PLPR (Plain Line Pattern Recognition) – delivering innovation through OmniVision Edge, positioned by RailLoc

The problem

Plain Line Pattern Recognition (PLPR) is a critical part of Network Rail's (NR) 'predict and prevent' strategy. PLPR is the state-of-the-art technology that monitors and records track condition information and can identify issues such as missing fasteners, excess ballast and ineffective rail clamps.

Currently PLPR data is routinely collected across over 70% of the UK rail network. There is a gap in service delivery for the remainder of the network, these sections rely on manual inspection processes which are expensive, inefficient and rely on having boots on ballast. As part of bridging this gap, it has been identified that some regions require additional services to provide more reliable and timely data.

Existing processes involve manual transfer of data, following recording, to a data centre in Derby within a standardised 72-hour turnaround from receipt to delivery of results. With the technology available today, this is a process which could be significantly improved upon. A team of inspectors validate the candidate defects and positional data with redundancy built into the recording plan to cover any omissions. For instance, these could be caused by the vehicle being off-routed or an incorrect line being reported.

The challenge is to consistently deliver insight directly into the hands of the engineers within a few hours of a defect being found, so that they can make informed maintenance decisions to deliver the 24/7 railway that is required by the modern world.

To highlight the above problem statement, as part of Network Rail's Route Services CP7 Strategic Plan, there is intent to:

Deliver safety critical data to front line staff to ensure productive access time is spent fixing faults not inspecting – resulting in a safer railway.

During requirements gathering for Network Rail's transformational IM Programme, the routes have told Asset Information Services (AIS) that some of their data requirements from future measurement services are[1]:

- More often and more predictable
- Delivered in near real time
- Accurate location
- Greater efficiency
- Data that is more consistent, accurate and reliable

Solving the problem

To solve the problem of delivering valuable, reliable, and accurate insight to end-users, it was critical that stakeholder engagement was put at the forefront of the project's thinking.

Omnicom Balfour Beatty (OBB) and Machines With Vision (MWV) proactively worked with a wider stakeholder group, including vehicle operators, planners, and maintainers, to not only prove the innovative technologies that were being introduced, but also to operationalise them in a way that successfully collects, processes, and delivers insight, to those that require the data, within a matter of hours.

RailLoc

RailLoc[2] from Machines With Vision is a positioning system capable of delivering an accuracy better than 1m everywhere on the rail network – including in GNSS denied environments.

RailLoc combines data from multiple sensors to build an accurate "fingerprint" of the network and uses this to deliver repeat measurements to companion measurement systems through tight time-based synchronisation, by matching visual features back to the fingerprint in a process known as "feature matching". An additional benefit of RailLoc is its capability to provide an assurance of path, this means that once an area has been mapped that the correct line(s) is always reported,

[1]Referenced from "What do our customers want – a technical dive" - IM Programme

[2]https://www.machineswithvision.com/blog/why-choose-railloc-here-are-the-takeaway-reasons

omissions are therefore reduced leading to greater efficiency in planning and reporting.

RailLoc processes data in near real time so that results are available during the shift meaning that maintenance decisions can be made faster and with surety of having the correct information.

On choosing RailLoc for this project, Brendan Rice, Principal Engineer for Mobile Monitoring at Network Rail said:

"*Network Rail owns and manages thousands of track assets and the ability to accurately position an asset or send somebody to a defect has long been an area for improvement.*

The drive to safely complete rectification work as efficiently as possible alongside the requirements for predictive maintenance regimes powered by data insights, has further increased the need for accurate and tightly synchronised asset datasets and meta data.

Complimenting OmniVision Edge on this project to support basic visual inspection, the RailLoc system was chosen as it offered rapid availability of data at the accuracy needed to support digital decision making across multiple assets.

The process flow developed gives a working insight into just how powerful a reality this is."

Figure 1 - RailLoc installed on a Class 153

OmniVision Edge

The award-winning OmniVision system from Omnicom Balfour Beatty is the incumbent system that has been used for PLPR on the Yellow Trains. It combines high resolution cameras and computer vision to provide an innovative technology for inspecting difficult-to-access areas of rail infrastructure.

Figure 2 - OmniVision installed on a Class 153

Using the latest advances in edge processing and machine learning, OmniVision now has the capability to accurately detect defects on-the-fly and deliver these up to the cloud for review and inspection by railway engineers. As a result, this provides value in making critical condition data available faster, allowing track engineers to rectify faults on the infrastructure sooner.

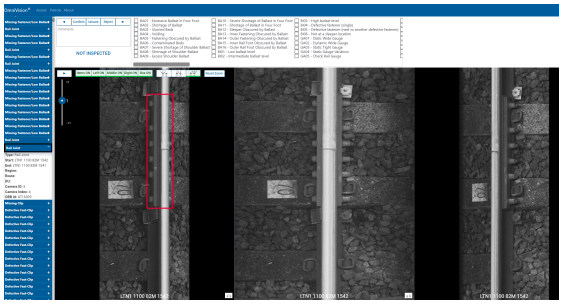

Figure 3 - OmniVision web viewer

The solution

The availability of higher mobile bandwidth, advances in machine learning and the introduction of intelligent edge processing, means that the defect and position data can be applied and automatically transferred off the vehicle for cloud processing. This facilitates faster access to data, gets the data directly to the engineers who need it, removes the cost of manual disk transfer and reduces the associated carbon footprint.

