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HONG KONG APPLIED SCIENCE AND TECHNOLOGY RESEARCH INSTITUTE

INNOVATING FOR TOMORROW
PUSHING THE FRONTIERS OF TECHNOLOGY

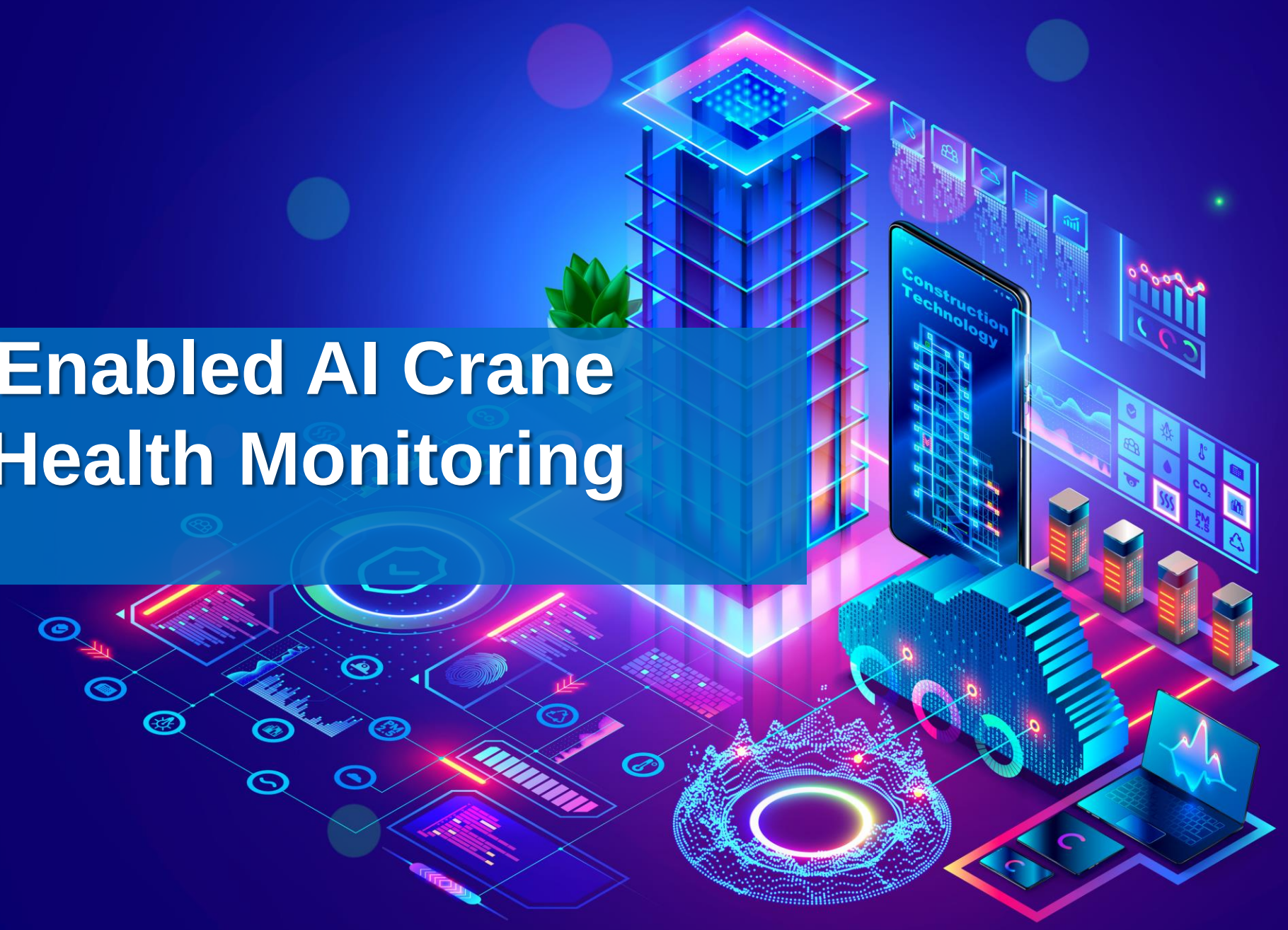
Mr Simon LEE
Director of Prop-Tech & Con-Tech

v 20231206

香港應用科技研究院有限公司
Hong Kong Applied Science and Technology Research Institute Company Limited

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Photonics Enabled AI Crane Structural Health Monitoring System





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Hong Kong / Society

Accidents and personal safety in Hong Kong

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Hong Kong crane accident: widow of victim stops accepting donations, urges public to help other victims and needy families

