產品可靠性暨系統安全研發中心
CENTRE FOR ADVANCES IN RELIABILITY AND SAFETY

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CAiRS E-NEWSLETTER

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Development of Functional Safety using AI

運用人工智能以提高功能安全指標

Research Focus

: A Conversation with Dr Nick Chung
與鍾世豪博士的對話

Centre for Advances in Reliability and Safety (CAiRS) introduces and implements artificial intelligence methods and machine learning techniques with reliability modelling, with the goal of improving the product reliability and system safety. The application of AI in functional safety is one of the topics we research. In this issue, we invited Dr Nick Chung who is the Associate Professor, Department of Industrial and Systems Engineering of The Hong Kong Polytechnic University to share his ideas on functional safety development. Dr Chung has rich experience in operations research and has been the principal investigator of about 10 research projects and published over 80 international journal papers.

產品可靠性暨系統安全研發中心有限公司（CAiRS）所引進的配備可靠性建模的人工智能方案及機器學習技術，能改善產品的可靠性和系統安全。我們的其中一個研究課題是人工智能在功能安全方面的應用。在這期通訊中，我們邀請了香港理工大學工業及系統工程學系副教授鍾世豪博士，分享他對於功能安全發展的見解。鍾博士在運籌學方面擁有豐富的經驗，並曾經擔任約10個研究項目的首席研究員，以及發表過80多篇國際期刊論文。

Research Focus

: What is your research interest? 你的研究興趣是什麼?

My research interest is in operations research. I have researched in various problems, such as production scheduling, vehicle routing, berth allocation, airline crew scheduling, and aircraft maintenance routing. I am also the project leader of the research project on “functional safety verification of systems that implement AI” in CAiRS.

我的研究興趣是運籌學。我曾經研究過不同的議題，例如生產編程、車輛路線編排、泊位分配、航空公司機組人員編更，以及飛機維修路線編排。此外，我亦在CAiRS「為已安裝人工智能的系統驗證功能安全」的研究項目中擔任項目負責人。

Research Focus

: How do you consider the topics on reliability and safety?
關於可靠性和安全性，你有什麼看法?

For the majority of applications, the two most important goals are to make sure the system is reliable and safe. Reliability is to make the system failure-free, and safety is to make the system accident-free. Depending on the application, the term “Reliability” and “Safety” can be analyzed separately and collectively. Generally, when the system has a high level of reliability, it is assumed that the system will be safer. For example, if the equipment has a high level of reliability, it will be exposed to less unplanned maintenance activities and human intervention. This may cause fewer accidents to happen on the floor. However, there may exist situations to tradeoff between Reliability and Safety. Error in the system may cause it to stop down thus reducing the reliability of the system because of safety requirements. For example, the escalator may reliably transport travelers up and down but may injury one or more because of falling or another reason. This can be considered reliable but not safe. The system may work failure-free according to design and still be not accident-free.

對於大部分應用情況而言，確保系統可靠和安全是兩大重要目標。其中可靠性是指系統不會出現故障；而安全性則指系統不會發生意外。根據不同的應用情況，我們可以將「可靠性」和「安全性」兩個詞彙單獨和綜合地分析。一般而言，當系統具有高可靠性時，我們會假設它較為安全。舉例說，假如某個設備的可靠性很高，則較少機會需要安排預期以外的維修工序和人為干預，同時發生意外的機率亦會較低。然而，在可靠性和安全性之間，有時可能會出現不能兩者兼得的情況。在考慮到安全要求下，系統一旦發生錯誤便可能需要停止運作，繼而減低系統的可靠性。例如，某部升降機雖然能可靠地運送乘客上樓下樓，但一旦發生墜落意外或其他原因，便可能會令乘客受傷，因此可視為可靠但不安全。即使系統可因出色的設計而達至零故障，但意外仍然難以避免。

Research Focus

: What are your opinions on the development of functional safety? 你對功能安全的發展有什麼意見?

International standard IEC 61508 defined functional safety as “part of the overall safety relating to the equipment under control (EUC) and the EUC control system that depends on the correct functioning of the electrical/electronic/programmable electronic (E/E/PE) safety-related systems and other risk reduction measures”. The current version of IEC 61508 does not recommend the usage of Artificial Intelligence (AI) in different levels of safety integrity level (SIL). For the development of functional safety, we propose below model to determine the SIL of the safety-related protection systems (safety functions) for the achievable risk reduction and develop & implement AI for the condition monitoring/fault diagnosis of safety functions to ensure their correct functionality and avoid hazardous events. Furthermore, safety criteria can be identified for the functional behavior of AI which would contribute to justifying the safety of AI.

