



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 FOCUS

Mar 2025

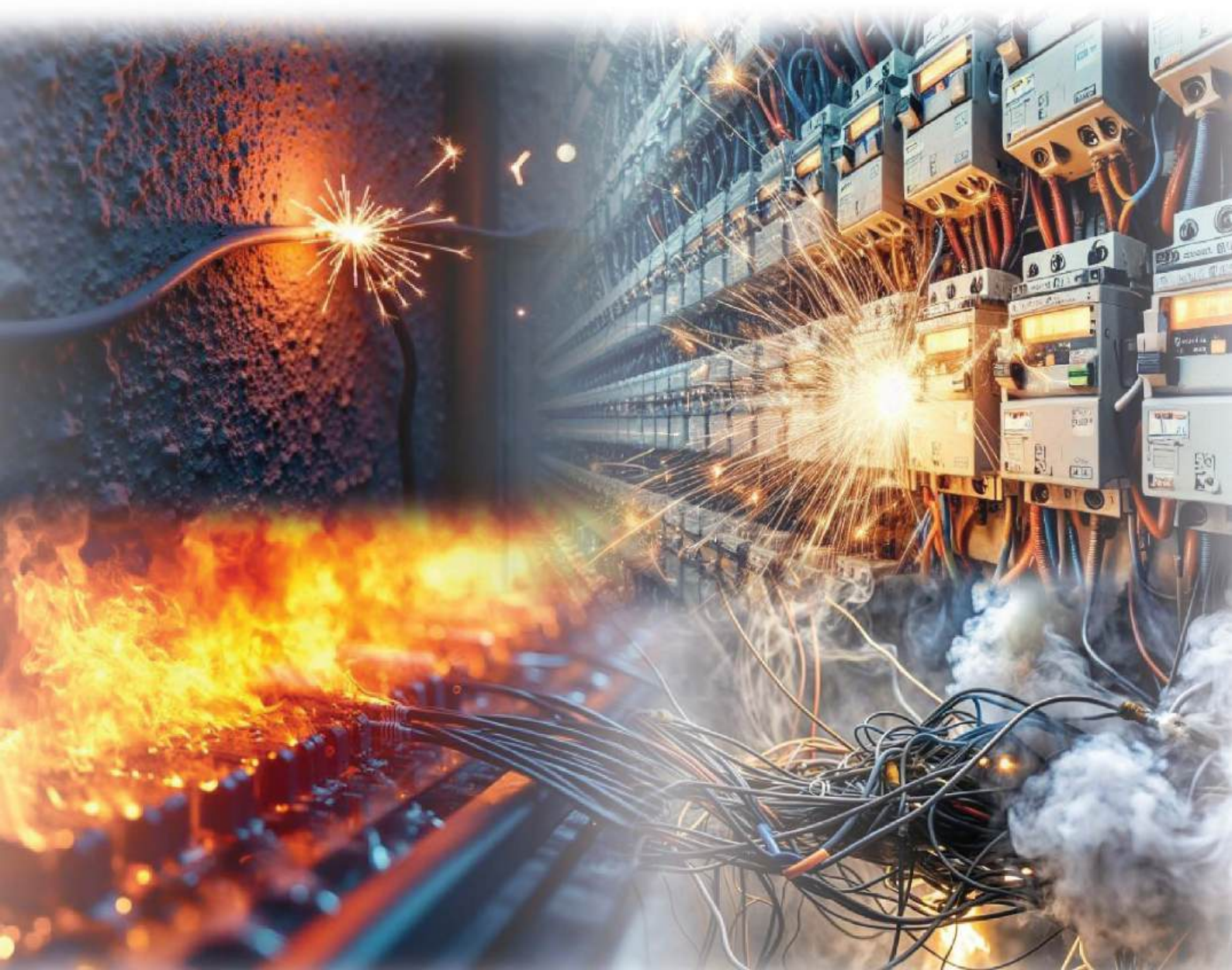


THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學



A. JAMES CLARK
SCHOOL OF ENGINEERING

“ **Reliability and Safety:**
Your Trusted Source for Excellence ”





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“ As we celebrate the fifth anniversary of the Centre for Advances in Reliability and Safety (CAiRS), I am filled with immense pride and gratitude for the remarkable journey we have undertaken together. Over the past five years, our Centre has evolved from a visionary idea into a leading institution, dedicated to advancing the fields of reliability and safety through cutting-edge research, innovation, and collaboration. ”



Message from
Prof. Kenneth K. M. Lam,

Director and CEO,
Centre for Advances in Reliability and Safety (CAiRS)

Reflecting on Our Journey

Since its establishment, CAiRS has been at the forefront of pioneering research and development initiatives aimed at enhancing the reliability and safety of critical systems across various industries. Our multidisciplinary approach has enabled us to tackle complex challenges and deliver practical solutions that have a tangible impact on society. From aerospace and automotive to healthcare and energy, our work has touched numerous sectors, driving progress and fostering a culture of safety and reliability.

Key Achievements and Milestones

This year has been particularly significant for CAiRS, marked by several key achievements and milestones. One of our most notable accomplishments was our participation in the **International Exhibition of Inventions Geneva 2024**. For the first time, CAiRS showcased its innovations on this prestigious international stage and achieved remarkable success. We were honored with **12 awards**, including **3 gold medals** and **the Prize of the International Federation of Inventors' Association (IFIA)**. This achievement underscores our team's dedication to advancing reliability and safety through innovative technologies and highlights our impact on the global scientific community.

In addition to our success in Geneva, we have made significant strides in expanding our research capabilities and fostering international collaborations. Our partnerships with leading institutions around the world have enriched our research endeavors and opened new avenues for cross-disciplinary exploration. These collaborations have not only enhanced our scientific knowledge but also provided valuable opportunities for our researchers and students to engage with global experts and contribute to groundbreaking projects.

Our Commitment to Excellence

At the heart of CAiRS' success is our unwavering commitment to excellence. Our researchers, staff, and students are the driving forces behind our achievements, and their passion, dedication, and perseverance are truly commendable. I am deeply grateful for their hard work and contributions, which have propelled us to new heights and solidified our reputation as a leader in the field.

We are also fortunate to have the support of our partners, sponsors, and stakeholders, whose trust and collaboration have been instrumental in our growth and success. Your continued support and belief in our mission have enabled us to pursue ambitious goals and make meaningful contributions to the advancement of reliability and safety.

Looking Ahead

Looking Ahead

As we look forward to the coming years, I am excited about the opportunities that lie ahead. The landscape of reliability and safety is constantly evolving, and we are committed to staying at the forefront of these developments. Our focus will remain on pushing the boundaries of knowledge, innovating with purpose, and addressing the emerging challenges of our time.

We will continue to invest in our research infrastructure, foster talent development, and strengthen our global partnerships. By doing so, we aim to create a vibrant ecosystem that nurtures innovation, encourages collaboration, and drives impactful research.

A Heartfelt Thank You

On this momentous occasion, I would like to extend my heartfelt thanks to everyone who has been a part of our journey. Your support, dedication, and belief in our mission have been the cornerstone of our success. Together, we have achieved remarkable milestones, and I am confident that the future holds even greater promise.

Thank you for being a part of our journey.

Let us embrace the future with optimism and determination.

About CAiRS

CAiRS was established in July 2020 from the collaboration between the Hong Kong Polytechnic University (PolyU) and University of Maryland (UMD), College Park, Maryland, USA and is a Research Centre admitted under AIR@InnoHK Cluster.

We have high level of world-renowned expertise in Artificial Intelligence methodologies, industry-based cluster data, and reliability and safety modeling and algorithm.

CAiRS technology is applicable to different industries (e.g. Public Utilities, Advanced Manufacturing, Electronics, Health Care, Consumer Products and Transportation) in Hong Kong with high potential Technology and Commercial impacts that contribute greatly towards the building of Smart City and Smart Manufacturing in Hong Kong.

Reliability and Safety Risks Everywhere!

Research Focus

CAiRS specializes in several cutting-edge areas:

- **Artificial Intelligence (AI) Methodologies:** Utilizing AI to enhance reliability and safety in various applications.
- **Industry-Based Cluster Data:** Leveraging large datasets from different industries to improve reliability and safety models.
- **Reliability and Safety Modeling and Algorithms:** Developing sophisticated models and algorithms to predict and enhance the reliability and safety of systems.

CAiRS's five key research programs

1. Anomaly Detection and Syndromic Surveillance

This program focuses on identifying unusual patterns or anomalies in data that could indicate potential issues or failures. Syndromic surveillance involves monitoring data to detect and respond to health-related events, which can be crucial for early warning systems in public health and other sectors.

2. Innovative Diagnostics for Health Management

This program aims to develop advanced diagnostic tools and techniques to monitor and manage the health of systems and components. By improving diagnostics, this program helps in early detection of faults and enhances the overall reliability and safety of various systems.

3. Prognostics for Remaining Useful Life Assessment

Prognostics involve predicting the remaining useful life of a system or component. This program focuses on developing models and algorithms to accurately estimate how long a system can continue to operate before it needs maintenance or replacement, thereby improving maintenance planning and reducing downtime.

4. Safety Assurance and Functional Safety Improvement

This program is dedicated to ensuring that systems operate safely and reliably. It involves developing methods and standards to improve the functional safety of systems, ensuring they perform correctly even in the presence of faults.

5. Data Analytics Platform for Reliability

This program leverages data analytics to enhance the reliability of systems. By analyzing large datasets, this program aims to identify patterns and insights that can be used to improve the design, operation, and maintenance of systems, ultimately leading to more reliable and safe products and infrastructure.

Applications and Impact

The research conducted at CAiRS has broad applications across various industries, including:

- Public Utilities
- Advanced Manufacturing
- Electronics
- Consumer Products
- Power Systems
- Transportation

These applications are crucial for the development of smart cities and smart manufacturing, positioning Hong Kong as a leader in producing high-quality, reliable, and safe products.

Reliability study in Product Life Cycle (PLC)

The Reliability Service in the Product Life Cycle encompasses several critical phases to ensure product longevity and performance.