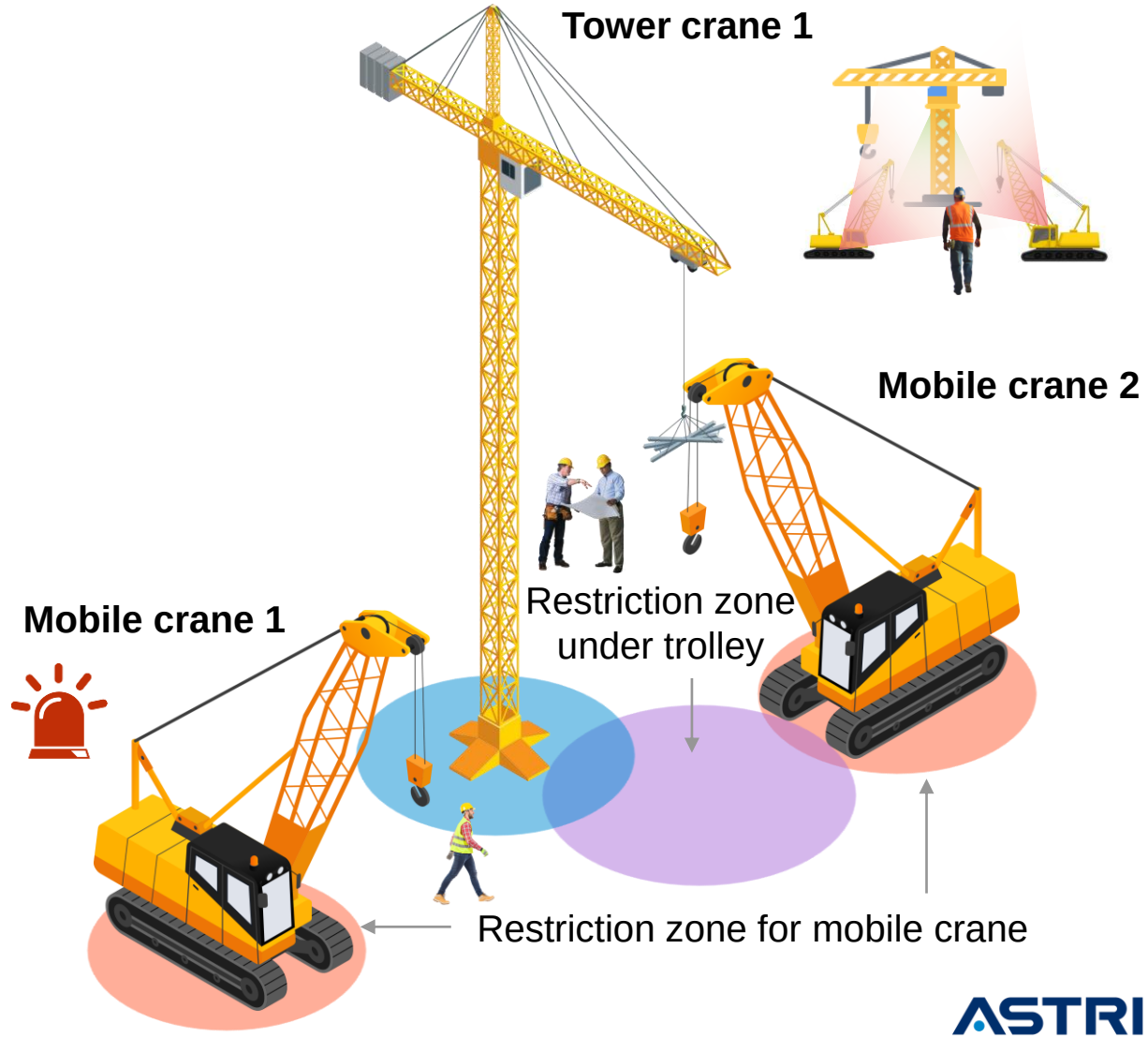
- Widow thanks donors for support and care but says she has enough money for now and there are others who are also need help
- She hopes all parties could look at the accident and find way to 'minimise risks without making operation of enterprises too difficult'



Sensing Fusion Management System for Crane Operation

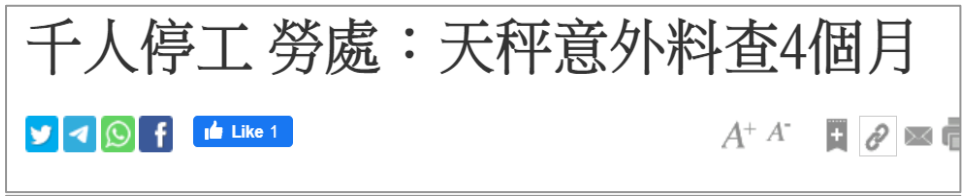
- **Human Machine** anti-collision system
- **Warning** and **Danger** Zone Alert
- **A**utomatic **S**afe **L**oad **I**ndicator
- **Safety** and **Driver** assistance
- **Realtime** monitoring and management





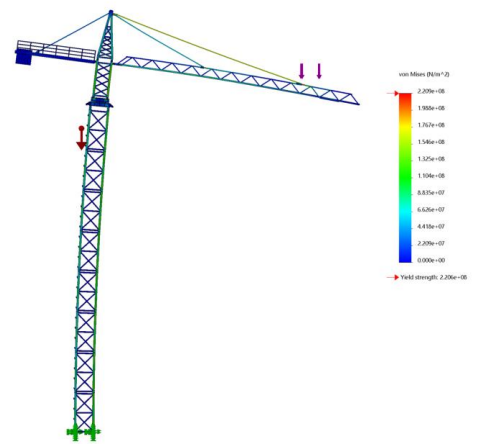
Human and Metal Fatigue Monitoring

- Recent incidents of Crane Collapse remind general public the importance of monitoring Cranes' daily operation.
- Metal fatigue is an important factor
- It is desirable:
  - **Regular monitoring**
  - **Abnormal structural behavior**
  - **Predictive maintenance**









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Crane Safety – Human Fatigue Monitoring

Paint Points:

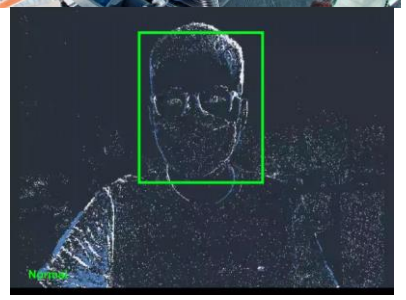
Facial condition unclear

Privacy vs. features extraction

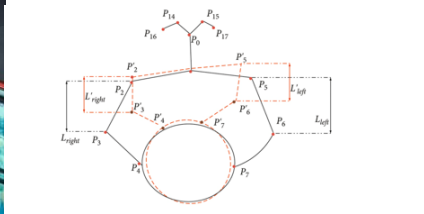
Sunlight reflection



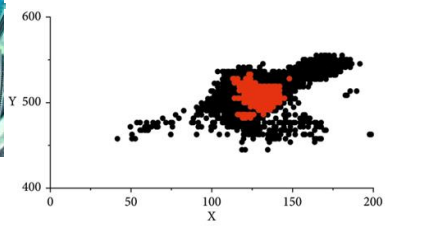
Patent filed in SEED Project ARD271



Event based Monitoring

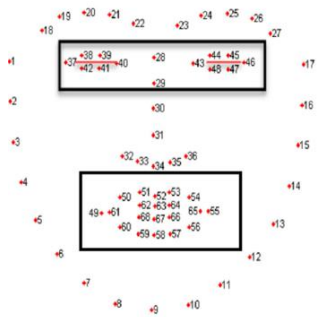


Euclidean Distance of the Arms Projection (L_{right} and L_{left})



Comparison of wrist coordinates between fatigue and normal state.

Head movement /Human Pose



68-Landmark model

Facial condition

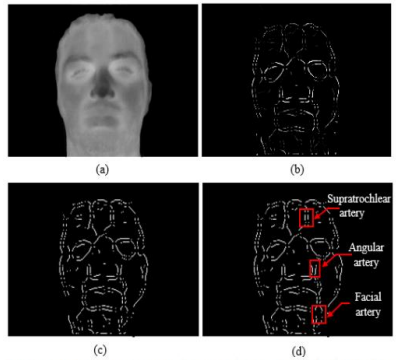


Figure 1. Face segmentation (a), image morphology (b), post-processing (c), target regions (d)

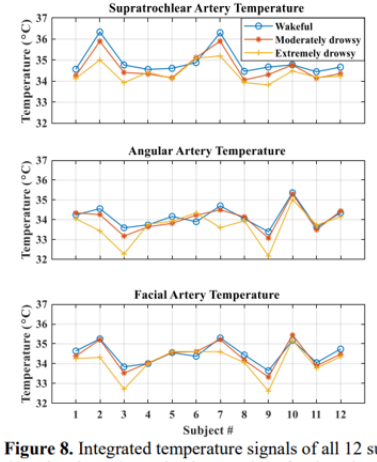


Figure 8. Integrated temperature signals of all 12 subjects in a box plot at the three regions for three levels of drowsiness

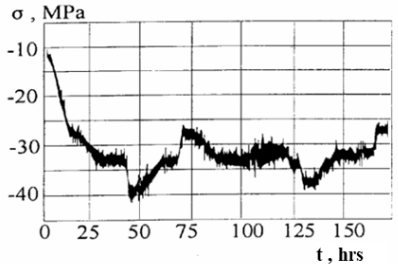
Drowsiness levels were estimated by the observer rating of drowsiness(**ORD**) method

Heart rate by IR/RGB/Thermal

Sensing Fusion Management System for Crane Operation

Photonics Device (Fibre Bragg Grating) for Mobile Crane Metal Fatigue Monitoring

- Real-Time Multi-point Crane Structural Parameter Sensing
- Instantaneous Abnormal Structural Warning
- Structural Health Profile for Crane Service Recommendation
- Systematic Structural Weakness Identification

