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Output from Aotearoa AI Summit – AIoT in infrastructure workshop hosted by Mott MacDonald on 20 September 2023.

Unveiling the future

Bridging AI and IoT in infrastructure

Embracing AIoT in infrastructure

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Automation and computational design global lead, Mott MacDonald

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Infrastructure is incredibly important for the future of our planet and is intricately tied to achieving the United Nations Sustainable Development Goals (SDGs). Unprecedented population growth - projected to reach 1.7 billion more people by 2050 and potentially nearly 11 billion by 2100[1] – is driving urbanisation and intensifying climate change. These challenges are reshaping our communities and putting strain on existing infrastructure. The Global Infrastructure Outlook projects that a $94 trillion investment is requirement over the next two decades[2]. New Zealand alone grapples with an estimated $180 billion demand[3].

With this context, digital technologies, specifically AI and IoT, are essential for boosting productivity and reducing costs in the design, construction, and management of infrastructure assets.

The rise of AI Large Language Models (LLMs) and increased IoT accessibility presents the construction industry with a unique opportunity. As global population growth and rapid urbanisation unfold, successful AIoT solutions will be crucial for ensuring well-designed and efficiently managed infrastructure, bringing us closer towards achieving the UN's SDGs.

As kaitiaki (stewards) of the built environment, we shoulder the responsibility of maximising the value of taxpayers' investments by judiciously harnessing these emerging technologies. AIoT equips us with the means to improve energy efficiency, security, and comfort in buildings; monitor the health of critical linear infrastructure such as bridges and roads; facilitate implementation of self-driving vehicles; and optimise traffic and utilities management.

At the 2023 AI Summit pre-event workshop, we had the privilege of hearing from experts, stakeholders, and infrastructure leaders who shared their insights into addressing current and future challenges with the aid of AIoT. Together, we explored the path to embracing AIoT in the construction industry.

I am pleased to share some of these valuable insights with you and eagerly anticipate further collaboration with our industry partners to facilitate the seamless adoption of AIoT within New Zealand's construction industry.

Footnotes:
[1] UN DESA 'Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100'
[2] Global Infrastructure Outlook - A G20 Initiative
[3] Global Infrastructure Outlook - New Zealand

What is AIoT?

Artificial Intelligence of Things

Understanding AI and IoT

Artificial Intelligence (AI) processes IoT data and uncovers valuable patterns that could be missed if handled manually.

In the infrastructure context, this enables smarter, more efficient decision-making leading to cost reduction, sustainability enhancements, and improved asset management.

Internet of Things (IoT) are interconnected devices embedded with sensors that collect and exchange real-time data over the internet or other communication networks.

In infrastructure, IoT can mean sensors for smarter energy management that automatically adjust lighting, heating, and cooling based on occupancy and environmental conditions. On construction sites, IoT cameras can be used to track equipment and materials, plus health and safety compliance requirements.

Co-design workshop:

Towards better AIoT outcomes

Co-design workshop

The infrastructure industry is the highest contributor to GDP (13%) but more than that it is responsible for making our planet habitable, for getting people to where they need to be safely and comfortably, and for providing shelter, water, energy, and other essential resources.

AI and IoT are two transformative technologies that when used wisely can help our industry do things better. But where do we start?

Collaboration and co-design are essential for embracing AIoT in infrastructure. By uniting stakeholders from all corners of the industry, we can unlock innovative solutions that benefit our communities and the environment we live in. It can also foster a sense of ownership and shared responsibility, leading to long-term commitment towards sustainability.

Therefore, it is imperative to encourage and facilitate collaboration and co-design among stakeholders as we move towards a digital future.

Nasrine Tomasi
Smart water product lead
Mott MacDonald

Participants were split into groups and asked to run through series of exercises to understand:

1. Their top five current problem areas
2. What they need AIoT to do to address these problem areas (objectives)
3. What they want AIoT to change (outcomes)
4. What resources would be required to achieve these outcomes

Each group explored these through both a current and future lens.

Current: What are the current problem areas that could be or are being solved with AIoT?

Future: What are the future problem areas that could be solved with AIoT?