During the **Design phase**, we focus on selecting appropriate parts, applying component derating practices, and conducting Failure Mode and Effects Analysis (FMEA) to preemptively address potential failures.

In the **Testing phase**, we perform Accelerated Life Testing (ALT) and qualification testing to assess product reliability under extreme conditions.

The **Manufacturing phase** involves rigorous process monitoring, control, and burn-in tests to identify and eliminate faulty components.

Once deployed, the **Deployment phase** includes ongoing health monitoring, diagnostics, and predictive maintenance to sustain product performance.

Finally, at the **End-of-Life (EOL)** phase, we conduct root-cause failure analysis and assist with the reuse, recycling, and disposal of the product. This comprehensive approach ensures that products are reliable, safe, and sustainable throughout their lifecycle.

Reliability study in Product Life Cycle (PLC)

Phase 2: Testing

We conduct the design and development of reliability test plans, including accelerate life testing (ALT) to root failure causes and estimate the product lifespan.



Phase 3: Manufacturing

At the manufacturing phase, we provide process monitoring and control, screening, and burn-in test to ensure product reliability.



Phase 5: End-of-Life (EOL)

At the end-of-life, we provide root-cause failure analysis and assist with the reuse, recycling, and disposal.



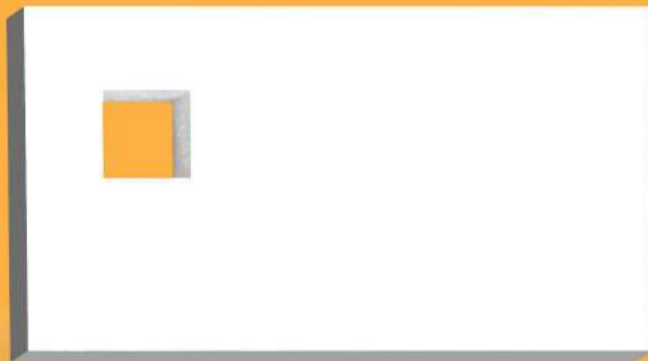
Phase 1: Design

We provide design for reliability services such as part selection for intended applications, component derating, Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), etc.



Phase 4: Deployment

The product in the field is continuously evaluated to determine it meets its reliability goals. We provide health monitoring with anomaly detection, prognostic studies and predictive maintenance.



CAiRS Solution

CaiRSGPT: Reliability and Safety Chatbot

MotorGuard: Revolutionizing Motor Maintenance with AI and Expert Knowledge

WireInspect: Revolutionizing Wire Inspection with Advanced Technology

ClearParkVision: Revolutionizing Car Park Management with AI-Powered Technology

Circuit Breaker Guard AI: Revolutionizing Maintenance with Advanced Diagnostics

CablePrognosis: Ensuring the Health and Safety of Underground Power Cables

LithioGuardian: Advanced Battery Health Monitoring with FBG Sensors

RoboGuide: Transforming Facility Management with Advanced Robotics

SolderSense: Advancing PCB Soldering Defect Detection

Accelerated Life Testing (ALT): Ensuring Product Reliability and Safety

Failure Prediction of Power Electronics: Enhancing Reliability and Safety

RailSwinX: Revolutionizing Defect Detection in Railway Tracks

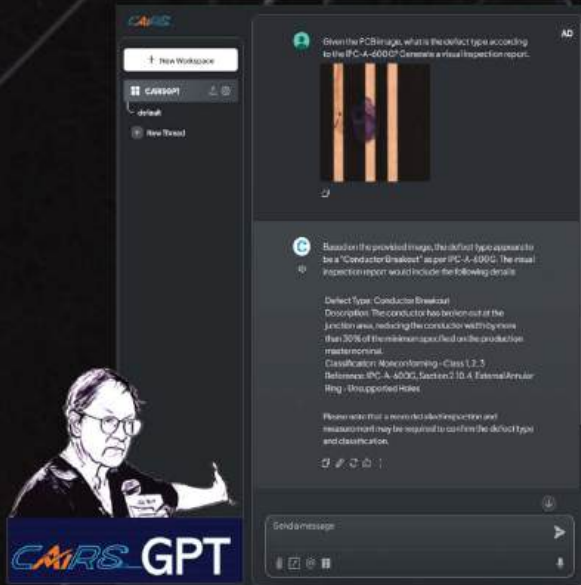
ReliabilityTwin: Revolutionizing Predictive Maintenance for Cyber-Physical Systems



CAiRSGPT

Revolutionizing Reliability Design and Predictive Maintenance with Multimodal AI

In the fast-evolving field of engineering, ensuring system reliability and safety is crucial. Many organizations, particularly in Hong Kong, struggle with a lack of expertise in reliability engineering. To bridge this gap, we introduce CAiRSGPT, an innovative chatbot that harnesses the power of multimodal large language models to support reliability and maintenance engineers in Reliability Design and Predictive Maintenance.



CAiRSGPT dashboard

Core Capabilities of CAiRSGPT

CAiRSGPT is powered by state-of-the-art AI technology that integrates large language models with multimodal capabilities. This synergy enables the chatbot to:

- **Retrieval-Augmented Generation:** Access and distill vast amounts of technical data to provide engineers with the most current and relevant insights on reliability design and maintenance.
- **Multimodal Processing:** Combine text-based data analysis with images in the predictive maintenance phase to deliver comprehensive insights—from sensor signals to system performance data.
- **User-Friendly Interface:** Designed with engineers in mind, CAiRSGPT offers a simple yet powerful interface, simplifying the process of solving complex reliability issues and streamlining maintenance procedures.

Conclusion

CAiRSGPT represents a breakthrough in reliability design and predictive maintenance. By combining multimodal AI with advanced large language models, it furnishes engineers with the tools necessary for both designing dependable systems and executing proactive maintenance. As engineering challenges evolve in Hong Kong and across the globe, CAiRSGPT stands ready to help engineers build and maintain systems that are not only innovative but also inherently reliable.

Enhancing Reliability Design

CAiRSGPT is designed to support engineers in developing systems that are both robust and reliable. By integrating state-of-the-art AI technology with a deep understanding of technical documents, the chatbot provides:

- **Accurate Technical Insights:** Retrieve and analyze technical documents, scholarly articles, and design regulations that inform reliability design strategies.
- **Best Practice Recommendations:** Generate human-like responses that offer design guidelines and recommendations, reducing the risk of system failures during the development phase.

Driving Proactive Maintenance

Beyond design, CAiRSGPT excels in the realm of predictive maintenance—ensuring that systems remain in optimal condition throughout their lifecycle. Its multimodal capabilities enable it to:

- **Predict System Failures:** Utilize sensor data, historical records, and visual inspections to forecast potential issues before they become critical.
- **Integrated Maintenance Solutions:** Support decision-making by retrieving up-to-date maintenance strategies and integrating with advanced analytical tools for detailed reliability assessments.

Benefits of Using CAiRSGPT

- **Improved System Robustness:** By adhering to best design practices and relying on comprehensive technical data, CAiRSGPT helps engineers build systems that resist failure.
- **Reduced Downtime:** With proactive maintenance strategies and early fault detection, engineers can prevent costly downtimes and extend the lifespan of critical systems.
- **Cost Efficiency:** Lower the costs associated with unexpected system failures, extensive testing, and reactive repairs, all while ensuring high safety standards.
- **Data-Driven Decision Making:** Leverage actionable insights derived from a rich database of technical resources to make informed choices during both the design and maintenance phases.

Future Developments

As we continue to refine CAiRSGPT, our objectives include:

- **Deeper Integration with Real-Time Sensor Data:** Providing instant feedback on system performance.
- **Enhanced Visual Processing:** Improving the analysis of technical schematics and maintenance visuals to further strengthen quality control measures.
- **Broader Knowledge Base:** Expanding both textual and visual datasets to deliver more comprehensive support for innovative reliability and maintenance initiatives.

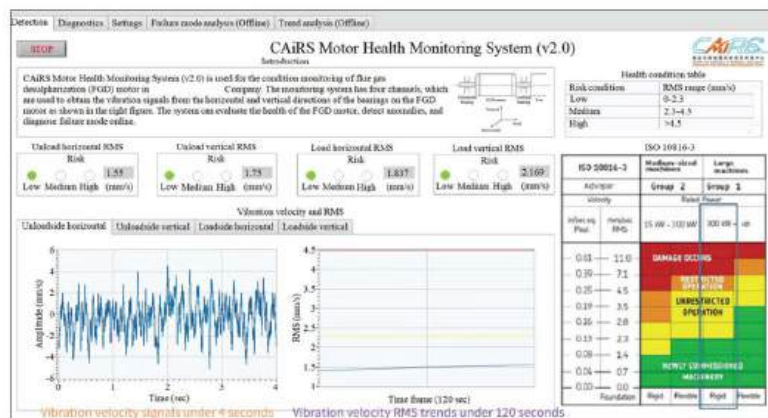
By remaining at the forefront of multimodal AI technology, we aim to equip engineers with the most advanced tools for reliability, quality control, and predictive maintenance.



MotorGuard

Revolutionizing Motor Maintenance with AI and Expert Knowledge

Maintaining industrial motors is a critical task that traditionally relies on regular inspections by experienced engineers. However, this approach is increasingly challenged by a shortage of expertise, time constraints, and high costs. Additionally, the retirement of seasoned professionals makes knowledge transfer more difficult, further complicating maintenance efforts. To address these challenges, we developed MotorGuard, a cutting-edge software product that leverages the physics of failure and machine learning to provide real-time motor anomaly detection and diagnosis.



MotorGuard dashboard

Benefits of MotorGuard

- Enhanced Reliability:** By detecting anomalies early, MotorGuard helps prevent unexpected motor failures, ensuring continuous and reliable operation.
- Cost Efficiency:** Reducing the need for frequent manual inspections and minimizing downtime leads to significant cost savings.
- Time Savings:** Real-time monitoring and diagnostics streamline the maintenance process, allowing engineers to focus on critical tasks.
- Knowledge Retention:** The expert knowledge database ensures that valuable insights and best practices are preserved and accessible, even as experienced professionals retire.
- Proactive Maintenance:** MotorGuard enables a shift from reactive to proactive maintenance, improving overall efficiency and effectiveness.