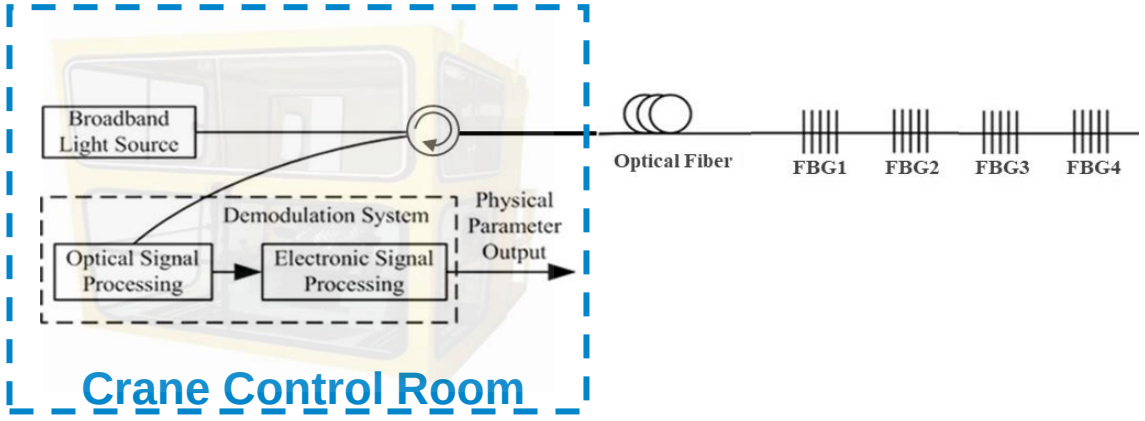


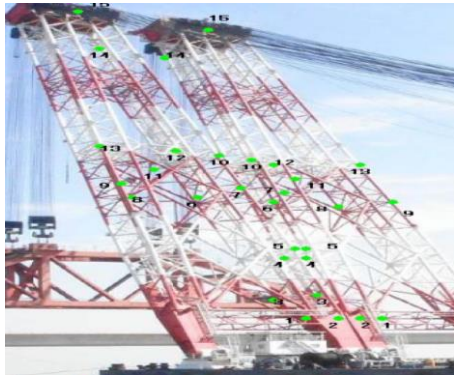
Location	Measurement number [MPa]				
	1	2	3	4	5
1	-85.22	-93.33	-87.27	-104.91	-95.62
2	-89.65	-89.42	-100.10	-94.76	-87.71
3	139.12	165.37	151.09	153.68	154.32
4	176.29	165.27	170.62	176.46	175.83
5	135.77	150.54	140.65	147.62	138.96
6	170.51	150.99	165.96	172.43	170.83
7	139.15	152.33	137.92	147.49	144.89

Structural Health Profile

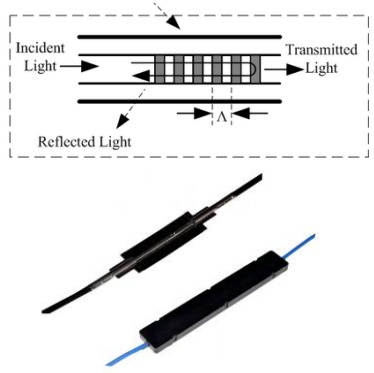


FEM FBG Location Analysis





FBG placements



FBG

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Real-Time Acquisition Sub-system: Crane peak zone monitor

- Monitor the stress at specific “peak zones” locations around the crane structure where metal fatigue process initiate
- Work in harsh construction site environments (electromagnetic interference, dust, rain, temperature variation, wind)
- Sensing elements should be easy to maintain (battery change, data transfer, inspection)