國際標準IEC 61508訂明，功能安全是「受控設備（EUC）及 EUC控制系統整體安全的一部分，並根據電機／電子／可編程電子（E/E/PE）安全相關系統及其他風險降低措施是否正確運作而釐定。」IEC 61508的現行版本並不建議在不同的安全完整性等級（SIL）中運用人工智能。在功能安全發展方面，我們建議採用以下模型來釐定安全相關保護系統（安全功能）的SIL，從而達到降低的風險目的，以及發展出能用作監測安全功能狀況／診斷故障的人工智能技術，以確保系統能正確運作，避免危險事故發生。此外，我們亦可以為人工智能的功能行為訂立安全準則，以協助證明人工智能的安全性。

Research Focus

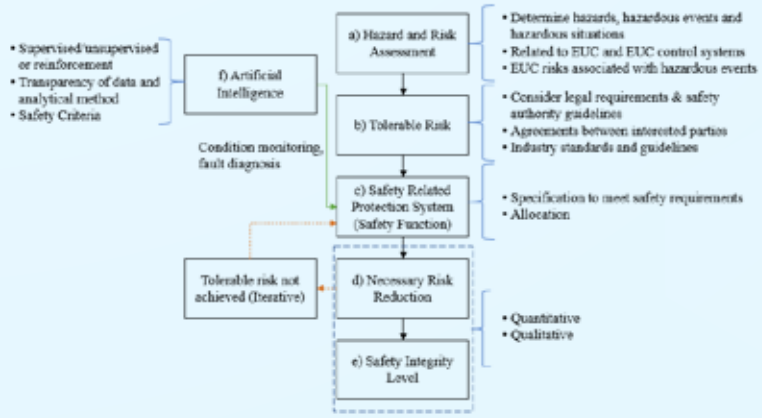

Figure 1: Proposed Model on how to determine the SIL of the safety-related protection systems (safety functions) for the achievable risk reduction and develop & implement AI for the condition monitoring/fault diagnosis of safety functions

圖1：此建議模型提供了如何釐定安全相關保護系統（安全功能）的SIL，以達到降低風險目的，以及發展出能用作監測安全功能狀況／診斷故障的人工智能

Safety, in particular functional safety, is very crucial nowadays to avoid hazardous events from occurring. The range of applications can vary from a simple machine to more sophisticated areas such as aviation, space, railway, automotive, and many others. For instance, ISO 26262 is an international functional safety standard for automotive. In addition, rather than only hardware system safety, the improvement in the area of software system safety is emerging. For instance, IEC 60880 is a safety standard used in nuclear plants and covers software that performs safety functions.

安全性，尤指功能安全性，是今天避免危險事故發生的一個關鍵因素。其中的應用範圍涵蓋簡單的機器，以至航空、航天、鐵路、汽車等更為精密的領域。舉例而言，ISO 26262是汽車方面的國際功能安全標準。另外，除了硬件系統安全外，軟件系統安全亦日漸得到改進。例如IEC 60880是一個用於核電廠的安全標準，並涵蓋了執行安全功能的軟件。

Research Focus

: What is the most interesting project you would like to have in coming future considering reliability and safety?
在可靠性和安全性方面，在未來你最感興趣的項目是什麼?

The transformation and automation of traditional manufacturing and industrial practices using smart technologies have also increased the application of safety-related systems. It is considered that safety is more critical in industry 4.0. The E/E/PE are fundamental in the implementation of Industry 4.0 and functional safety. AI is considered a driving force for Industry 4.0. In the coming future, we aim to specify the safety criteria for AI that may be beneficial for industry 4.0.

在傳統生產和工業營運的轉型和自動化工序上運用智能技術，亦提升了安全相關系統的應用比率。在工業4.0中，安全性相信將會變成一個更為關鍵的因素。E/E/PE是實踐工業4.0和功能安全的基礎，而人工智能則獲視為工業4.0的推動力。我們未來的目標，是為有助推動工業 4.0 的人工智能訂立安全準則。

Research Focus

: What is the challenge to apply AI or machine learning technique on functional safety?
將人工智能或機器學習技術應用在功能安全上，面對著什麼挑戰?

The popularity and usage of machine learning techniques, especially deep learning, in various safety-related applications cannot be denied. However, the current version of international standards, such as IEC 61508, does not allow usage of AI other than SIL 1, i.e; SIL 2, SIL 3, and SIL 4. The major challenge is that AI-based algorithms do not have the final decision to reduce the risk. By specifying safety criteria for the functional behavior of AI, we propose that AI implementations be certifiable to the standards. An example of safety criteria is repeatability, which requires that any learned valid mapping or output does not become unlearned during future learning due to forgetting of previously learned samples. The safety criteria would contribute to justify the safety of AI-based algorithms.