Conclusion

MotorGuard represents a significant advancement in the field of motor maintenance. By leveraging the physics of failure and machine learning, it provides a robust solution for real-time anomaly detection and diagnosis. The integration of an expert knowledge database further enhances its capabilities, ensuring that engineers have access to the information they need to maintain motors effectively. As industries continue to face challenges related to expertise shortages and knowledge transfer, MotorGuard stands as a vital tool for ensuring the reliability and efficiency of industrial motors.

The project, MotorGuard has won a Bronze Medal at the Geneva Inventions 2024.

Introducing MotorGuard

MotorGuard is designed to overcome these challenges by integrating advanced technologies and expert knowledge into a single, powerful tool. Here's how it works:

- Real-Time Anomaly Detection:** MotorGuard continuously monitors motor performance, using machine learning algorithms to detect anomalies in real-time. This proactive approach ensures that potential issues are identified early, before they lead to failures.
- Diagnosis and Insights:** The tool not only detects anomalies but also provides detailed diagnostics, helping engineers understand the root causes of issues and take appropriate action.
- Expert Knowledge Database:** MotorGuard integrates a comprehensive knowledge database that combines operational data, lab experiments, and insights from industry experts. This database serves as a valuable resource for conducting motor inspections and diagnostics.

The Challenges of Traditional Motor Maintenance

Traditional motor maintenance involves periodic inspections and diagnostics performed by skilled engineers. While effective, this method faces several significant challenges:

- Shortage of Expertise:** There is a growing gap in the availability of experienced engineers, making it difficult to maintain motors effectively.
- Time Constraints:** Regular inspections are time-consuming and can lead to operational downtime.
- High Costs:** The cost of manual inspections and the potential for missed issues can be substantial.
- Knowledge Transfer:** As experienced professionals retire, the transfer of critical knowledge becomes increasingly difficult.

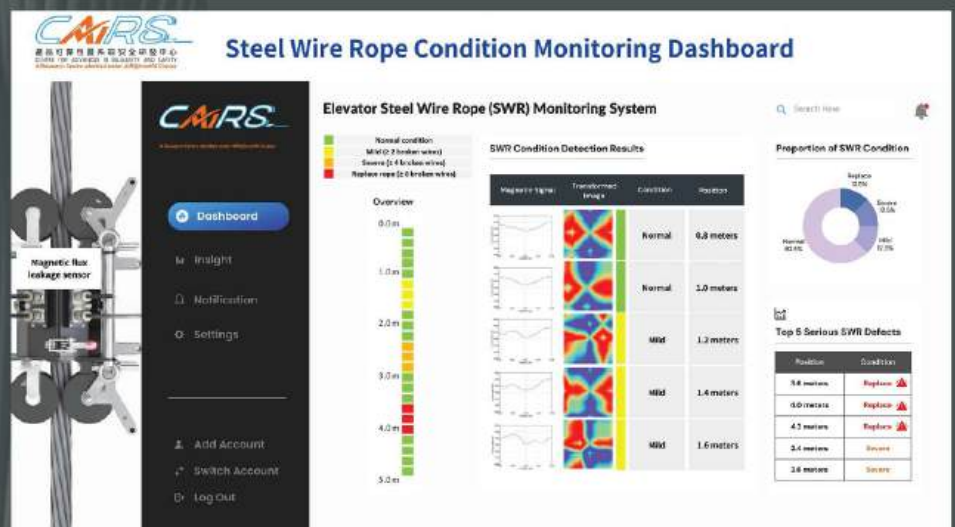
WireInspect

Revolutionizing Wire Inspection with Advanced Technology

Defects in wire systems can lead to severe accidents, as evidenced by a recent incident in Hong Kong where four broken ropes caused seven injuries in an elevator just over 100 days after a routine check. Traditional inspection methods, which rely heavily on human judgment, are prone to errors due to insufficient training and tight schedules, often resulting in missed defects. Although nondestructive testing sensors are available, local contractors are hesitant to adopt them due to the complexities in interpreting sensor data and the lack of training samples for machine learning models.

Introducing WireInspect

To address these challenges, we developed WireInspect, an automatic inspection system that employs sensors to detect magnetic flux leakage. This innovative system combines a deep understanding of the physics of wire degradation with advanced machine learning models to identify anomalies, significantly improving the accuracy and reliability of wire inspections.



Key Features of WireInspect

- Magnetic Flux Leakage Detection:** WireInspect uses sensors to detect magnetic flux leakage, a reliable indicator of wire defects. This method allows for precise identification of anomalies that might be missed by traditional inspection techniques.
- Physics of Failure Integration:** By incorporating a physics of failure approach, WireInspect understands the underlying mechanisms of wire degradation, enhancing its ability to predict and identify potential defects.
- Machine Learning Models:** Advanced machine learning algorithms analyze the sensor data to detect anomalies. These models are trained using a mix of onsite measurements, lab samples, and synthetic data, ensuring robustness and accuracy.
- Uncertainty Awareness:** One of the standout features of WireInspect is its uncertainty awareness approach, which allows the system to identify new and previously unseen defects. This capability represents a significant advancement over existing methods.

WireInspect dashboard

Benefits of WireInspect

- Reduced False Negatives:** In comparison to existing technologies, WireInspect has reduced false negatives in defect detection by 89%. This improvement ensures that more defects are accurately identified and addressed.
- Enhanced Safety:** By providing more reliable and accurate inspections, WireInspect helps prevent accidents and enhances the overall safety of wire systems.
- Efficiency and Reliability:** The automatic and continuous monitoring capabilities of WireInspect reduce the reliance on human judgment, leading to more consistent and reliable inspections.
- Ease of Adoption:** Despite the advanced technology, WireInspect is designed to be user-friendly, making it easier for local contractors to adopt and integrate into their existing workflows.

Conclusion

WireInspect represents a significant leap forward in the field of wire inspection. By combining magnetic flux leakage detection with a deep understanding of wire degradation and advanced machine learning models, it offers a robust and reliable solution for identifying wire defects. The system's ability to reduce false negatives and its uncertainty awareness approach ensure that even the most elusive defects are detected, enhancing the safety and reliability of wire systems. As the demand for safer and more efficient inspection methods grows, WireInspect stands out as a vital tool for the future of wire inspection.

The project, WireInspect has won a Silver Medal at the Geneva Inventions 2024.

ClearParkVision

Revolutionizing Car Park Management with AI-Powered Technology

In the dynamic world of car park management, ClearParkVision emerges as a cutting-edge AI-powered solution designed to transform operations. Equipped with advanced license plate recognition technology, ClearParkVision seamlessly captures and processes vehicle license plate numbers at entry and exit points, ensuring accurate gate operations for a smooth and efficient user experience.



ClearParkVision Detection

Advanced Vehicle Access Control

ClearParkVision's core strength lies in its ability to manage vehicle access with unparalleled precision. Utilizing state-of-the-art license plate recognition technology, the system swiftly identifies and processes license plate numbers, triggering gate operations without delay. This enhances the user experience by streamlining traffic flow within the car park, reducing congestion and wait times.

Robust Anomaly Detection

Beyond its impressive access control capabilities, ClearParkVision excels in anomaly detection. The system identifies and addresses various issues that could compromise its performance, such as camera view contamination by dust, obstruction by obstacles, or shifts in alignment and rotation. This proactive approach ensures optimal system performance and security at all times.

AI Vehicle Presence Detection

ClearParkVision leverages AI to detect vehicle presence at the gate, eliminating the need for costly loop detectors. This intelligent detection system improves efficiency and reduces infrastructure expenses, making it a cost-effective solution for car park management.

Enhancing Operational Efficiency and Security

ClearParkVision's robust capabilities extend beyond access control and anomaly detection. By enhancing the operational efficiency, reliability, and safety of car parks, the system delivers a superior experience for both operators and users. Car park operators benefit from reduced maintenance needs and improved system uptime, while users enjoy a hassle-free parking experience.

Conclusion

In conclusion, ClearParkVision is not just an AI-powered solution; it is a comprehensive system designed to revolutionize car park management. With its advanced technology and robust features, ClearParkVision sets a new standard for efficiency, reliability, and security in car park operations.

Circuit Breaker Guard AI

Revolutionizing Maintenance with Advanced Diagnostics

Circuit breakers are essential components in electrical systems, designed to protect against component failures and disturbances such as overcurrent, overload, and short circuits. Traditionally, the maintenance of circuit breakers has relied on regular inspections, which can be inefficient and sometimes ineffective. To address these challenges, we have developed an innovative approach that leverages the fusion of physics of failure, artificial intelligence (AI), and signal processing to enhance the maintenance and reliability of circuit breakers.

The Role of Circuit Breakers

Circuit breakers play a critical role in safeguarding electrical systems by interrupting the flow of electricity in the event of a fault. This prevents damage to the system and ensures the safety of both the equipment and personnel. However, the effectiveness of circuit breakers depends on their timely maintenance and accurate diagnosis of potential issues.



Online Circuit Breaker dashboard

Challenges in Traditional Maintenance

Traditional maintenance practices for circuit breakers primarily involve scheduled inspections. While this approach ensures regular checks, it has several drawbacks:

1. **Risk of Missed Issues:** Serious problems may develop between scheduled inspections, leading to unexpected failures.
2. **Inefficiency:** Regular inspections can be a waste of manpower and resources if no issues are found.
3. **Reactive Maintenance:** This approach often leads to reactive maintenance, where issues are addressed only after they have occurred.

Innovative Fusion Approach

To overcome these challenges, we have adopted a fusion approach that combines the physics of failure, AI, and signal processing. This advanced method focuses on assessing trip coil waveform signals in circuit breakers to detect degradation trends and plan maintenance proactively.