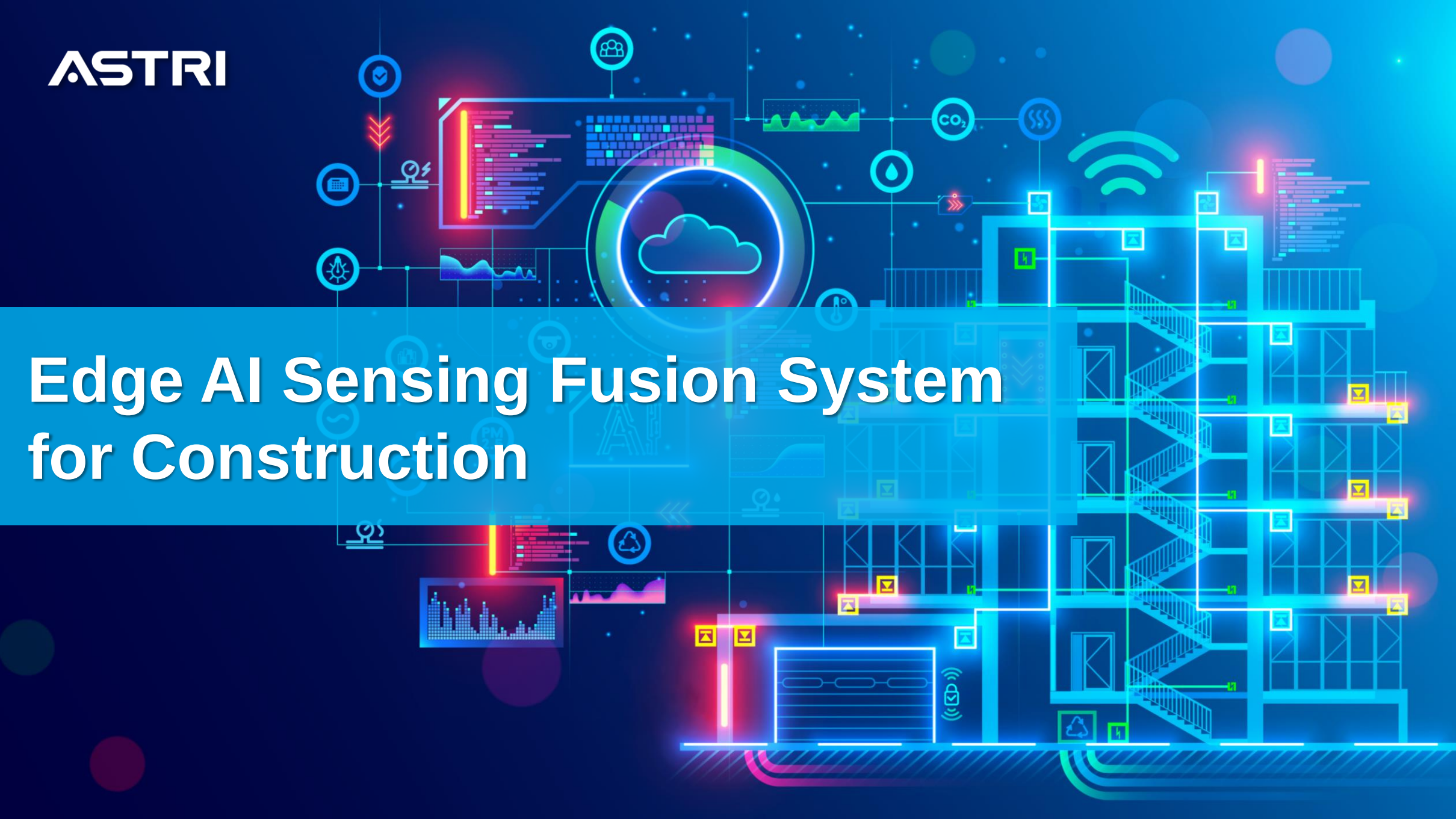
Fiber Optics Sensing Systems

Power	No power to transducer	✓
EMI	Immune	✓
Dust	Not affected	✓
Rain, Humidity	Not affected	✓
Corrosion	Not afftected	✓

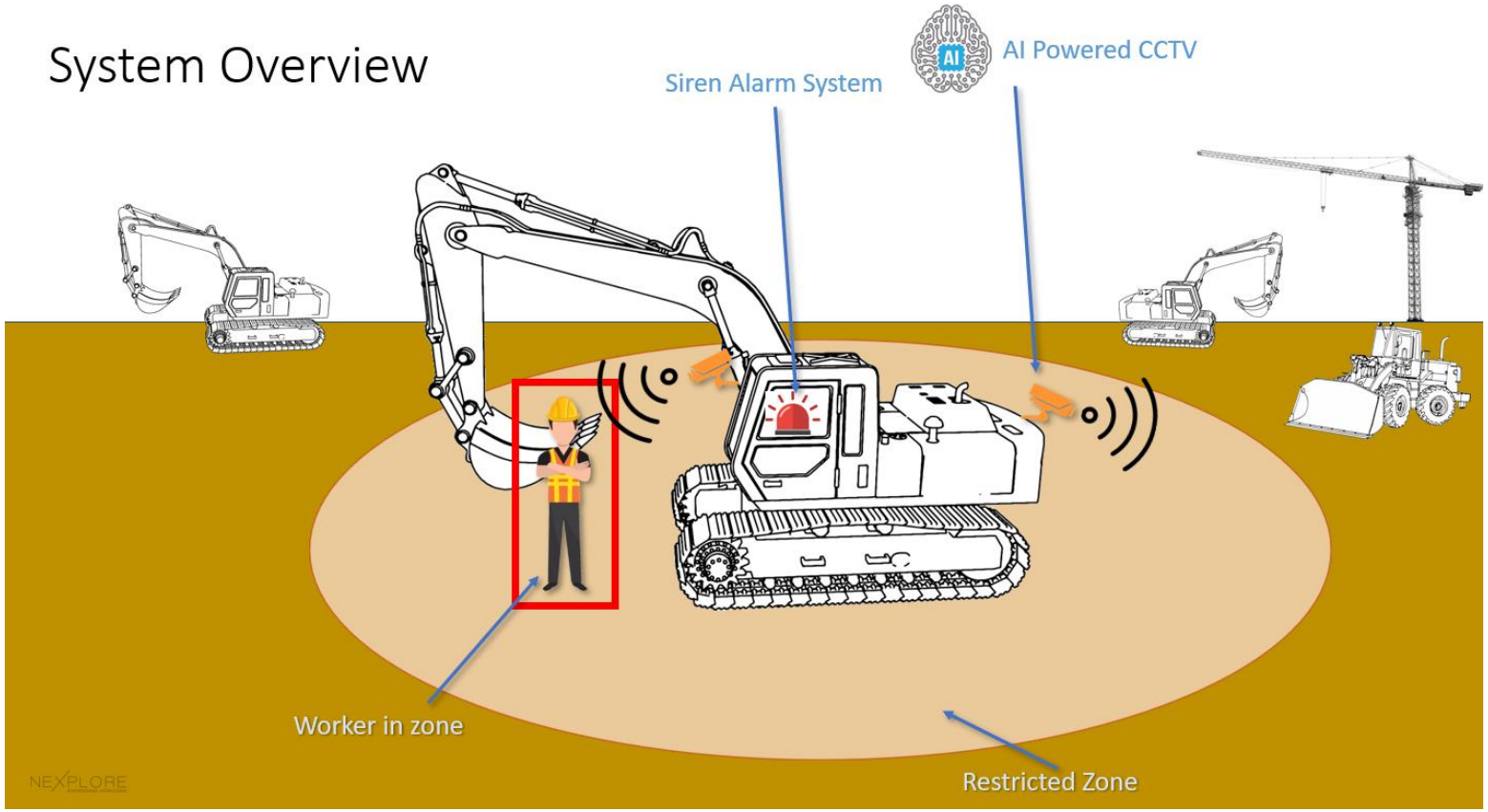
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Edge AI Sensing Fusion System for Construction



Solution overview



ASTRI's Edge AI sensing fusion system addresses the pain point of safety issues in construction site through innovations in leveraging edge computing, deep learning, and object detection with emerging sensing technology.

