索，並取得了顯著改善的結果。相位檢索（PR）旨在僅根據其傅里葉強度測量值重建復值信號。它是晶體學、光學成像、天文成像、衍射成像、全息成像等的關鍵問題。例如，在顯微成像中，相位檢索可以獲取生物細胞的相位圖像，以便研究人員可以在正常幅度圖像看不到的細胞紋理中可視化細胞的詳細變化。然而，傳統基於優化的相位檢索方法往往耗時長，而且結果質量得不到保證。此外，有些方法需要依次捕獲許多圖像幀以提高估計精度。它在具有移動樣本的動態應用程序中引入了動態模糊。而近期開發的相位檢索方法便使用了基於人工智能的不同深度神經網絡方法。然而，由於不適定問題嚴重，這些方法的準確性通常很低。為了解決這個問題，我們的團隊開發了一種基於物理驅動的深度學習相位檢索方法。它只需要對每個相位檢索重建進行一次傅里葉強度測量，並且可以實時運行。為了提高準確性，我們允許傅里葉強度測量不僅為訓練提供信息，還為人工智能模型的推理過程提供信息，從而指導它給出正確的解決方案。該方法在顯微成像平台上進行了測試，與最先進的方法相比，性能有了顯著提升。雖然這項工作剛剛完成，但我們已經收到來自海外研究團隊的查詢，希望就此課題進行合作。我相信這項工作的結果將對研究領域和相關行業帶來強烈的衝擊。



## A Conversation with Dr Daniel Lun 與倫栢江博士的對話

### 5 What is your future research direction considering reliability and safety? 您未來在可靠性和安全性方面的研究方向是什麼？

In the area of reliability and safety, I am working with my colleagues in CAiRS on a number of interesting research projects. For indoor positioning, we are working on an attentional filtering method that can extract quality Bluetooth packets received from the tag to enhance the estimation accuracy of our deep neural network model. For constructing an unbiased dataset to train our printed circuit board (PCB) soldering defect detection model, we are working on using the self-supervised learning technique to fully utilize the abundant normal PCB samples. Also, we use a multitasking approach, which simultaneously segments the soldering points of the PCB, to enhance the feature extraction ability of the model even with a very small amount of training samples. We will also develop different AI-based signal and image processing techniques for robotic control. We will explore how the stereo vision signal and lidar signal can be fused to enable the object tracking and crash prediction functions to patrol robots. I am particularly grateful to the industrial partners of these projects who provide resources to allow us to build, test and evaluate our solutions on some realistic platforms. And with the support of CAiRS, I believe these projects will achieve fruitful results and contribute significantly to society.

有關可靠性和安全領域方面，我正在與CAiRS團隊一起開展許多具趣味性的研究項目。對於室內定位，我們正在研究一種注意力過濾方法，可以提取從標籤接收到的高質量藍牙數據包，以提高我們的深度神經網絡模型的估計精度。為了構建無偏數據集來訓練我們的印刷電路板 (PCB) 焊接缺陷檢測模型，我們正致力於使用自我監督學習技術來充分利用大量的正常 PCB 樣本。此外，我們使用多任務方法，同時分割 PCB 的焊點，即使訓練樣本量非常小，也能增強模型的特徵提取能力。另外，我們將會為機器人控制開發不同基於人工智能信號和圖像處理的技術。我們將探討如何融合立體視覺信號和激光雷達信號，使巡邏機器人具備物體跟踪和碰撞預測功能。我特別感謝這些項目的業界合作夥伴，他們提供了資源，使我們能夠在一些現實的平台上構建、測試和評估我們的解決方案。在CAiRS的支持下，我相信這些項目將取得豐碩的成果，為社會作出重大的貢獻。



## RESEARCH SEMINAR

**ON-LINE RESEARCH SEMINAR**  
**網上研討會**

The Distinguished Research Seminar titled “Prognostics and Health Management for the Predictive Maintenance of Components and Systems” was successfully held on 3 February 2023. This seminar was co-organized by the Department of Industrial and Systems Engineering, PolyU and CAiRS. Thanks to Professor Enrico Zio from the Department of Energy, Politecnico di Milano, Milan, Italy for sharing his extensive insights with us on predictive maintenance.

For more information and details of this and other upcoming activities, please visit our website [www.cairs.hk](http://www.cairs.hk).