1. **Physics of Failure:** This aspect involves understanding the mechanisms that lead to the failure of circuit breakers. By identifying these mechanisms, we can predict potential failures before they occur.
2. **Artificial Intelligence:** AI algorithms analyze the trip coil waveform signals to detect patterns and anomalies that indicate degradation. This allows for more accurate and timely predictions of maintenance needs.
3. **Signal Processing:** Advanced signal processing techniques are used to extract meaningful information from the waveform signals, enhancing the accuracy of the diagnostics.

Benefits of the Fusion Approach

Our fusion approach offers several significant advantages over traditional maintenance methods:

- **Improved Accuracy:** By analyzing trip coil waveform signals, we can detect degradation trends with greater accuracy, reducing the risk of unexpected failures.
- **Proactive Maintenance:** This approach enables proactive maintenance, addressing potential issues before they lead to failures.
- **Cost Savings:** Our method outperforms existing maintenance practices by over 90%, resulting in substantial cost savings.
- **Efficient Resource Utilization:** By targeting maintenance efforts based on accurate diagnostics, we can optimize the use of manpower and resources.

Conclusion

The development of the online circuit breaker diagnostic tool marks a significant advancement in the field of electrical system maintenance. By integrating the physics of failure, AI, and signal processing, we have created a robust and efficient method for predicting the health of circuit breakers and planning maintenance proactively. This innovative approach not only enhances the reliability and safety of electrical systems but also offers considerable cost savings and resource efficiency. As we continue to refine and expand this technology, the future of circuit breaker maintenance looks brighter and more reliable than ever.



CablePrognosis

Ensuring the Health and Safety of Underground Power Cables

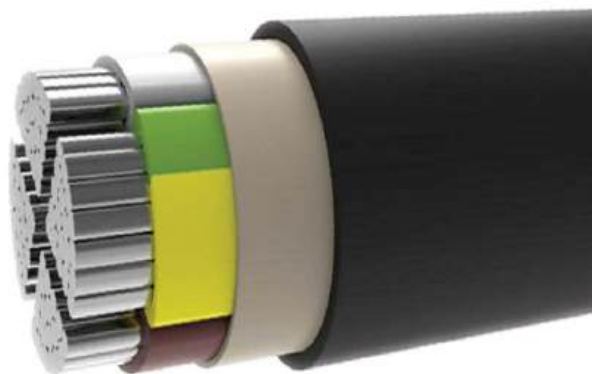
Underground power cables are critical components of modern infrastructure, responsible for delivering electricity safely and efficiently. However, their concealed nature makes it challenging to monitor their condition and predict potential failures. CablePrognosis addresses this challenge by providing a comprehensive diagnostic tool designed to assess and predict the health of underground power cables, thereby enhancing safety and reliability.

The Functionality of CablePrognosis

CablePrognosis utilizes a sophisticated health index system that evaluates the condition of underground power cables based on various operating parameters. These parameters include:

- **Capacitance:** Measures the ability of the cable to store electrical charge.
- **Resistance:** Indicates the opposition to the flow of electric current.
- **Geometry:** Refers to the physical dimensions and structure of the cable.
- **Cable Specification:** Includes details such as material composition, insulation type, and manufacturing standards.

By analyzing these parameters, CablePrognosis can accurately determine the health condition of the cables.



Health Index System

The health index system is a core feature of CablePrognosis. It categorizes the condition of underground power cables into three distinct categories:

1. **Healthy:** Cables that are in good condition and do not require immediate attention.
2. **To Be Monitored:** Cables that show signs of potential issues and need regular monitoring to prevent deterioration.
3. **Requiring Maintenance:** Cables that exhibit significant wear or damage and need immediate maintenance to prevent failures. This categorization allows utility companies to prioritize maintenance efforts and allocate resources effectively.

This categorization allows utility companies to prioritize maintenance efforts and allocate resources effectively.

Benefits of CablePrognosis

1. **Enhanced Safety:** By predicting potential failures, CablePrognosis helps prevent power outages, fires, and explosions caused by underground cable failures.
2. **Proactive Maintenance:** The health index system enables proactive maintenance, reducing the likelihood of unexpected failures and extending the lifespan of the cables.
3. **Cost Efficiency:** Early detection of issues allows for timely interventions, minimizing repair costs and preventing costly downtime.
4. **Improved Reliability:** Ensuring the health of underground power cables enhances the overall reliability of the power distribution network.

Reducing Power Outages and Hazards

One of the most significant advantages of CablePrognosis is its ability to reduce the occurrence of power outages and hazards associated with underground cable failures. By continuously monitoring the condition of the cables and providing accurate health assessments, CablePrognosis enables utility companies to take preventive measures before issues escalate into major problems. This proactive approach not only enhances the safety of the power distribution network but also ensures a more reliable supply of electricity to consumers.

Conclusion

CablePrognosis represents a significant advancement in the field of power cable diagnostics. By leveraging a health index system that evaluates key operating parameters, it provides a reliable and accurate assessment of the condition of underground power cables. This innovative tool helps utility companies enhance safety, improve reliability, and reduce maintenance costs. As the demand for reliable power distribution continues to grow, CablePrognosis stands as a vital solution for ensuring the health and safety of underground power cables.

The project, CablePrognosis won a Gold Medal at the Geneva Inventions 2024.

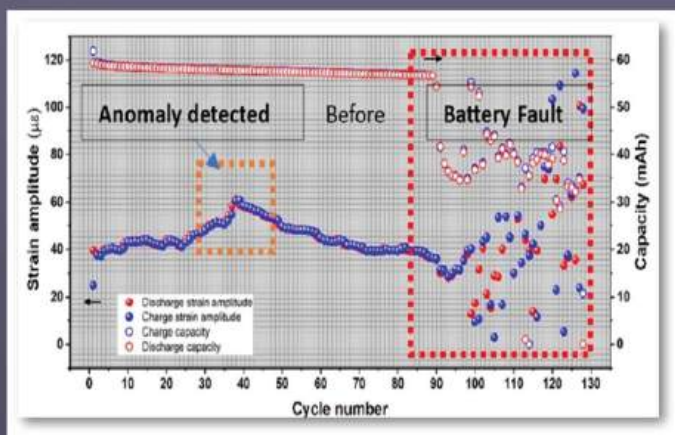
LithioGuardian

Advanced Battery Health Monitoring with FBG Sensors



In the quest for safer and more reliable battery systems, innovative monitoring techniques are essential. LithioGuardian represents a significant advancement in this field, utilizing Fiber Bragg Grating (FBG) sensors to provide detailed insights into the health of battery cells. This cutting-edge technology offers a proactive approach to battery management, ensuring early detection of potential issues that conventional Battery Management Systems (BMS) might miss.

LITHIUM-ION



Prediction of battery fault from detected anomaly

The Role of FBG Sensors

FBG sensors are highly sensitive devices that can be attached to the surface of battery cells or integrated within them. LithioGuardian employs a dual-sensor configuration, comprising Single-Mode Fiber (SMF) and Plastic Optical Fiber (POF), to monitor both strain and temperature profiles at a microscopic level. This dual-sensor setup allows for comprehensive monitoring of the battery's physical state, providing critical data that can be used to predict and prevent failures.

Benefits of LithioGuardian

- 1. Early Detection of Issues:** By monitoring strain and temperature at a microscopic level, LithioGuardian can detect abnormal profiles before they lead to battery failure.
- 2. Enhanced Safety:** Early warning signals allow for timely intervention, reducing the risk of catastrophic failures such as fires or explosions.
- 3. Proactive Maintenance:** Continuous online health monitoring enables proactive maintenance strategies, extending the lifespan of battery systems.
- 4. Improved Reliability:** By providing detailed insights into battery health, LithioGuardian enhances the overall reliability of battery-powered systems.

Sensing Battery Strain and Temperature

The ability to sense both strain and temperature is crucial for understanding the health of battery cells. Strain measurements can indicate mechanical stress or deformation, while temperature profiles can reveal thermal anomalies. By carefully assessing these parameters, LithioGuardian can identify abnormal profiles that may signal impending battery failure. These abnormalities often go undetected by conventional BMS, making LithioGuardian an invaluable tool for advanced battery health monitoring.

Applications of LithioGuardian

LithioGuardian can be employed in various applications where battery reliability and safety are paramount. These include:

- Electric Vehicles (EVs):** Ensuring the safety and longevity of battery packs in EVs.
- Energy Storage Systems:** Monitoring large-scale battery installations used for grid storage.
- Consumer Electronics:** Enhancing the safety and performance of batteries in smartphones, laptops, and other devices.
- Industrial Applications:** Providing reliable power for critical industrial equipment and machinery.

Conclusion

LithioGuardian represents a significant leap forward in battery health monitoring technology. By leveraging the advanced capabilities of FBG sensors, it offers a detailed and proactive approach to battery management. The dual-sensor configuration allows for precise monitoring of strain and temperature, providing early warning signals that conventional BMS might miss. As the demand for reliable and safe battery systems continues to grow, LithioGuardian stands out as a vital tool for ensuring the health and safety of battery-powered applications.

The project, LithioGuardian has won a Gold Medal at the Geneva Inventions 2024.



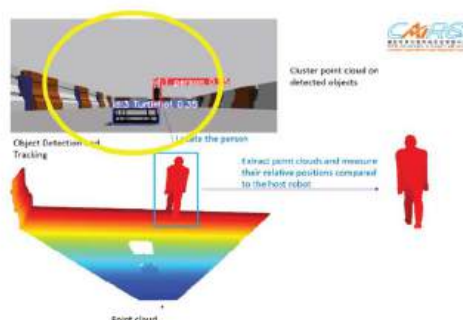
RoboGuide

Transforming Facility Management with Advanced Robotics

In the ever-evolving landscape of property and facility management, the adoption of advanced technologies is crucial for enhancing efficiency and safety. RoboGuide is at the forefront of this transformation, offering innovative intruder and object detection solutions that leverage the power of robotics. This cutting-edge research is designed to automate labor-intensive, repetitive, and tedious tasks, exemplifying efficiency and providing real-time anomaly signals around the clock.