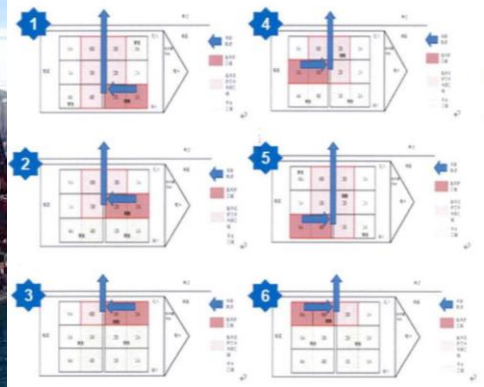
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Moving machinery in construction site









Barge (躉船)



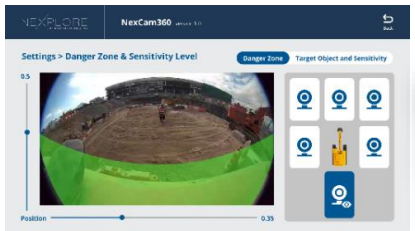
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Edge AI Sensing Fusion System for Heavy Machine

Leveraging edge computing, deep learning, and object detection with emerging sensing technology

Innovations

- Edge AI powered architecture capable for ultra fast warning and alert messages to stakeholders
- Smart Optics based sensing fusion system realize environmental understanding at extreme outdoor conditions



Rich User Interface

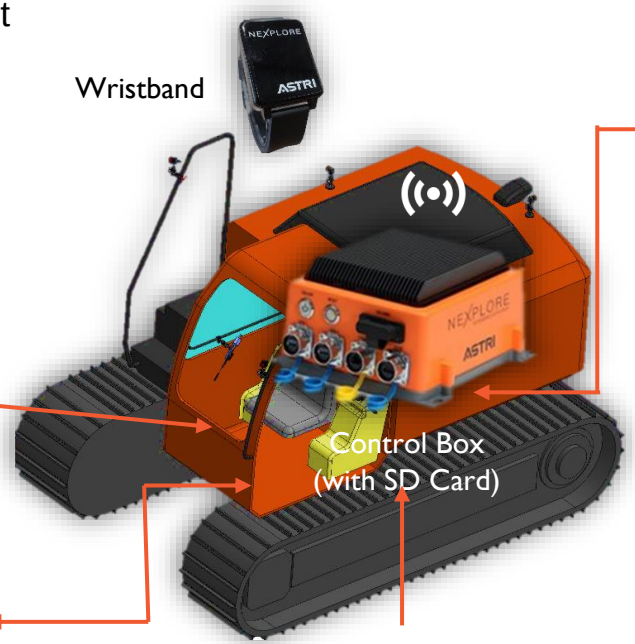
- Easy to control
- Touch and user-friendly interface



LCD Display
(touch screen)



Siren Beacon





Camera



Operator/
Signalman



Features

- Real-time cost-effective edge processing system
- Support up to 8 cameras simultaneously
- Blind spot free surround sensing
- High quality video recording, activity and progress monitoring
- Automating Safety Audits, Non-compliant workers and operations detection
- Assisting the machine operator in executing routine tasks

Key Impact

- Enhanced construction safety and operation standard
- Enhanced productivity, accuracy, and efficiency
- Real-time safety and progress monitoring

Award

2021-22
香港工商業獎
HONG KONG AWARDS FOR INDUSTRIES
設備及機械設計獎
EQUIPMENT AND MACHINERY DESIGN AWARD

Hong Kong Award for Industry: Equipment and Machinery Design Certificate of Merit, 2021-2022

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Edge Computing on Neuromorphic Vision Sensor

Accuracy
Little to no false alarm

Fast
Response time must be within 50ms

Easy to install
Can be installed within 15 mins

Durable
Works in harsh conditions: water, dust, heat

Coverage
Wide angle coverage and depth of field (DOF) of camera (blind spot free)

Cost effective
Highly Affordable

Easy to use
Configurable danger zone – Suitable for most machinery







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Real time Positioning System for Modular Integrated Construction (MiC) by Smart Optics



Background

- Assembling MiC modules in a construction site involves ***heavy lifting*** and ***frequent human interaction***, which poses danger to ground workers.





- Unexpected large swing motion could be resulted during lifting and moving of MiC modules. This leads to ***positioning difficulties*** and ***potential collision*** with approaching objects.

- The viewpoint from both ground workers and crane operator are restricted and therefore a couple of banksmen are required to monitor the lifting and installation process from different locations.



Ground view

- Not all potential safety issues can be immediately noticed and alerted, especially under long work hour.

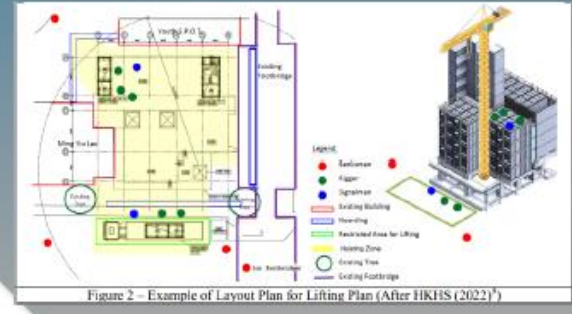


Figure 2 – Example of Layout Plan for Lifting Plan (After HKHS (2022)[3])