> Walking around the room during the workshop exercises and sensing the positive energy levels all participants brought to the discussions was reinvigorating. If not us, who? If not now, when?
>
> **Maria Mingallon**
> Automation and computational design global lead, Mott MacDonald

Current state:

Identifying key problems

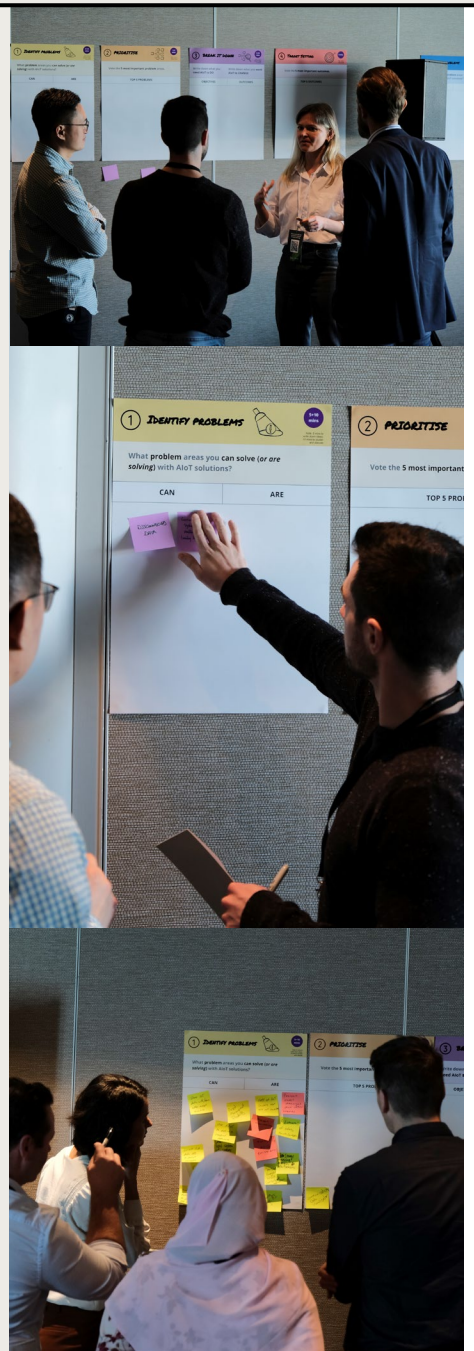
Exercise 1:
Addressable pipeline

Amongst those in the room working, the strategic challenges were broadly similar.

1. **Accessing and sharing data:** This challenge spans across sectors, emphasising the need for robust mechanisms to facilitate data exchange.
2. **Acquiring and retaining a skilled workforce:** This extends beyond technical competence, encompassing broader aspects like organisational culture, education, and ongoing upskilling efforts.
3. **Collaborative frameworks:** It essential that we bring together diverse stakeholders, including governments, businesses, and communities.

Successfully addressing these challenges demands a cultural shift towards allowing experimentation and learning from failures, essential for building AI capabilities. However, this approach inherently carries risk.

Sreedath Ikarath
Data scientist
Mott MacDonald



Current problem areas

- Not enough talent/expertise/knowledge
- Merging data from multiple sources (lack of shared schemas)
- Sharing data between organisations
- Disconnected or missing data
- Data security and transparency (including policies for data governance, provenance, ownership, and privacy)
- Data/IoT system resilience
- Natural hazards, disasters, climate change
- Inefficient use of assets
- Inefficient current traffic systems causing congestion, wasting time and money
- Lack of NZ-based data centres
- Insufficient infrastructure to support AIoT (5G implementation, sensor technology etc.)
- Reusability of data is a challenge
- Lack of a holistic view of our systems
- Making IoT data available to people in the field, including subcontractors

What we need AIoT to do and change

- Ability to inform data/AI policy and governance
- Reactive interventions in operations, fixing incidents, and consequences (e.g., rail incidents)
- Unsafe cities (using computer vision to improve safety)
- Converting vision data/images into useful information
- Enablement of a digital city
- Communicating data insights and data visualisation challenges
- Explainable AI and explainable decisions

Future state:

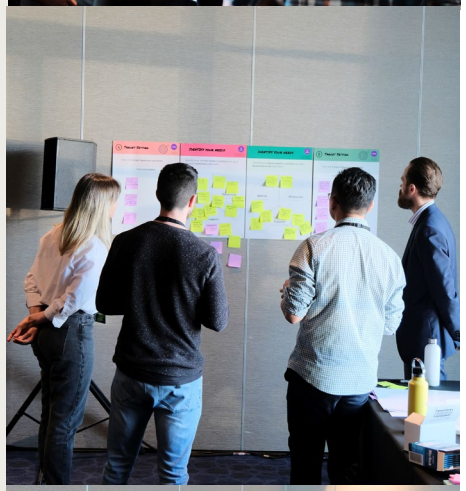
Envisaging desired outcomes

Exercise 2:
Potential pipeline

During this session, we delved into a transformative technological shift, emphasising the importance of innovation in our processes, companies, and cities. The discussion highlighted the challenges faced by growing cities like Auckland, leading to the need for a new wave of innovation. AI, bolstered by available technology, IT infrastructure, and IoT devices, emerges as the logical next step in optimising processes and enabling cities to become more resilient.

IoT plays a significant role in advancing process optimisation and acts as the sensory system for AI, facilitating progress in various sectors such as smart industries, infrastructure, buildings, and cities. With the rise of increasingly complex processes, AI integration becomes inevitable. The timeline for adoption will vary, but AI and IoT integration are poised to reshape processes over the next 3-10 years, leading to a vast interconnected network of processes. The central question shifts from 'if' we should start implementing AI and IoT to 'when' in the context of this technological evolution.

Anna Moskvitina
Digital delivery practice lead – New Zealand
Mott MacDonald



Future problem areas

- Insufficient satellite coverage and limited data centre capacity
- Addressing low-accuracy data issues
- Legal issues hindering data use and innovation
- Lack of holistic views of our systems
- Issues with scalability from city to region to country levels
- Clearer policy and governance protocols for data, including culturally significant "Taonga data"
- Ensuring dependable, predictive, real-time data
- Extensive expansion of sensor networks to support future AIoT growth
- Development of national infrastructure asset information standards
- Establishing frameworks for data sharing, including shared schemas, data governance, security standards, and policies
- Proactive management of asset life cycles

What we need AIoT to do and change

- Expansion of digital twins and expert systems across various domains
- Personalised health solutions through data and AIoT
- Integration of AIoT in nature-based solutions (particularly in food production)
- Improved traffic and transport systems informed by probabilistic methods
- Climate resilience and carbon reduction strategies
- Enhanced management of sustainable food systems amidst climate change challenges
- Increasing understanding of complex problems integrated with robotics
- Automating parts ordering and installation for infrastructure maintenance

Action plan:

Acknowledging needs to accelerate the AIoT journey

Exercise 3: Towards better AIoT outcomes

Workshop participants were receptive to the hotspot camera case study that was presented. Seeing three organisations collaborating alleviated fears of having to implement AIoT solutions entirely in house. Given the relatively small population and job market in New Zealand, collaboration is key.

Working in small groups gave participants the opportunity to speak up with their ideas and have others engage with them. I think we all came away with a clearer idea of what problems exist and what solutions AIoT can offer.

Sam Greenwood
Data scientist
Mott MacDonald

Current needs

Workforce development:

- Educate non-data/AIoT stakeholders
- Recruit for the right skills and provide professional development at all levels, from graduates to C-Suite
- Executive corporate IT support and upskilling
- Establish communities of practice
- Learn from big giants

Awareness and acceptance:

- Communications strategies to teach people that AI can help Create positive awareness of AIoT solutions
- Vision and business alignment

Regulation and governance:

- Government Investment and funding (e.g., clear pipeline of major projects)
- Less restrictions on data collection
- Government regulations, standards, and strategies
- Dedicated research and development (R&D) budget

Infrastructure and technology:

- Reliable sensors and hardware
- Better support from ICT
- Low-cost IoT devices (more of them deployed)
- Robust data infrastructure (data centres based in NZ, 5G networks availability and coverage, etc)
- Democratised data capability, accessible to all.