The Vision Behind RoboGuide

RoboGuide is developed with the vision of revolutionizing the property and facility management industry. By integrating advanced robotics into daily operations, RoboGuide aims to shift the paradigm towards more automated and efficient processes. This approach not only saves human labor but also ensures continuous monitoring and rapid response to any anomalies.



Tracking distance and velocity



Hazardous Object Detection

Key Features of RoboGuide

- 1. Intruder and Object Detection:** RoboGuide employs sophisticated sensors and algorithms to detect intruders and objects within a facility. This capability enhances security and ensures that any unauthorized access is promptly identified and addressed.
- 2. 24/7 Real-Time Monitoring:** The system provides continuous monitoring, delivering real-time anomaly signals to the facility management control room. This ensures that any issues are detected and resolved immediately, minimizing potential risks.
- 3. Labor Efficiency:** By automating repetitive and tedious tasks, RoboGuide frees up human resources for more strategic and complex activities. This leads to significant labor savings and improved operational efficiency.
- 4. End-to-End Automation:** RoboGuide is designed as a fully end-to-end automatic process, from detection to alerting and response. This seamless integration ensures that the system operates efficiently with minimal human intervention.

Benefits of RoboGuide

- 1. Enhanced Security:** Continuous monitoring and advanced detection capabilities ensure that facilities are secure at all times.
- 2. Operational Efficiency:** Automating labor-intensive tasks leads to significant improvements in operational efficiency and resource utilization.
- 3. Cost Savings:** Reducing the need for manual labor and minimizing risks associated with intrusions and anomalies result in substantial cost savings.
- 4. Scalability:** RoboGuide's design allows for easy scalability, making it suitable for a wide range of facilities, from small properties to large industrial complexes.

Social Impact and Commercialization

CAIRS, the organization behind RoboGuide, is committed to developing reliable and safe mobile robots that have a positive social impact. The adoption of RoboGuide in facility management not only enhances security and efficiency but also creates new opportunities for commercialization in the robotics industry. The potential for widespread adoption of RoboGuide is significant, given its ability to address common challenges in property and facility management.

Conclusion

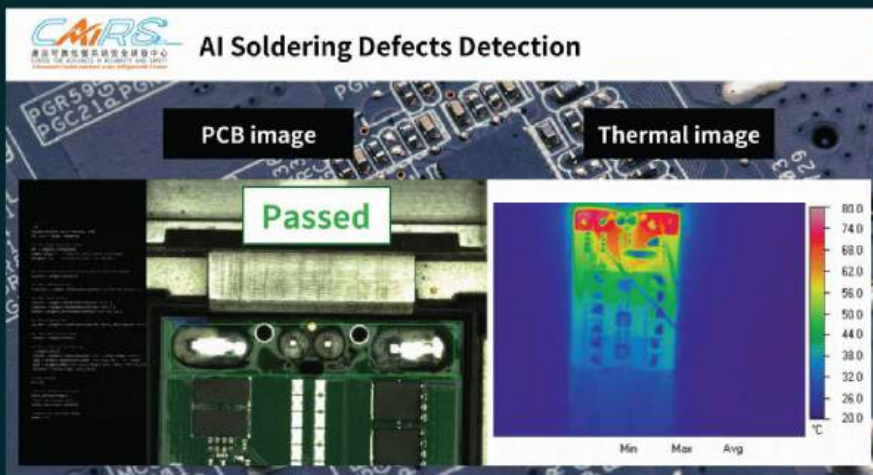
RoboGuide represents a significant advancement in the field of facility management. By integrating advanced robotics and real-time monitoring, it offers a comprehensive solution for enhancing security and efficiency. The system's ability to automate labor-intensive tasks and provide continuous anomaly detection makes it an invaluable tool for property and facility managers. As CAIRS continues to innovate and expand the capabilities of RoboGuide, the future of facility management looks increasingly automated, efficient, and secure.

The project, RoboGuide has won a Silver Medal at the Geneva Inventions 2024.

SolderSense

Advanced Detection and Classification of Soldering Defects via AI-Driven Technology

In the intricate world of electronics manufacturing, ensuring the quality and reliability of printed circuit boards (PCBs) is paramount. One of the critical aspects of this process is the detection of defects in solder joints, which can significantly impact the performance and longevity of electronic devices. Enter SolderSense, a cutting-edge tool designed to revolutionize the detection and classification of soldering defects using advanced imaging techniques.



SolderSense dashboard

The Core Functionality of SolderSense

SolderSense employs a sophisticated camera system to automatically detect PCB soldering regions from various angles and distances. This comprehensive approach ensures that all potential defects are captured, regardless of their location or orientation on the PCB. Once the soldering regions are identified, SolderSense classifies the images into different types of defects, providing detailed insights into the quality of the solder joints.

Benefits of SolderSense

- 1. Comprehensive Detection:** By using cameras at various angles and distances, SolderSense ensures that all soldering regions are thoroughly inspected.
- 2. Detailed Classification:** The tool's ability to classify defects into specific types provides valuable insights for quality control.
- 3. Thermal Imaging Integration:** The use of thermal imaging under high current usage enhances the detection of hidden defects, improving overall reliability.
- 4. High Accuracy:** With an accuracy rate of over 85%, SolderSense offers a dependable solution for defect prediction.
- 5. Proactive Maintenance:** Early detection of defects allows for proactive maintenance, reducing downtime and improving product quality.

Conclusion

SolderSense represents a significant advancement in the field of PCB manufacturing. By combining advanced imaging techniques with robust defect classification algorithms, it provides a comprehensive solution for detecting and predicting soldering defects. The integration of thermal imaging further enhances its capabilities, ensuring that even the most elusive defects are identified. With its high accuracy and detailed analysis, SolderSense is poised to become an essential tool for ensuring the quality and reliability of electronic devices.

Defect Classification and Inference

The tool's ability to classify defects is powered by advanced image processing algorithms. SolderSense can output inference results with predicted labels, indicating the specific types of defects present in the soldering regions. This detailed classification helps engineers quickly identify and address issues, ensuring that only high-quality PCBs move forward in the production process.

SolderSense System and Patent

Building on the capabilities of the SolderSense tool, a comprehensive system has been developed and patented (HK Patent - HK30094933). This system integrates camera-based thermal imaging under high current usage, providing an additional layer of analysis for detecting and predicting failure mechanisms in solder joints. The use of thermal imaging allows SolderSense to identify defects that may not be visible through standard imaging techniques, such as internal voids or thermal fatigue.

High Accuracy in Defect Prediction

One of the standout features of SolderSense is its impressive accuracy. The system can predict soldering defects with an accuracy of over 85%, making it a reliable tool for quality assurance in PCB manufacturing. This high level of accuracy ensures that potential failures are detected early, reducing the risk of defective products reaching the market.

This project won a Silver Medal at the Geneva Inventions 2024. It is widely applicable to all types of PCBs, especially those in high-power applications and it could be extended to electrical failure detection.

Accelerated Life Testing (ALT):

Ensuring Product Reliability and Safety

In the realm of reliability engineering and product lifecycle management, Accelerated Life Testing (ALT) plays a crucial role. This research methodology is designed to ensure that products meet their reliability requirements while minimizing time-to-market and costs. By simulating the stresses and strains that products will encounter over their lifetime in a shorter period, ALT provides valuable insights into potential failure modes, their causes, and mechanisms.

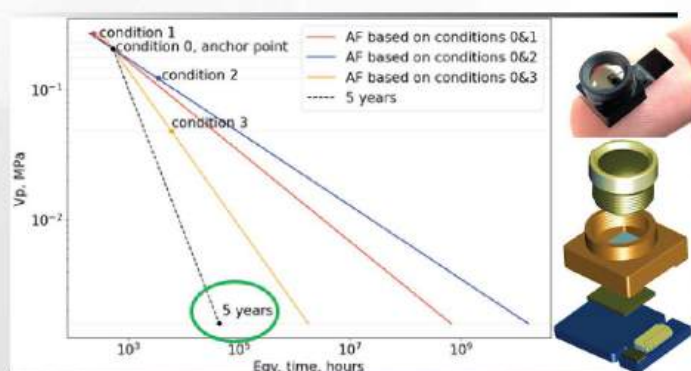
The Importance of ALT

Unanticipated product failures can have severe consequences, including costly recalls, significant financial losses, and damage to a company's reputation. ALT helps mitigate these risks by identifying potential issues before products reach the market. This proactive approach allows companies to make informed decisions about design changes, material selection, and manufacturing processes, ultimately enhancing product reliability and safety.

How ALT Works

ALT involves subjecting products to accelerated stress conditions, such as increased temperature, humidity, vibration, or electrical load, to induce failures more quickly than under normal operating conditions. The data collected from these tests provide insights into how products degrade over time and help predict their remaining useful life. Key steps in ALT include:

- 1. Identifying Stress Factors:** Determining the environmental and operational stresses that the product will encounter during its lifecycle.
- 2. Designing Test Protocols:** Creating test protocols that simulate these stresses in an accelerated manner.
- 3. Conducting Tests:** Subjecting the product to the accelerated stress conditions and monitoring its performance.
- 4. Analyzing Data:** Analyzing the data to identify failure modes, their causes, and mechanisms.
- 5. Implementing Improvements:** Using the insights gained to make design changes, select better materials, or modify manufacturing processes.



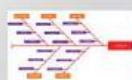
Useful life exceeds five years

Benefits of ALT

- 1. Enhanced Reliability:** By identifying potential failure modes early, companies can take steps to eliminate or reduce the likelihood of these failures, ensuring that products are reliable and safe for consumer, commercial, and industrial applications.
- 2. Cost Savings:** ALT helps avoid costly recalls and repairs by addressing potential issues before products are released to the market.
- 3. Reduced Time-to-Market:** Accelerating the testing process allows companies to bring products to market more quickly without compromising on reliability.
- 4. Regulatory Compliance:** Ensuring product reliability and safety helps companies avoid costly litigation and regulatory repercussions.
- 5. Improved Customer Satisfaction:** Reliable products lead to higher customer satisfaction and loyalty, enhancing a company's reputation and market position.