目前機器學習技術，尤其是深度學習，在不同的安全相關應用範圍上的普及和使用情況是無可置疑的。然而，諸如IEC 61508等國際標準的現行版本，卻除了SIL 1 外，在其他等級（即SIL 2、SIL 3和SIL 4）上不容許使用人工智能。而最大的挑戰，是以人工智能為基礎的運算法並不能直接降低出現問題的風險。我們認為透過為人工智能的功能行為訂明安全準則，便可令人工智能的運作符合標準。可重覆性是安全準則的其中一個例子，當中要求任何已學習的有效映射或輸出，在未來的學習時不會因忘記過往曾經學習的樣本而變成未有學習。對於以人工智能為基礎的運算法而言，安全準則有助證明它的安全性。

News Highlights

: PolyU developed Smart All-electric Antilock Braking System enhancing motorists' safety
理大研發「智能純電動防鎖死煞車系統」 提升汽車安全

Anyone needs to be alert on the road because accidents can happen at any time. For example, if there is a sudden problem with the braking system, both pedestrians on the road and people in the car will be in danger. Recently, the Hong Kong Polytechnic University has developed "Smart All-electric Antilock Braking System" for safer and better control on the braking effect. The system won a silver medal at the Special Edition 2021 Inventions Geneva Evaluation Days - Virtual Event, an online version of the prestigious International Exhibition of Inventions of Geneva. The details can be viewed in the August 2021 issue of "Technology Frontiers" of the Polytechnic University.

任何人在道路上都需要提高警覺，因為意外是會隨時發生，例如煞車系統如果突然出現問題，不論是路上行人或車內的人都會有危險，最近香港理工大學研發了一套「智能純電動防鎖死煞車系統」更獲得日內瓦發明獎，詳細內容可以到理工大學《技術前沿》2021年8月號瀏覽。

For more details, please scan the QR code
請掃瞄二維碼查看詳細資料

News Highlights

: PolyU collaborates with EMSD to develop Artificial Intelligence-enabled escalator combs enhance passenger safety

理大研發扶手電梯梳齒板結合AI技術　提升乘客安全

In order to prevent escalator accidents, PolyU undertook a consultancy project for the Electrical and Mechanical Services Department (EMSD) of the HKSAR Government to redesign and re-engineer the combs used in escalators. The invention won a Gold Medal at the Special Edition 2021 Inventions Geneva Evaluation Days – Virtual Event. For more details, please visit the Excel x Impact Summer 2021 – Issue 5 from PolyU website.

為防止扶手電梯事故發生，理大於香港特區政府機電工程署（機電署）的一個顧問項目中，利用AI重新設計及製造扶手電梯的梳齒板。這創新項目在瑞士日內瓦「國際發明展」網上特別版 Special Edition 2021 Inventions Geneva Evaluation Days – Virtual Event 中榮獲金獎，大家可以到理工大學勵學利民2021年夏季號第5期瀏覽詳情。

For more details, please scan the QR code
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Upcoming Events

Organizer

CMRS 產品可靠性暨系統安全研發中心 CENTRE FOR ADVANCES IN RELIABILITY AND SAFETY

Technical Support

A. James Clark School of Engineering

Supporting Organizations *Logos are listed in alphabetical order

HKIE · HKEIA 香港電子業商會 · Hong Kong Electronics Industry Council · HKSTP · IET The Institution of Engineering and Technology · The Institution of Mechanical Engineers Hong Kong Branch · soe engineering success soe hong kong region 營運工程師學會 香港分會

Reliability and Failure Analysis for Electronics

Time & Date: 09:15 AM – 11:30 AM HK Time , 27 Oct 2021 (Wednesday)
09:15 PM – 11:30 PM US Time , 26 Oct 2021 (Tuesday)