National data standards

- Collaboration and partnership:
- Collaboration across wide domains to solve increasingly complex problems
- Agreement between asset owners to share open data
- Promote/prioritise interoperability

Future needs

Workforce development:

- Predicting future staffing requirements, future skills, and capabilities
- Support for STEM Learning
- Attract and retain talent and skills in AIoT, inc. government support for skilled migrant visas

Collaboration and sharing:

- Commercial models enabling data sharing across different organisations (public and private)
- International collaboration, share all models
- Agreement between asset owners to share open data
- Community practice forums (e.g., AI Forum membership)

Regulation and governance:

- National date standards
- Endorsement of data governance strategy
- Public private governance organisation for AIoT

Infrastructure and technology:

- Focus on digital twins in every domain
- Neural chipset for powerful AIoT
- Decentralised edge computing is more of the norm
- Computational resources
- Higher reliability networks
- Resilient AIoT infrastructure

Data management and policies:

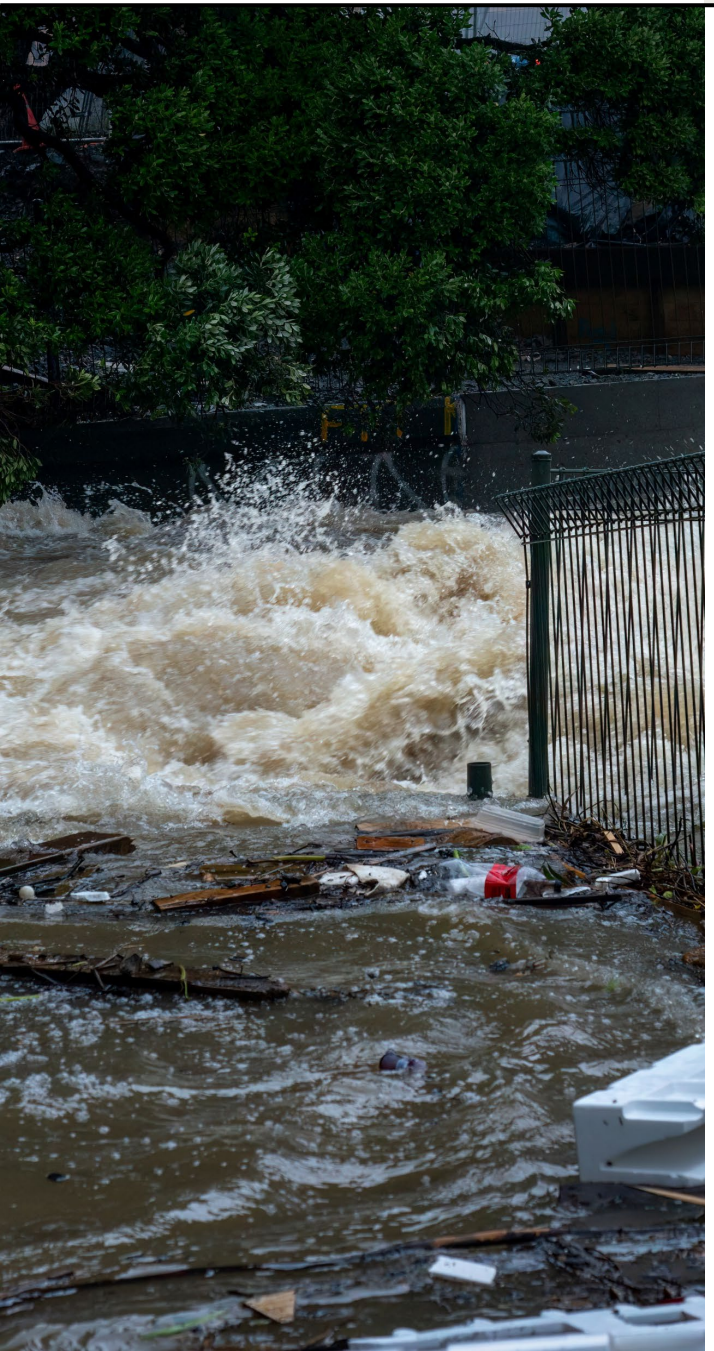
- Open-source data
- Managing of ‘digital rights’
- Data sharing policies/requirements

Research:

- Studies and research from universities
- Ongoing R&D funding for improvement of AIoT

AIoT in action

Examples of projects successfully integrating AIoT into delivery



AIoT in flood management systems

Piha, Auckland

Severe weather events, including frequent and devastating flooding, have posed significant challenges for communities around the world, leading to the rise of innovative solutions to manage flood risks. One such solution is the integration of AI into flood management systems (FMS). In Piha, Auckland, a pioneering pilot project is underway, using AI to predict stormwater flooding and transform flood management practices.