Reliability Research Output

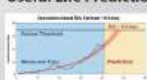
Physics of Failure Analysis



System Reliability Analysis



Remaining Useful Life Prediction



AI Model Prediction



Accelerated Life Testing (ALT) process

Applications of ALT

ALT is widely used across various industries, including:

- Automotive:** Testing components such as engines, transmissions, and electronic systems to ensure they can withstand the rigors of daily use.
- Electronics:** Evaluating the durability of consumer electronics, such as smartphones and laptops, under accelerated stress conditions.
- Aerospace:** Ensuring the reliability of critical components in aircraft and spacecraft.
- Renewable Energy:** Testing the longevity of solar panels, wind turbines, and other renewable energy systems.

Conclusion

Accelerated Life Testing (ALT) is an indispensable tool in the field of reliability engineering. By simulating the stresses that products will encounter over their lifetime, ALT provides valuable data on potential failure modes and their causes. This information allows companies to make informed decisions about design changes, material selection, and manufacturing processes, ensuring that products are reliable and safe for their intended applications. As a result, ALT helps companies avoid costly recalls, reduce time-to-market, and enhance customer satisfaction, ultimately contributing to their long-term success.

Failure Prediction of Power Electronics

Enhancing Reliability and Safety

Power electronics are vital components in renewable energy systems, electric vehicles, and various other applications. Despite their importance, these devices often exhibit relatively high failure rates, particularly in converter systems. Unexpected failures can lead to catastrophic malfunctions and serious safety hazards. To address these challenges, we have developed advanced methods for predicting the failure of power electronics, combining physics-of-failure and machine learning techniques.

The Importance of Power Electronics

Power devices are crucial for the efficient operation of renewable energy systems and electric vehicles. They manage the conversion and control of electrical power, ensuring that systems operate smoothly and efficiently. However, their high failure rates pose significant risks, making reliable failure prediction essential for maintaining safety and performance.

Our Approach to Failure Prediction

To predict the failure of power electronics, we employ a multifaceted approach that includes:

- 1. Physics-of-Failure Methods:** Understanding the fundamental mechanisms that lead to device failure is crucial. By studying these mechanisms, we can identify potential failure modes and develop strategies to mitigate them.
- 2. Machine Learning Models:** We use machine learning to analyze degradation data and develop lifetime prediction models. These models are trained on data collected from accelerated life testing, which simulates the stresses that power devices experience in real-world conditions.
- 3. Accelerated Life Testing:** This testing method involves subjecting power devices to high levels of stress to accelerate their aging process. The data collected from these tests provide valuable insights into the degradation patterns of the devices.

Superior Performance and Future Directions

Our developed models have demonstrated superior performance compared to conventional methods, providing more accurate predictions of the remaining useful life of power devices. This enhanced accuracy helps prevent unexpected failures and ensures the reliability and safety of power electronics.

Advanced Testing and Analysis Tools

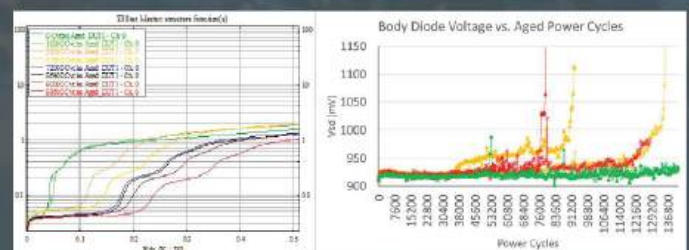
Our lab is equipped with state-of-the-art tools to support our research:

- 1. Power Tester:** The first and only Power Tester in Hong Kong, capable of supplying up to 1500 A current for power cycling and handling various types of power devices. This tester measures transient thermal data and electrical characteristics, which are crucial for identifying precursors to failure.
- 2. Curve Tracer:** Used to measure electrical characteristics and identify early signs of degradation.
- 3. Non-Destructive Failure Analysis Tools:** Including the X-ray Microscope and Scanning Acoustic Microscope, these tools detect delamination or wire bond movements inside the device package. These inspections help us understand the physics-of-failure and provide data for our machine learning models.

Conclusion

The failure prediction of power electronics is a critical area of research that has significant implications for the safety and reliability of renewable energy systems, electric vehicles, and other applications. By combining physics-of-failure methods, machine learning, and advanced testing tools, we are developing robust models that provide accurate predictions of device lifetimes. As we continue to expand our research, we aim to further enhance the reliability and safety of power electronics, contributing to the advancement of these vital technologies.

Results and Findings



Thermal and electrical precursor parameters



AI-based prediction results



Scanning electron microscopy and focused ion beam (FIB) cross-section



Scanning acoustic microscopy (SAM)

Expanding Research

While our research has primarily focused on discrete devices, we are now expanding to more complex and higher power modules. Additionally, we are developing digital twins of third-generation power devices. These digital twins will provide virtual representations of physical devices, allowing for more detailed analysis and prediction of their behavior under various conditions.



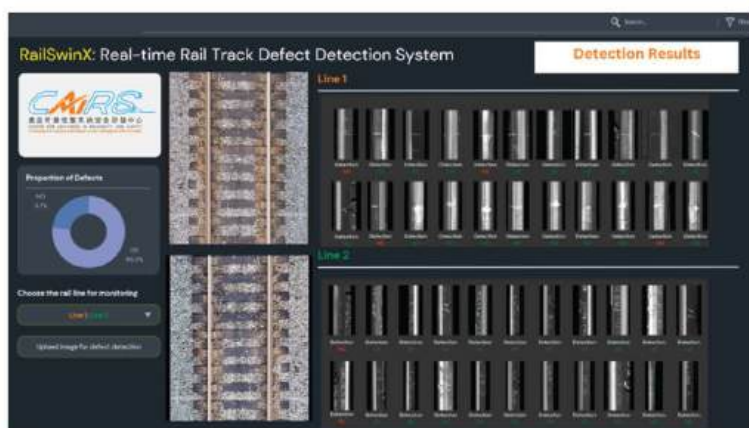
RailSwinX

Enhanced Steel Surface and Rail Track Defect Detection Through Cutting-Edge AI Technology

In the realm of infrastructure maintenance, the ability to accurately detect defects is crucial for ensuring safety and reliability. **RailSwinX** is at the forefront of this innovation, offering a cutting-edge solution for defect detection on steel surfaces and railway track images. By leveraging the advanced capabilities of the Cascade Swin Transformer model, RailSwinX sets a new standard in defect detection technology.

The Power of the Cascade Swin Transformer

The **Swin Transformer model** is renowned for its superior feature extraction capabilities. Unlike traditional convolutional neural networks (CNNs), the Swin Transformer employs a **self-attention mechanism** that enhances its ability to detect defects with greater accuracy. This model excels in defect detection tasks due to its ability to focus on relevant features while ignoring irrelevant noise. Our **Cascade Swin Transformer model** – a cutting-edge development and patented innovation (HK30096108 A) – takes this capability a step further by reducing false alarm rates and improving the accuracy of rail track defect detection.



RailSwinX dashboard

Key Features and Advantages

- 1. Self-Attention Mechanism:** The self-attention mechanism allows the model to weigh the importance of different parts of the input data, leading to more precise defect detection.
- 2. Hierarchical Architecture:** The hierarchical structure of the Swin Transformer reduces computational demands while boosting performance. This architecture processes data at multiple levels, capturing both local and global features.
- 3. Shift Window Attention Mechanism:** This innovative mechanism further enhances the model's ability to detect defects by shifting the attention window, ensuring comprehensive coverage of the input data.
- 4. Accurate Defect Detection:** Our innovative Cascade Swin Transformer model excels at detecting defects in railway track images with exceptional accuracy, minimizing false alarm rates, while ensuring high reliability and preventing potential damage to railway systems.

Benefits of RailSwinX

Enhanced Safety: Accurate defect detection helps prevent accidents and ensures the safety of railway operations.

Proactive Maintenance: By identifying defects early, RailSwinX enables proactive maintenance, reducing downtime and extending the lifespan of railway infrastructure.

Cost Efficiency: Minimizing false alarms and optimizing maintenance schedules lead to significant cost savings.

Improved Performance: The advanced capabilities of the Cascade Swin Transformer model ensure high performance and reliability in defect detection tasks.

Defect/False-Alarm Image Analysis

One of the standout features of RailSwinX is its ability to analyze defective and false-alarm images. This capability ensures that the system not only detects defects accurately but also minimizes the occurrence of false positives. By distinguishing between actual defects and false alarms, RailSwinX enhances the reliability of maintenance operations and reduces unnecessary interventions.

Extending Capabilities to Railway Tracks

Originally designed for detecting defects on steel surfaces, RailSwinX has been extended to analyze railway track images. This extension is particularly significant for the railway industry, where early detection of defects can prevent accidents and ensure the smooth operation of trains. By accurately identifying defects in railway tracks, RailSwinX contributes to proactive maintenance strategies, reducing downtime and enhancing safety.

Conclusion

RailSwinX represents a significant advancement in the field of defect detection. By leveraging the Cascade Swin Transformer model, it offers unparalleled accuracy and reliability in detecting defects on steel surfaces and railway tracks. This innovative solution not only enhances safety and efficiency but also introduces a new era of proactive maintenance in the railway industry. As infrastructure continues to evolve, RailSwinX stands as a testament to the power of advanced AI technology in ensuring the reliability and safety of critical systems. The project, RailSwinX, has won a Gold Medal and a Special Prize from the International Federation of Inventors' Association (IFIA) at the Geneva Inventions 2024. The tool is not only applicable to rail track defects but can also be used for other metal defect detection.