由香港理工大學工業及系統工程學系與產品可靠性暨安全研發中心合辦有關「用於組件和系統預測性維護的預測和健康管理」的研討會已於2023年2月3日完滿結束。感謝來自意大利米蘭理工大學能源學系的 Enrico Zio 教授與我們分享他對預測性維護的全面見解。

想了解更多有關CAiRS的最新消息及活動資訊，歡迎瀏覽我們網頁[www.cairs.hk](http://www.cairs.hk)。



Featured speaker (Professor Enrico Zio from the Department of Energy, Politecnico di Milano, Milan, Italy)  
講者 (意大利米蘭理工大學能源學系的 Enrico Zio 教授)



**For more details, please scan the QR code**  
**請掃描二維碼以索取詳細資訊**

## VISITORS TO CAIRS

We welcomed guests from different sectors visiting CAIRS. Accompanied by our Executive Director & Centre Director - Ir Professor Winco Yung, the guests toured around our Centre and advanced equipment laboratories that highlight our research works and achievements in product reliability and system safety using AI methodologies.

歡迎各界嘉賓蒞臨本中心參觀指導。在我們的總監及執行董事容錦泉教授的陪同下，嘉賓們參觀了我們的中心和先進設備實驗室，重點介紹了我們使用人工智能方法在產品可靠性和系統安全方面的研究工作及成果。

**DONGGUAN MUNICIPAL GOVERNMENT OFFICIALS  
VISIT TO CAIRS ON 16 FEB 2023****東莞市政府官員到訪  
(2023年2月16日)****創新科技及工業局副局長  
張曼莉女士到訪 (2023年2月23日)****MS LILLIAN CHEONG, JP UNDER SECRETARY FOR INNOVATION,  
TECHNOLOGY AND INDUSTRY VISITS TO CAIRS ON 23 FEB 2023****POLYU VICE PRESIDENT (RESEARCH AND INNOVATION)  
- IR PROFESSOR CHRISTOPHER CHAO AND TEAM VISIT TO CAIRS ON 24 FEB 2023****理大副校長(研究及創新)  
趙汝恒教授及團隊到訪 (2023年2月24日)**



## VISITORS TO CAiRS

COLLABORATORS & INDUSTRIAL VISITORS TO CAiRS  
合作夥伴及業界到訪CAiRS

Guests from different local industries visited CAiRS to exchange insights in the areas of product reliability and system safety and had fruitful discussions on collaboration opportunities.

來自本地不同行業的合作夥伴參觀了CAiRS，就產品可靠性和系統安全領域上交流，並討論了協作的機會。

31 Jan 2023

Business Development Team from Hong Kong Science and Technology Parks Corporation (HKSTP)  
香港科技園公司 (科技園公司) 業務拓展團隊



28 Feb 2023

Yau Lee Construction Co., Ltd.  
有利建築有限公司



24 Mar 2023

HK Electric  
香港電燈有限公司



1 Feb 2023

Robocore Technology Limited  
博歌科技有限公司



3 Mar 2023

Intertek Testing Services HK Limited  
天祥公證有限公司



## CAiRS TEAM BUILDING SERIES CAiRS 團隊建立系列



30 Jan 2023

Chinese New Year Lion Dance Parade  
新春舞獅巡遊



15 Feb 2023

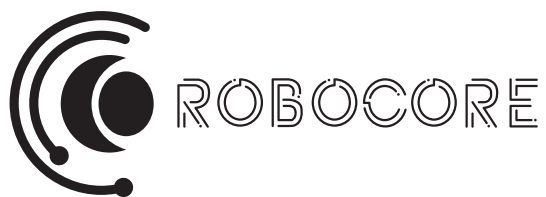
Workshop on Advantages and Applications of  
Supercomputer in AI Research by Nvidia  
Nvidia超級電腦在人工智能研究中的優勢與應用工作坊

## NEWLY GRANTED PATENT 新批予專利

We are pleased to update that a new patent has been granted lately. If you are interested in our technology and would like to learn more about it, please feel free to contact us. We would be happy to provide you with more information.

我們很高興公佈一項新的專利已被批予。如果您對我們的技術感興趣並想了解更多，請隨時與我們聯繫。我們很樂意為您提供更多資訊。

Title: System and method for spray paint image synthesis in surveillance camera anomaly detection  
Patent No. : 30076502



## WELCOMING NEW COLLABORATOR 歡迎新合作夥伴加入

We are delighted to have a collaboration with Robocore Technology Limited. Now we have a total of 35 industrial collaborators engaged in Smart City & Smart Manufacturing.