Predictive capabilities of AI

Located in a flood-prone area, Piha faces recurring flood events that have resulted in property damage, road closures, power outages, and the need for emergency evacuations. To address these challenges, Auckland Council developed the Piha FMS, incorporating emerging technologies such as IoT devices, rain radar, hydraulic modelling, and machine learning.

By integrating these components, the FMS creates an integrated digital twin of the rainfall and flood forecasting system. It enables proactive, efficient, targeted, and evidence-based operational responses, significantly reducing simulation times and providing immediate insights for flood managers.

AI-powered flood forecasting

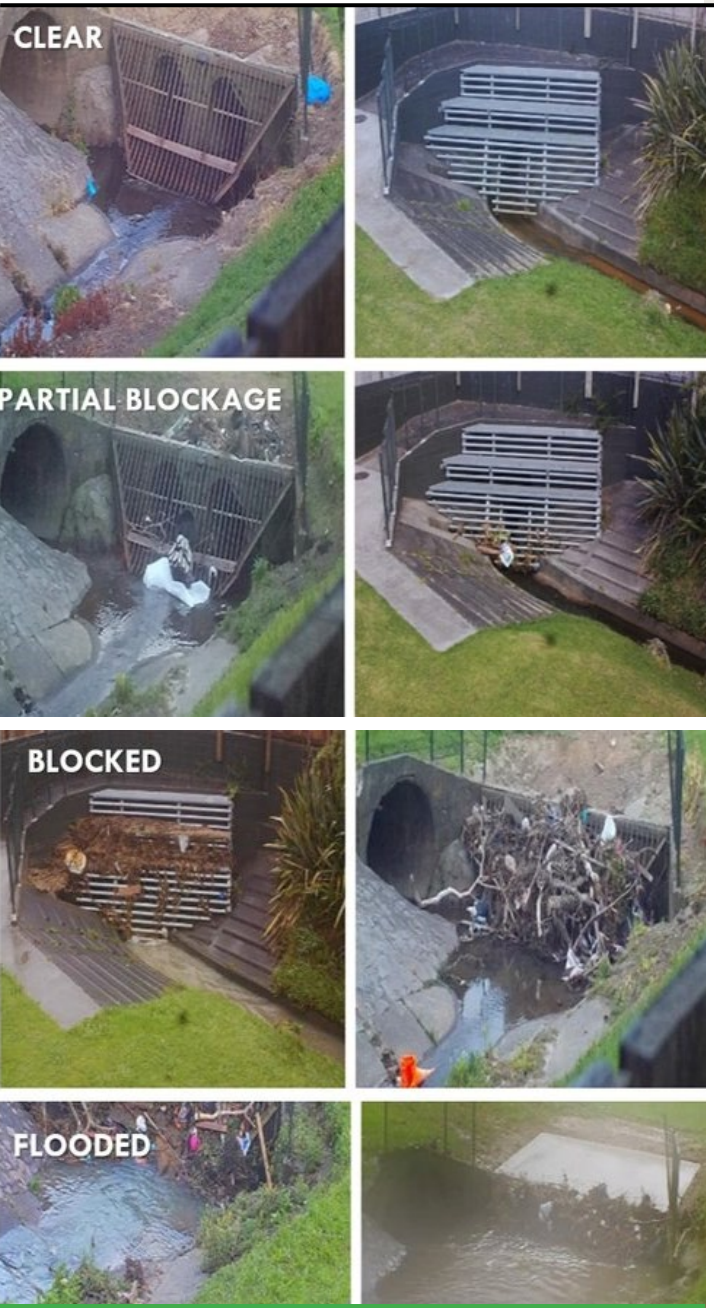
Traditional hydraulic models often fall short in providing timely flood predictions, particularly during rapid rain events. By combining rainfall nowcasts and machine learning techniques, the FMS generates real-time stormwater flood prediction maps with remarkable speed. The machine learning model, trained using historical rainfall radar data and calibrated hydraulic model outputs, delivers accurate flood forecasts in just seconds.