ReliabilityTwin

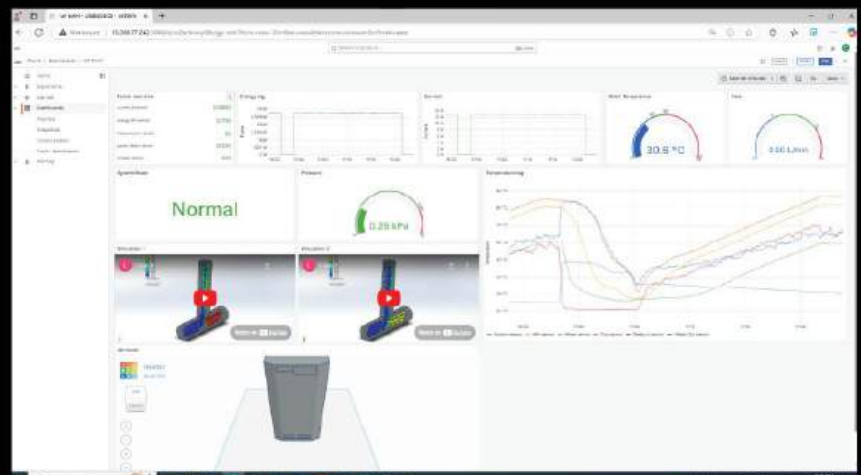
Revolutionizing Predictive Maintenance for Cyber-Physical Systems

In the rapidly evolving technological landscape, the integration of advanced modeling techniques with real-time data has emerged as a critical foundation for enhancing the reliability and efficiency of complex systems. A notable innovation in this domain is **ReliabilityTwin**, a digital twin model that combines physics-based Finite Element Method (FEM) models with real-time Internet of Things (IoT) sensor data. This powerful integration establishes a robust foundation for predictive maintenance. Predictive maintenance is a more advanced approach that has emerged to overcome limitations in reactive maintenance and preventive maintenance—a sophisticated approach designed to address the limitations inherent in reactive and preventive maintenance strategies.

Predictive maintenance employs data-driven methodologies and advanced analytics to anticipate and mitigate failures prior to their occurrence. By collecting and analyzing real-time data from the system, predictive maintenance algorithms can discern patterns and indicators of potential failures. This capability enables maintenance teams to undertake proactive measures, such as scheduling repairs or replacements before breakdowns arise, thereby significantly enhancing the reliability and resilience of complex cyber-physical systems (CPS).

The Core of ReliabilityTwin

At its core, ReliabilityTwin leverages the strengths of FEM models and IoT sensor data. FEM models are extensively recognized for their ability to simulate the physical behavior of structures and materials under various conditions. By integrating these models with real-time data from IoT sensors, ReliabilityTwin delivers a dynamic and highly accurate representation of the physical asset's current state. This integration facilitates continuous monitoring and analysis empowering proactive maintenance strategies.



ReliabilityTwin dashboard

Enhancing Reliability and Resilience

ReliabilityTwin is specifically designed to confront one of the most pressing challenges in CPS: hardware degradation. By continuously monitoring the condition of hardware components and the anticipation of potential failures, ReliabilityTwin mitigates hardware degradation as a cause of systemic failures. This capability is paramount for systems integral to operations, missions, and infrastructure, where any failure may lead to significant consequences.

Key Benefits of ReliabilityTwin

1. **Improved Predictive Accuracy:** The combination of FEM models and real-time IoT data ensures that predictions are based on the most current and accurate information available.
2. **Proactive Maintenance:** By identifying potential issues before they lead to failures, maintenance can be scheduled proactively, reducing unplanned downtime and extending the lifespan of assets.
3. **Cost Efficiency:** Optimizing maintenance schedules and preventing unexpected failures can lead to substantial cost savings.
4. **Enhanced Safety:** Early detection of issues helps prevent accidents, ensuring the safety of operations and personnel.
5. **Operational Efficiency:** Ensuring that systems operate efficiently and effectively enhances overall productivity and performance.

Applications of ReliabilityTwin

ReliabilityTwin is applicable across various industries, including manufacturing, aerospace, energy, and transportation etc. In manufacturing, it can monitor machinery and equipment to prevent breakdowns and optimize production processes. In aerospace, it ensures the reliability of critical aircraft components, thereby enhancing safety and performance. In the energy sector, it monitors infrastructure such as pipelines and power grids, preventing failures that could lead to significant disruptions. In transportation, it maintains the reliability of vehicles and infrastructure, ensuring smooth and efficient operations.

Conclusion

ReliabilityTwin signifies a substantial advancement in the realm of predictive maintenance. By integrating FEM models with real-time IoT sensor data, it offers a comprehensive and dynamic approach to monitoring and maintaining complex cyber-physical systems. This innovative model not only enhances the reliability and resilience of these systems but also ensures they operate efficiently and effectively, ultimately contributing to safer and more cost-effective operations. As industries continue to embrace digital transformation, solutions like ReliabilityTwin will play a pivotal role in shaping the future of maintenance and operational efficiency.

Our Activities



Geneva 2024



CAiRS proudly debuted at the International Exhibition of Inventions Geneva 2024, securing 12 awards, including the prestigious Prize of the International Federation of Inventors' Association (IFIA), 3 gold medals, 4 silver medals, and 4 bronze medals. This milestone highlighted our cutting-edge technologies in reliability and safety. Our team's dedication and advanced AI models were key to this success. Despite being operational for just over four and a half years, CAiRS' achievements have gained global recognition. We extend heartfelt gratitude to our team, researchers, partners, and supporters, and look forward to sharing more innovative work globally.

PolyU Geneva 2024 Press

PolyU won 45 awards at the 49th International Exhibition of Inventions Geneva, including two Special Prizes, five Gold Medals with Congratulations of the Jury, 18 Gold Medals, 13 Silver Medals, and seven Bronze Medals. Among these, 19 awards were from InnoHK research centres' projects. Highlights include the world's first portable High-Definition corneal topographer, which earned the Prize of the Saudi Arabian Delegation and a Gold Medal, and RailSwinX by CAiRS, which won the Prize of the International Federation of Inventors' Association (IFIA) and a Gold Medal. Professor Christopher Chao praised the teams, emphasizing their global impact and commitment to innovation.



Hong Kong R&D achievements shine at international I&T arena press

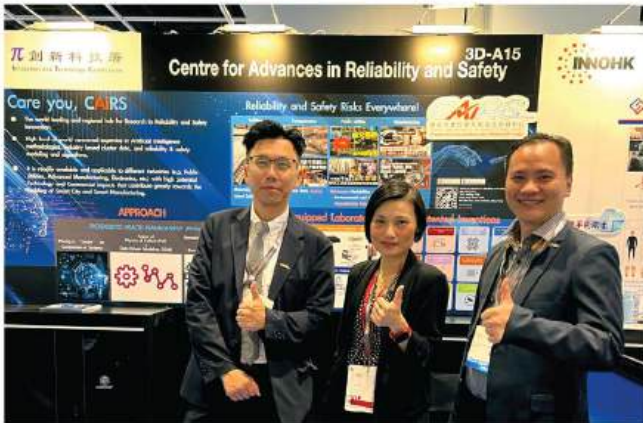
On July 15, 2024, CAiRS attended the Reception for I&T Awards 2024 hosted by the ITC, HKSARG, celebrating Hong Kong's R&D achievements in innovation and technology. Over 300 representatives from the I&T sector, including academics, scientists, and government officials, attended. Chief Executive Mr. John Lee congratulated the achievements and emphasized continued support for the I&T sector. Remarkable technologies were showcased, and CAiRS was proud to present among the awardees. As CAiRS marks its fourth year of operations, it looks forward to continued growth and success.





Our Activities

InnoEx 2024



CAiRS attended InnoEx 2024, organized by the Innovation, Technology and Industry Bureau of the Hong Kong SAR Government (ITIB, HKSARG) and the Hong Kong Trade Development Council (HKTDC), from April 13th to 16th at the Hong Kong Convention and Exhibition Centre. This was our second year participating in this prestigious event, where we showcased our cutting-edge technologies and AI methodologies in reliability and safety solutions. We were thrilled by the diverse audience and the widespread interest in our work, spanning various applications both large and small.

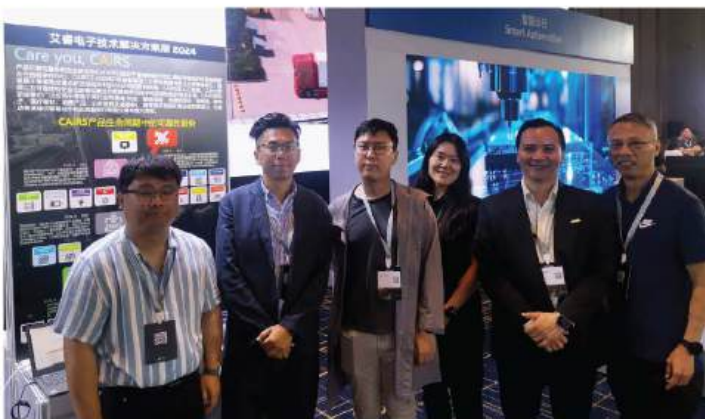
HKSTP x Arrow Hardware Lab Innovation Day

On December 6, HKSTPxArrow Hardware Lab Innovation Day celebrated the first year of collaborative achievements between HKSTP and Arrow Electronics at Hong Kong Science Park. The event features exhibitors showcasing the latest in Microelectronics and Electronics Engineering technology. Prof. Michael G. Pecht from the University of Maryland delivered a keynote speech on "Advances in Microelectronics Qualification," and our Senior Consultant, Ir Prof. Winco Yung, moderated a panel discussion on "Microelectronics Innovation and How to Bring it to Real Applications and Market." CAiRS is honored to be part of this dynamic community and celebrate these successes.

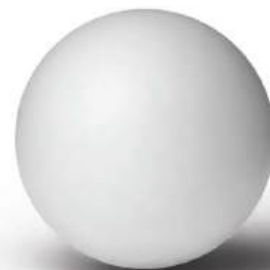


Arrow ACT 2024 exhibition

On November 12, 2024, CAiRS participated in the prestigious Arrow ACT 2024 exhibition at Sheraton Nanshan Shenzhen, China. This event brought together leading innovators and industry experts, providing an excellent platform for CAiRS to showcase its latest advancements and collaborative projects in AI for product reliability and safety assessments. The participation marked a significant milestone for CAiRS, reinforcing its position as a leader in AI-driven reliability and safety research. The event highlighted the center's technological prowess and opened new opportunities for partnerships and innovation, leaving a lasting impression on attendees.