After automatically receiving and sorting through the defect candidates received from the on board

OmniVision Edge system, OBB request positions from the MWV API to locate the candidate defect. The resultant data is made available to end users via the OmniVision Cloud platform. OmniVision Cloud is an easy-to-use, front-end software that allows users to analyse assets and defect imagery in detail to help inform maintenance decisions. This means that the engineers can comprehensively inspect the defect candidate to inform decisions around intervention. A precise position for the defect is provided via RailLoc to ensure that engineers can correctly target the correct location for interventions that need to be applied to the infrastructure.

Collaboration

The Class153 project has been an excellent example of collaboration across multiple organisations. Once the requirements had been identified, OBB and MWV worked closely to establish the optimum interfaces to ensure that all the requirements would be satisfied. This included open and honest lines of communication between the two project teams, by sharing designs and interfaces in a detailed and timely manner. A cloud-based test interface was set up early in the project which allowed developers to test and debug functionality before either system was installed. This approach meant that when both systems were first switched on, the integration worked first time and data was able to flow during commissioning runs.

Corinne Wray, PM from OBB said:

“The communication has been clear and consistent throughout the project lifecycle, with an open and honest approach being taken. This allowed for the successful implementation of intelligent edge-processing to provide defects to engineers within a matter of hours”.

Performance

OmniVision Edge consists of seven linescan cameras, each capable of capturing lines (up to 4096 pixels) at 70KHz. This allows OBB to acquire a synchronised line from each camera every 0.8mm at 125 mph (201 km/h). Images are passed through a set of machine learning models applied on the edge. Detections from the machine learning models are stamped with a time and written to a staging fileshare for transfer to OmniVision Cloud.

Whereas the live PLPR systems operating OmniVision rely heavily on high performance computers within a dedicated data centre to apply image processing routines, OmniVision Edge benefits from the latest in industrial performance computing to apply optimised machine learning to undertake the processing in real time on the recording vehicle.

The staging application can buffer the data, allowing it to be uploaded as and when the network allows.

OmniVision Cloud operates an automated pipeline of applications integrating the OmniVision Edge candidates with other data streams including 3rd party Track Geometry data. The processing routine applies a set of business rules applied to mimic Network Rail Standards for track inspection.

As the OBB and MWV systems are tightly synchronised, OmniVision benefits from the positional accuracy and repeatability of RailLoc. When feature matching, RailLoc can calculate position internally to within 15mm accuracy, outside of these times the accuracy is better than 1m, more than 99% of the time. As part of a system wide validation process, MWV and OBB monitored recordings over two areas over a week-long period. In these areas (SOB2 3100 7 to 11 miles and LTN1 1100 69 to 83 miles), a number of assets were monitored, as the vehicle covered these - the position and imagery were extracted and analysed. These assets include Rail Joints, Crossings and Points.

As an example, a rail joint on LTN1 1100 at 82 miles 1536 yards was monitored. This joint was covered on the 22, 23, 24 and 29 August 2023. The positional spread of the joint measured at the centre was better than 0.2 yards over the four shifts. On each of these shifts, RailLoc exhibited high levels of feature matching at this location. The analysis shows that when RailLoc has high levels of feature matching that the positional spread (the worst-case error) is at this level (better than 0.2 yards). Note

that this figure comprises component error from positional error, timing error and measurement error, overall demonstrating excellent results and synchronisation between the two systems.

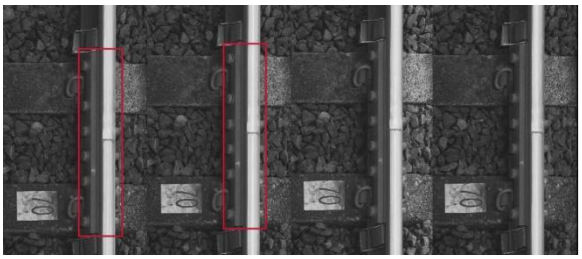

Figure 4 - Joint LTN1 1100 82.1536 across 4 shifts

Where RailLoc does not have feature matching (for example, an unmapped section or an area where remedial action has taken place), then the positional spread has been observed to be better than +/-1 metre, for example, a crossing on SOB2 1100 8 miles 805 yards has a positional spread of 1 metre (+/-0.5m) over the four runs (22, 23, 24, 29 August).

Jonathan Owen from MWV said:

"We have been able to demonstrate and evaluate not only the positional accuracy from RailLoc, but also the ability to synchronise tightly to other systems. The ease of use of the OmniVision Web viewer providing automated identification of assets and defects has made this process swift and simple."

Delivering value

By delivering this new service to routes affected by lower coverage, not only can NR infill omissions and maintain compliance, but the automated nature of the service delivers data more quickly and directly. A minimum overall performance of 84% is needed to achieve compliance (with the existing PLPR service on the IM Fleet), this additional service reduces the pressure on the existing fleet and reduces the need to run recoveries.

The future?

The service is initially being delivered to the Anglia region. The obvious next stage is to open the capability to other routes. The nature of the Class 153s means that areas struggling for compliance can be targeted quickly and data made available within hours of a recording.

On a technical basis, having data at this level of accuracy opens the possibility of change detection of assets that are produced using OmniVision along with automated validation. Having the knowledge that assets and defects are exactly where the system says they are means that these could be automatically monitored. The additional benefits of RailLoc mean that manual validation processes around position can now either be automated or retired.

When does one missing fastener become two? Remedial work on a specific defect can then be automatically tracked and validated. Being able to directly compare images by knowing that they are the same location without ambiguity opens the possibility of detecting defects before they become defects. The goal is to provide less but more valuable data to the engineers by extracting more insight automatically.