This AI-powered solution significantly outperforms traditional methods, which would require approximately hours to achieve the same results and are not suitable for flash flooding catchments such as Piha. Advancements like this enable authorities to make critical decisions promptly, such as road closures and evacuations, ultimately reducing the risk to life and property.

Moata Smart Water platform

The FMS operates through the Moata Smart Water platform, which consolidates real-time data, forecast information, and analytical pipelines. This digital twin platform provides flood managers with a centralised source of truth, offering geospatial visualisation of flood-related information.

Read more: AI Transforms Flood Management: Enhancing Resilience to the Climate Crisis



Images courtesy of Lynker Analytics Ltd.

Early detection of blockages and flooding with computer vision

Auckland

To improve management of their stormwater network, Auckland Council has developed a pilot system relying on simple hunting outdoor cameras to monitor critical discharge sites.

Opportunity

The opportunity lies in enhancing the performance, optimisation, and maintenance of water assets through visualising their how they perform during different scenarios. Early detection of blockages will improve efficiency of maintenance operations, reducing costs and minimising disruptions to the community.

Solution

Solar-powered cameras installed at seven critical discharge sites across Auckland are configured to capture images ten images per day. These site images are processed by a cloud-based ML we developed in collaboration with Lynker Analytics. The model classifies the images into categories such as clear, partial blockage, substantial blockage, and flooded. These results are then integrated into Moata, our smart infrastructure monitoring system used by Auckland Council.

Outcome

Auckland Council's pilot system utilising outdoor cameras, machine learning, and the Moata monitoring system presents an opportunity to enhance stormwater network management, allowing for early detection of blockages and flooding.

The current pilot will be scaled up to include an additional 20 cameras which will vastly improve the management of the stormwater network, reducing the risk of flooding and subsequent damage.

Predicting ash dieback

UK and Europe

Ash dieback is a fungal disease that affects Ash trees and has spread across the UK at a rapid rate over recent years. The prevalence of ash dieback poses significant risks as when the tree deteriorate, they can fall wholly or partially onto highways without warning.

Opportunity

The scale of the ash dieback problem and how rapidly trees deteriorate is relatively unknown. But the costs to infrastructure, buildings, and people in the UK and Europe is estimated at £15.6b. However, conventional surveys are expensive and pose numerous health and safety risks.

Solution

Our Data Analytics team, in collaboration with arboriculture specialists and data scientists, has developed a vehicle-borne survey and mapping system. It utilises a stereo-camera and real-time kinematic GPS technology to capture consistent datasets for ash dieback surveys, providing accurate tree health characteristics and predicting the likelihood of developing or having ash dieback.

Outcome

The vehicle-borne survey and mapping system as proved a cost-effective solution to manage the ash dieback problem. Visualising survey data through a digital twin enhances monitoring and decision-making. The system is now being applied in various locations across the UK, including Conway, Kerrigan, Glasgow, and North Yorkshire. We are now looking at how the systems adaptability can extend to other applications like pavement health solutions and surveys of endemic fauna for environmental impact assessment and monitoring.

Health and safety monitoring with AI

UK and Europe

What if we could enhance construction site safety by utilising AI to monitor the wearing of personal protective equipment (PPE)?