Our Activities



NowTV interview

Building on our success at InnoEx 2024 and the 49th International Exhibition of Inventions Geneva 2024, our CEO and Centre Director, Prof. Kenneth Lam, was interviewed by NowTV in June. This interview, aired on July 26, 2024, at 12:20 PM on the Now 333 Business News Channel, allowed us to discuss our work on reliability and safety with a broader audience. We are grateful for this platform to highlight our innovative efforts and look forward to continuing our dialogue with the public.

Goodjob HR award

CAiRS won two prestigious awards at the CTgoodjobs HR Awards 2024: Gold in Best Learning and Development Technology Implementation and the Grand Best AI Implementation Award. Deputy COO Mr. Spencer Ling and Head of People and Culture Ms. Joyce Chan represented CAiRS at the ceremony on December 5, 2024. This recognition underscores CAiRS' commitment to innovation and excellence in HR practices, reflecting the team's dedication and hard work. Thank you to everyone who has supported CAiRS on this journey. Stay tuned for more exciting updates!



CAiRS Webinar



On March 6, 2024, we held our first UMD webinar of the year, featuring speakers Dr. Diganta Das and Mr. Rudra Vora from CALCE at the University of Maryland (UMD). The session focused on Probabilistic Sensitivity Analysis (PSA) for Part Reliability Assessment, discussing how PSA can be used to evaluate the impact of operational, environmental, and geometric factors, both collectively and individually, to ensure the selection of parts for safe and reliable system operation.

HKSTP Public seminar

The HKSTP x CAiRS Public Seminar on "Battery Performance, Ageing, Reliability, and Safety" was held on September 4, 2024, at Hong Kong Science Park, with around 100 participants. Speakers included Dr. Lingxi Kong (University of Maryland) on dendrite growth in lithium batteries, Mr. Fiske Lin (CAiRS) on battery anomaly detection using machine learning, and Prof. Steven Boles (PolyU and NTNU) on mechanical issues in batteries. Ir. Prof. Winco Yung, chairman of the IEEE Reliability Society (Hong Kong Chapter), introduced the society's activities.





Our Activities

HKTDC forum

CAiRS organized the “Reliability Assurance for Electronic System Forum” with HKTDC, HKEIA, and the IEEE Reliability Society at the Hong Kong Electronic Fair, attracting around 100 guests. The forum featured discussions on reliability assurance for electronic systems, highlighting its importance in preventing failures with severe consequences. Esteemed speakers included Dr. Diganta Das (University of Maryland) on detecting counterfeit electronics with machine learning, Mr. Peter Ng (IEEE Reliability Society) on designing reliable power electronic systems, and Ms. Gabriela Ehrlich (IECQ and IECEx) on verifying reliability as a foundation for trust.



ASMPT training

On December 11, 2024, Dr. Rainbow Lee and CAiRS researchers conducted a training session on Prognostics and Health Management (PHM) of Advanced Power Semiconductors at ASMPT. The session covered PHM, diagnostics, and digital twins of SiC Power MOSFETs and IGBT IPMs. It was highly interactive, featuring engaging discussions and quizzes. Dr. Lee and the CAiRS team's expertise and dynamic teaching styles made complex concepts accessible and interesting.



CHINT Visit

On November 30, 2024, our CEO & Centre Director Prof. Kenneth Lam, Deputy COO Mr. Spencer Ling, General Manager Dr. Gary Wong, and Assistant Programme Manager Mr. Fiske Lin joined a PolyU delegation to visit CHINT headquarters in Wenzhou, China. The visit involved productive discussions and solidified our collaboration with CHINT, paving the way for exciting opportunities and advancements. We look forward to the innovative projects and achievements that will result from this partnership.



Our Activities



Student Visits

Student visit – CUHK, Hang Seng University, Binus University and HK Youth Industrialist Council visit



CUHK student visit

On March 7, 2024, we hosted our first student group visit of the year, welcoming 30 students and their lecturer from CUHK's Department of Computer Science and Engineering. Our management team provided overviews of various CAiRS projects, and the students enjoyed a laboratory tour showcasing our technical work. Engaging with students is crucial for advancing innovative AI technologies in real-time applications. We cherish the opportunity to share trends and insights with young minds and wish them all the best in their future endeavors. We look forward to more enriching interactions.

Malaysia Student visit

On June 20, 2024, CAiRS hosted a visit for around 40 students and their lecturers from the Hang Seng University of Hong Kong and three university colleges from Malaysia, as part of the Malaysia-Hong Kong Cultural Exchange Programme 2024. Coordinated by AiDLab, the visit included overviews of CAiRS projects. Despite not having typical engineering backgrounds, the students showed keen interest in our innovative AI technologies. We always welcome opportunities to engage with young people and share current trends. We wish them all the best for their exchange trip in Hong Kong.



BINUS university student visit

On November 20, 2024, 20 students and their lecturer from Binus University, Indonesia visited CAiRS to gain practical insights into AI advancements in reliability and safety. The CAiRS team warmly welcomed them, providing an overview of the center's mission and projects. The session highlighted CAiRS' pioneering research and innovation in AI. The visit inspired and motivated the students, reinforcing their passion for technology and innovation. They expressed gratitude to both Binus University and CAiRS for this enriching experience.





Our Activities

STEM Activities

Internship

// Throughout this nearly 2-month Technical Marketing Engineer internship period from 2nd July to 23rd Aug 2024, I worked on both the research work from Research Programme 1 and the technical marketing team. For the research work, I collaborated with Jiayi Zhao on a project regarding rail track surface defect detection using an enhanced Swin-Transformer method, integrated with the Convolutional Block Attention Module (CBAM). For the marketing work, I developed a web application that automatically finds competition and funding opportunities, with useful information extracted and summarized. The working process and task details are described below. //



Alison Yeung Wun Lam
23 Aug 2024



Peter Ip Ka Hung
9 Aug 2024

// During my internship, I focused on rail defect labeling for AI-based railway inspection systems. I gained hands-on experience with various AI models, particularly the Swin model, which deepened my understanding of machine learning applications in critical infrastructure. This work demonstrated AI's tangible impact on daily life, especially in enhancing transportation safety and efficiency. I observed the complete workflow of an AI research company, from data collection to model implementation. This experience strengthened my technical skills in data labeling and AI model comprehension, while providing insight into how innovative solutions are developed. //

Our Team



Prof. Kenneth Kin-man LAM
CEO & Centre Director
Professor,
Department of Electrical and
Electronic Engineering,
The Hong Kong Polytechnic
University



Prof. BOLES, Steven
Adjunct Professor (EEE)



Prof. CHUNG, Chin-Shin Edward
Professor (EEE)



Prof. LAU, Chung-Ming Francis
Professor (EEE)



Prof. LOO, Ka-Hong
Associate Professor (ISE),
Assistant Dean (External
Engagement, FENG)



Ir Prof. YUNG, Kam-Chuen Winco
Senior Consultant



Prof. CHAN, Yui-Lam
Associate Professor (EEE)



Prof. BU, Siqi Steve
Associate Professor and Associate
Head (EEE)



Prof. LEE, Ka-Man Carman
Associate Professor (ISE)



Prof. HU, Haibo
Professor (ISE)



Prof. ZHANG, Xiaoge
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Deputy Chief Operating Officer



Dr Gary WONG
General Manager



Ms Jan YEUNG
Liaison & Marketing Manager



Ms Joyce CHAN
Head
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Research Program Managers



Dr Vincent NG
Senior Programme Manager and
Senior Research Fellow
(Programme 1)



Mr Fiske LIN
Assistant Programme Manager
(Programme 2)



Dr Rainbow LEE
Programme Manager
(Programme 3)

CAiRS Focus Areas

1. Corrective, Preventive, and Predictive Life:

CAiRS employs advanced methodologies to predict and prevent failures before they occur. This ensures uninterrupted operation and significantly reduces downtime.

2. Failure Prevention and Enhanced Service Reliability:

By focusing on failure prevention, CAiRS enhances the reliability of services, ensuring they meet the highest standards of safety and performance.

3. Maintenance Reduction and Life Cycle Cost Savings:

CAiRS' strategies are designed to minimize maintenance requirements and reduce overall lifecycle costs. This provides significant savings for clients while maintaining optimal performance.

How to Collaborate with CAiRS

1. Initial Consultation:

Begin with an initial consultation to discuss your organization's specific needs and challenges. CAiRS' experts will assess your current systems and identify areas for improvement.

2. Customized Solutions:

Based on the consultation, CAiRS will develop customized solutions tailored to your organization's unique requirements. These solutions will leverage their core capabilities and focus areas to enhance reliability and performance.

3. Implementation and Support:

CAiRS will assist in the implementation of the proposed solutions, providing ongoing support and monitoring to ensure success. Their team will work closely with your organization to adapt and refine strategies as needed.

4. Continuous Improvement:

Collaboration with CAiRS is an ongoing process. They will continuously analyze data, monitor system performance, and make adjustments to ensure optimal results and long-term success.



Our Laboratories

We have our own laboratories and supercomputer that facilitate the data collection from wide variety of components, products, or systems for our research projects. Below are some of the equipment and please visit our website (www.cairs.hk) for more details.

HIGH PERFORMANCE COMPUTING

Supercomputer NVIDIA DGX A100



LIFE CYCLE ASSESSMENT



Interrogator



Power Device Analyzer



Shock Machine



Powertester



Benchtop Vibration Table



**Battery Charge/
Discharge Testing
System**

Our Laboratories

TEMPERATURE & ENVIRONMENT TESTING



Temperature and Humidity Chamber



High Temperature Oven



Highly Accelerated Stress Test (HAST) Chamber



Thermal Shock Chamber

FAILURE ANALYSIS



X-Ray Microscopy



X-Ray Fluorescence Spectrometer



Electrodynamic Tester



Nanoindenter



Scanning Acoustic

Contact and Subscription



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