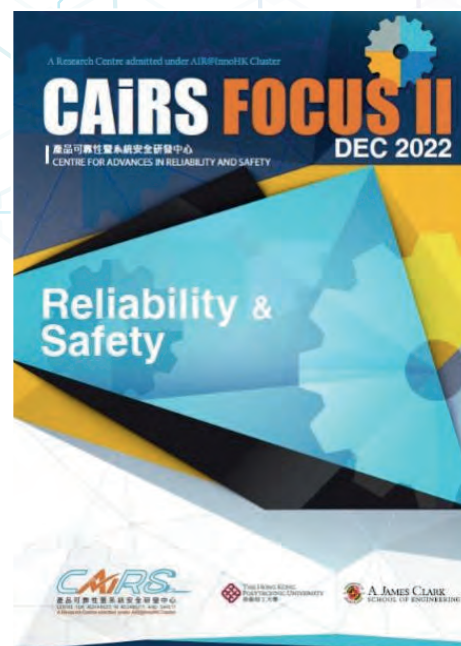
我們非常高興與博歌科技有限公司協作，現在我們合共有35間來自智慧城市和智能製造不同市場領域的合作夥伴。



## PUBLICATION: CAiRS FOCUS II 刊物: CAiRS年刊 (第二期)

We are pleased to announce the launch of CAiRS Focus II! This new issue highlights the latest research works, information and activities about CAiRS. You are welcome to view the e-copy via our website [www.cairs.hk](http://www.cairs.hk).

For more details, please scan the QR code  
請掃描二維碼以索取詳細資訊



## VIDEOS

Exciting news! We are thrilled to announce the new release of CAiRS video @ I&T New Era II programme which was being broadcast on RTHK in early March, as well as our latest video showcasing our collaboration project with Kenta Enterprise Company Limited on anti-lock braking system (ABS) related plastic part for vehicles. Let's check out our new videos today!

好消息!很高興向大家發布我們於三月初在香港電台 - 創科新里程II節目上架的特輯,以及展示我們與健大企業有限公司在車輛防鎖死煞車系統 (ABS) 相關塑料組件方面合作項目的最新視頻。請立即觀看我們的新視頻吧!





# UPCOMING EVENTS



## CAIRS PUBLIC SEMINAR

# TRUSTS IN PRODUCT RELIABILITY AND SAFETY



**09  
MAY  
2023 (TUE)**



**3-5:30pm**



**Eng**



**Inno2, Multi-function Room 2-3,  
2/F., 17W, Hong Kong Science Park**

**REGISTER HERE**



Registration Deadline  
7 May 2023

### Breaking the Trust: How Companies are Failing Their Customers

**Speaker: Prof. Michael Pecht, PhD, PE**

Life Fellow, IEEE  
Distinguished Professor and Director, CALCE  
Center for Advanced Life Cycle Engineering  
University of Maryland



#### ABSTRACT

When numerous well-known suppliers and original equipment manufacturers engage in deceptive practices, including falsifying product data or neglecting to report known defects, the fundamental question that arises is whether any claim from any company can be trusted. This presentation sheds light on the importance of tackling supply chain fraud more rigorously. This presentation discusses the current state of supply chain complexity and customer practices and then highlights the prevalence of fraud and its impact on all consumers. Examples of renowned companies that have either publicly acknowledged fraudulent practices or were caught in some level of deception in their supply of products are provided. Solutions related to laws, regulations, standards and supply chain practices for fraud detection and risk mitigation are discussed.

### Building Trust and Markets

**Speaker: Ms Gabriela Ehrlich**

Director of Communications  
International Electrotechnical Commission, IEC



#### ABSTRACT

Electronic products need to be safe and reliable during their whole product life cycle. Just one low quality component can cause a product to fail. Early product failure can lead to an erosion of trust and loss of reputation for the component supplier, OEM or consumer brand. It can limit market growth and revenue opportunities and hinder the broad adoption of new technologies. This talk will look at standards that help ensure reliability & safety and explain how the IECQ global supply chain management and control system helps ensure that the many parts that enter into the production of electronics are of the high quality that is required today.

Certificate of Attendance will be issued after attending the seminar.

**Centre for Advances in Reliability and Safety**

Unit 1212-1213, 12/F, Building 19W, Hong Kong Science Park, Pak Shek Kok, NT, Hong Kong



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