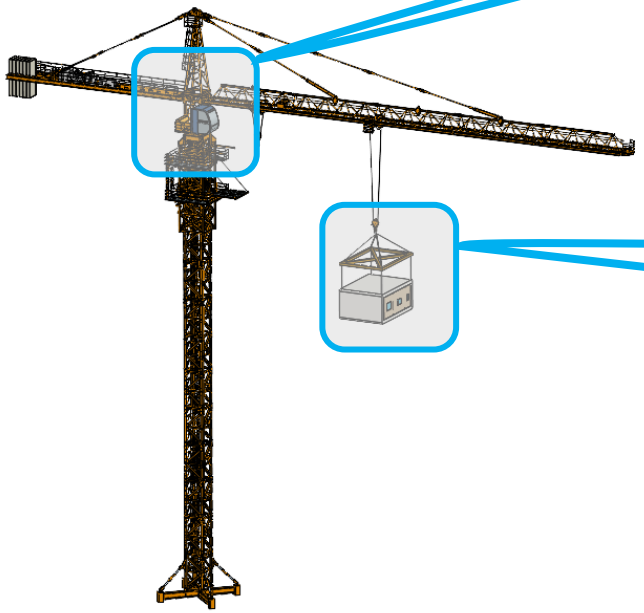


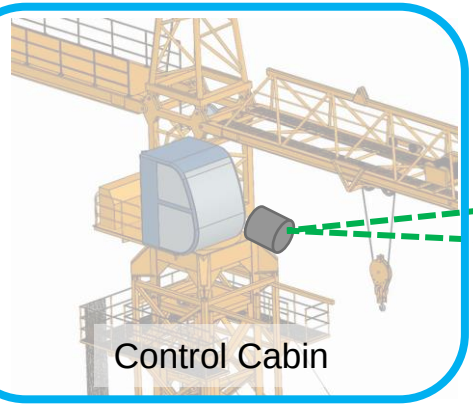
Crane cabin view

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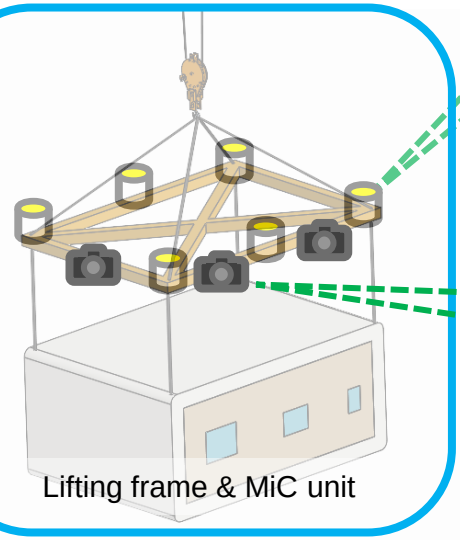
Smart Optics for Modular Integrated Construction(MiC) Safety Monitoring

- Assistive technology for **safety monitoring** in MiC lifting operation
- Main Features:
  - Accurate position and orientation tracking of the MiC unit
  - Speed and swing monitoring
  - Human, objects and environment detection
  - Instance alert for potential danger events
  - Lifting operation history logging
  - Digital twin model





Camera and sensing module installed near the control cabin for identifying tracker location