Opportunity

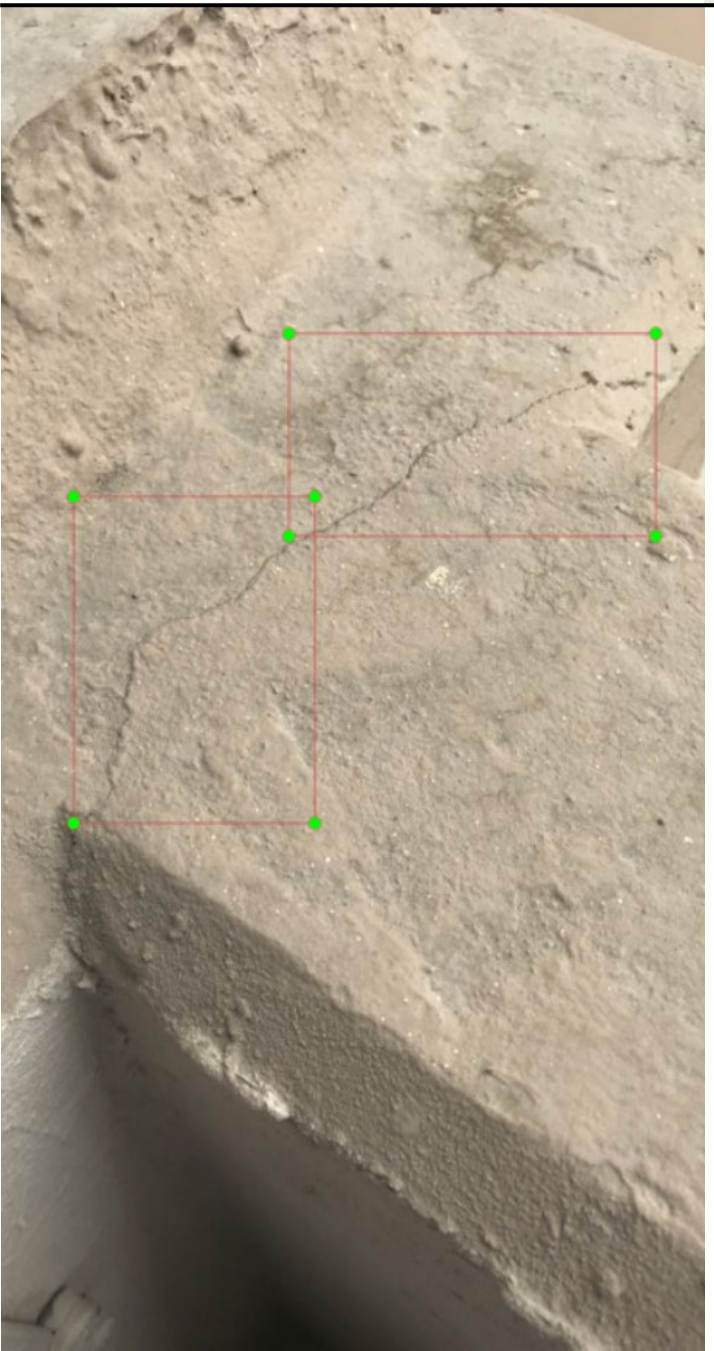
One of the significant challenges in the construction industry is ensuring that workers are consistently wearing the correct PPE. Non-compliance can lead to accidents, injuries and even fatalities. Promoting a culture of safety is a key priority and real-time monitoring can encourage workers to wear the correct PPE, leading to a shift in the overall mindset towards safety.

Solution

We implemented an AI-based system that can detect and report violations of health and safety PPE protocols at construction sites. The solution utilises computer vision technology to analyse video feeds and identify individuals not adhering to PPE requirements on site. When an individual is identified, real-time alarms are generated to alert supervisors and enable immediate corrective actions.

Outcome

Leveraging AI to monitor PPE has led to improved safety compliance and risk reduction at construction site. The solution enhances worker protection, mitigates potential accidents, and fosters a proactive safety culture. Real-time detection and reporting enable timely interventions, allowing for prompt enforcement of PPE protocols. Ultimately, this leads to a safer work environment, fewer workplace injuries, and increased awareness of health and safety practices in the construction industry.



Structural damage detection and monitoring with AI computer vision

By harnessing the power of AI, we can proactively identify and address potential structural damage to key infrastructure assets, ensuring their continued functionality.

Opportunity

AI-based structural damage detection and monitoring systems represents a significant opportunity for enhancing infrastructure safety. We had an opportunity to use AI to improve the maintenance operations and safety of critical infrastructure, including highways, bridges, tunnels, and other key components of emergency evacuation routes.

Solution

This AI-powered solution automatically detects and monitors damages in infrastructure such as surface cracks, potholes, and ground movements using image analysis. This solution is particularly valuable for structural components without easy access and infrastructure located in remote areas. By analysing images, the system identifies potential issues and alerts authorities, enabling timely interventions to address structural damage.

Outcome

By detecting issues that may compromise safety, authorities can take prompt action, preventing further deterioration and ensuring the longevity of key infrastructure.

Ultimately, this solution promotes safety and resilience of critical transportation infrastructure in emergency situations and leads to cost savings, increased efficiency, and great public trust in the reliability of essential assets.

Building smarter infrastructure for a better tomorrow. **Together.**