Format: Webinar

Language: English

Registration QR code

Dr Michael Osterman, CALCE
Senior member of IEEE,
Member of ASME, IMAPS and SMTA

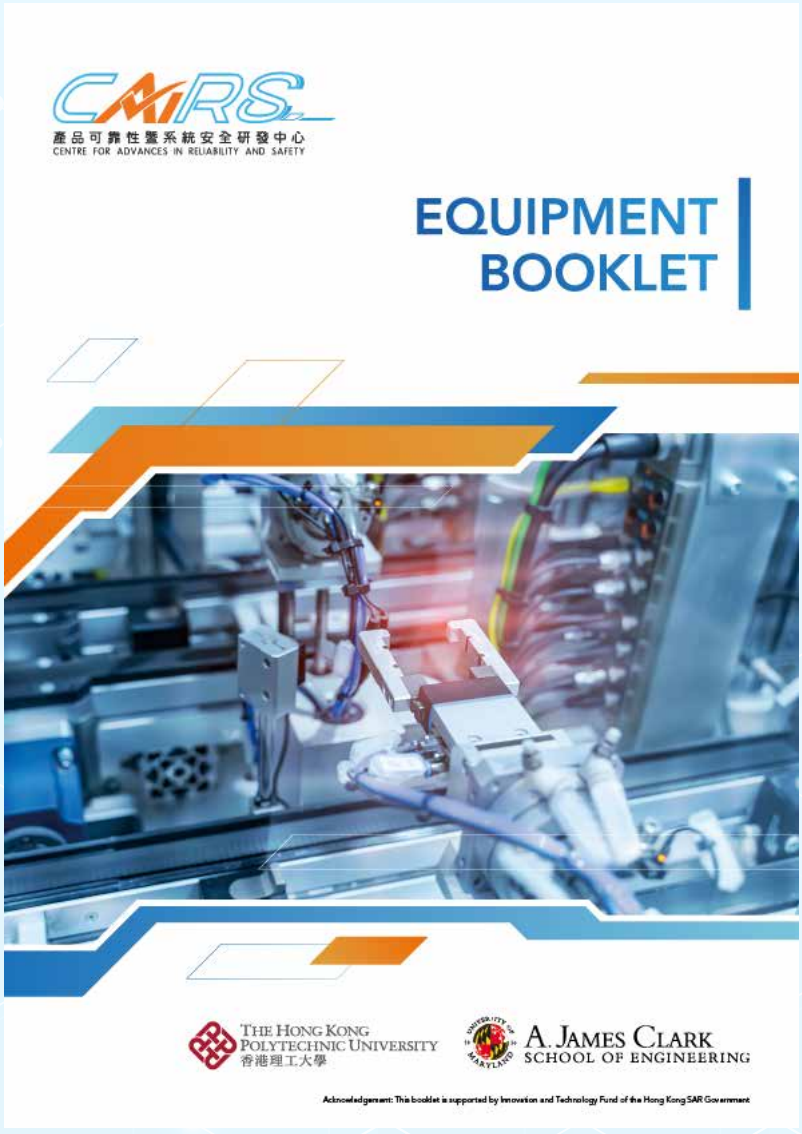
Mr Alex Chan
General Manager,
Tronico Technology Company Limited

Ir Dr Daniel Lun
Associate Professor and Interim Head,
The Hong Kong Polytechnic University

HK Time (AM)	US Time (PM)	Topics & Guest Speakers
9:15 - 9:20	9:15 - 9:20	**Welcome remarks**
9:20 - 9:55	9:20 - 9:55	**Section 1: Failure Analysis Methods for Electronics** Dr Michael Osterman, CALCE Senior member of IEEE, Member of ASME, IMAPS and SMTA
9:55 - 10:00	9:55 - 10:00	**Break**
10:00 - 10:30	10:00 - 10:30	**Section 2: IoT products Reliability and Testing** Mr Alex Chan General Manager, Tronico Technology Company Limited
10:30 - 11:00	10:30 - 11:00	**Section 3: Surveillance Video Anomaly Detection for Smart Systems** Ir Dr Daniel Lun Associate Professor and Interim Head, The Hong Kong Polytechnic University
11:00 - 11:15	11:00 - 11:15	**Q&A**
11:15 - 11:30	11:15 - 11:30	**Closing remarks**

Publication

: CAiRS Equipment Booklet
CAiRS 專業設備小冊子



CAiRS recently published a booklet about different kinds of lab equipment at our laboratory. We will deliver the CAiRS Equipment Booklet to our Collaborators, Industries Association, Professional organization, Institutions and Government departments. We will update and post the latest information about product reliability and system safety time to time. Please feel free to contact us if you have any questions on our publication.

為了讓大家對CAiRS的研究項目及應用的設備有更深入了解，我們特意製作了一本關於本中心的設備小冊子，以便大家參考。CAiRS會將我們的刊物派送到合作伙伴、商會、專業機構、大專院校及政府部門等。我們會繼續為大家介紹最新關於產品可靠及系統安全的資訊。如有任何有關刊物的查詢，歡迎與我們聯絡。