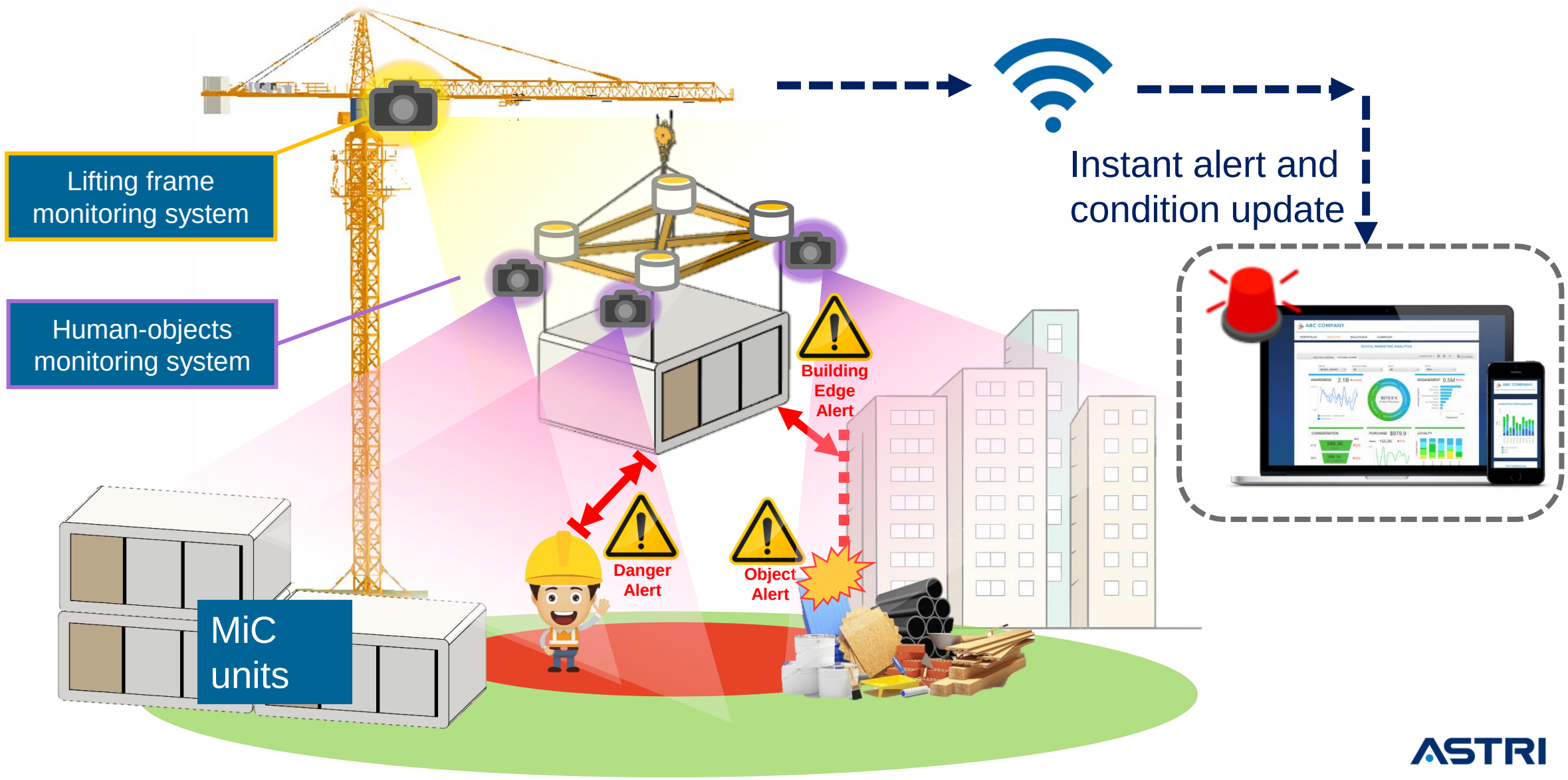


Trackers placed on the lifting frame to provide MiC condition information

Camera around the lifting frame to monitor surrounding events

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Smart Optics for Modular Integrated Construction(MiC) Safety Monitoring (cont'd)



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AR Technology

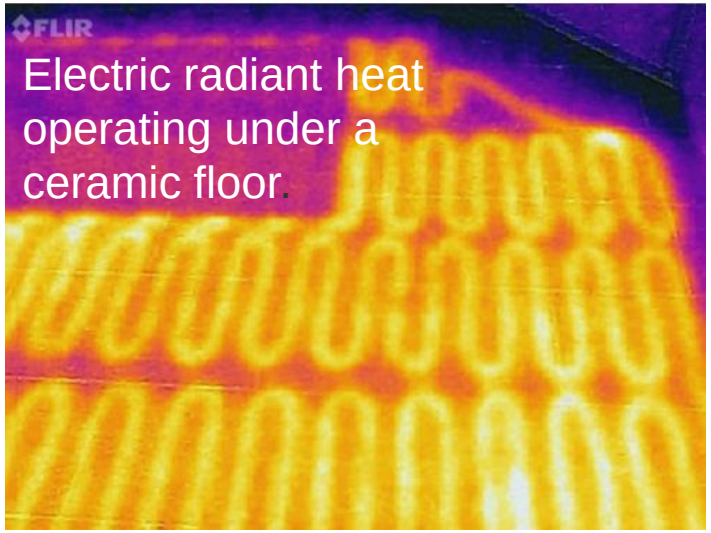


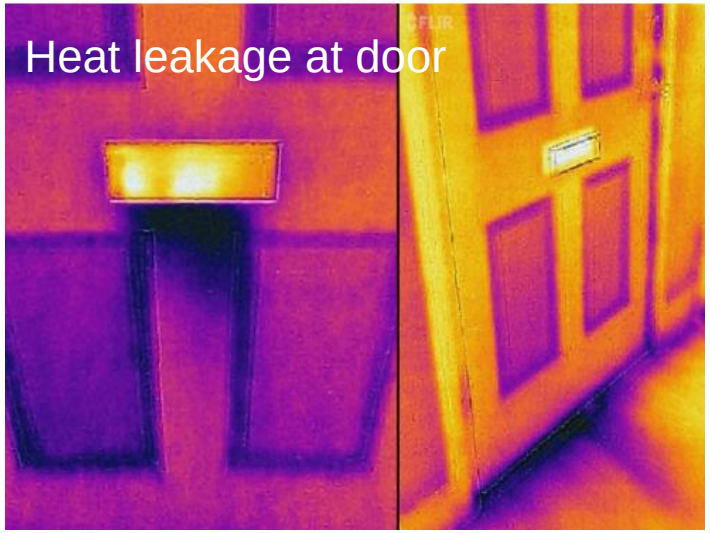
Light Weight ARVR Helmet with Thermal Sensing

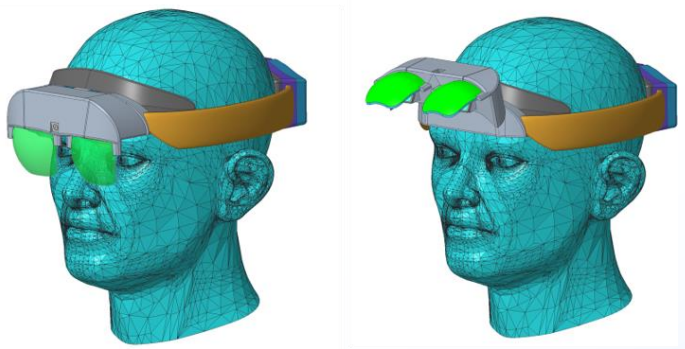
Integrated or Handheld portable Thermal Sensor on HMD enabled safety helmet

- Instant thermal data capturing and visualization
- Building diagnosis for embedded pipe inspection
- Energy leak detection









Thank You

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