Computer Vision applied to turnout Inspection with Drone

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IHHA 2025
13TH INTERNATIONAL HEAVY HAUL ASSOCIATION CONFERENCE 2025

November 17-21, 2025 | The Broadmoor, Colorado Springs, CO, USA

Introduction

Heavy haul rail transport is vital for the economy, surpassing road transport in cost-effectiveness and safety over long distances. The reliability of assets like Turnouts (AMVs) is crucial for operational safety and efficiency. This work presents an innovative solution for turnout inspection, utilizing drones equipped with high-resolution cameras and computer vision systems. This approach enables the early detection of defects such as missing fasteners and wear, facilitating preventive maintenance and increasing turnout reliability. The use of drones reduces risks for workers, optimizes inspection accuracy, and decreases operational costs and service interruptions. This solution has great potential to optimize turnout maintenance, contributing to a safer, more efficient, and competitive railway system.

Experimental work

In the railway universe, Turnouts (AMVs) are essential for safety and efficiency, yet their failures can cause derailments and interruptions. Traditional manual inspections are costly, time-consuming, and risky due to human fatigue and subjective results.
To overcome these issues, this work proposes an innovative solution: using drones with high-resolution cameras to acquire precise AMV images. These images are processed by specific software, generating detailed visual and topographic data. Computer vision then automates the analysis, employing algorithms to identify components, anomalies, critical situations, and perform precise measurements, Figure 1.
This combination of drones and computer vision offers significant benefits:
High-Resolution Data and Precise Analysis: Drones capture detailed images, allowing algorithms to analyze components and anomalies more accurately and reliably than manual methods.
Standardized Inspection: Defined anomaly signatures ensure consistent and reliable results.
Enhanced Safety: Drones inspect areas from a safe distance, reducing risks for workers.
The data generated is essential for strategic maintenance planning, enabling targeted investments, ensuring operational safety, and reducing unnecessary costs. This automated process also reduces service interruptions, significantly improving the railway system's overall competitiveness.

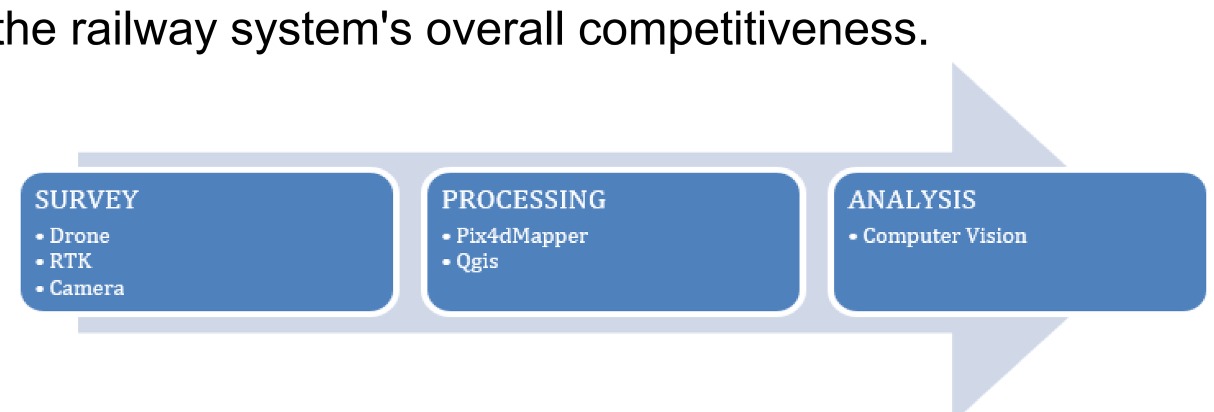

Figure 1. Inspection Process

Results

The automation of railway inspection leverages drone image capture for enhanced efficiency, precision, and safety. This involves a clear methodology: selecting appropriate hardware (drones, high-resolution cameras) and software (Pix4DMapper, QGIS, Civil 3D), alongside comprehensive team training. A detailed workflow, from image acquisition to analysis and continuous testing, is crucial for successful implementation, minimizing risks and maximizing operational benefits.
Processed data, including mosaics, point clouds, and 3D models, are manipulated in QGIS and Civil 3D to extract valuable information like altimetric profiles and geometric irregularities. This detailed analysis, encompassing qualitative and quantitative data (e.g., gauge measurements), ensures millimeter precision, vital for railway safety. Validation through comparisons with traditional surveys confirmed the drone method's superior efficiency and accuracy in fault detection.

Despite initial advancements, manual data analysis presented challenges. Thus, Computer Vision was implemented for automation. The YOLOv8 model, trained on an expanded database of 12,493 images (from an initial 4,417 via augmentations), accurately detects components such as Railway Screw, Clamp, Plate, and various defects like Missing Clamp or Joint Defect, with precision between 87% and 98% per class.
This system generates precise fault reports, boosting efficiency and safety for predictive maintenance. Automation reduced main line turnout inspection cycles by 35%, shifting manual inspections from quarterly to semi-annually. The ability to perform conditional inferences, take quota measurements, and highlight specific risks further refines analysis and decision-making.

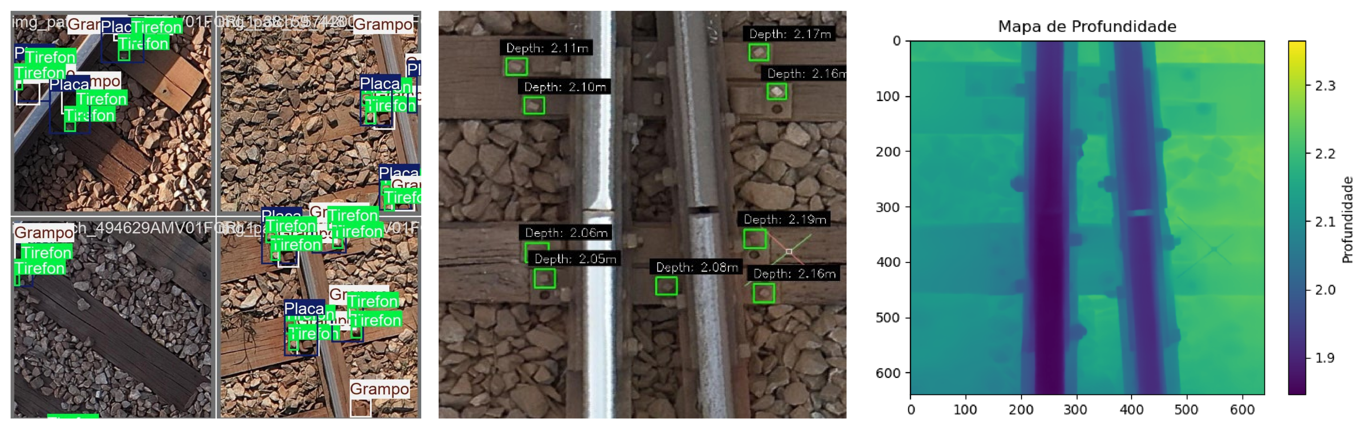

Figure 2: Model Training

Conclusions

Automation with drones and computer vision reduced subjectivity, improved quality, and enhanced safety in inspections. Next steps include comprehensive superstructure analysis and developing intuitive tools for strategic maintenance planning.

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Acknowledgments

We thank all professionals from the involved departments for their dedicated time and guidance in the development of this work.

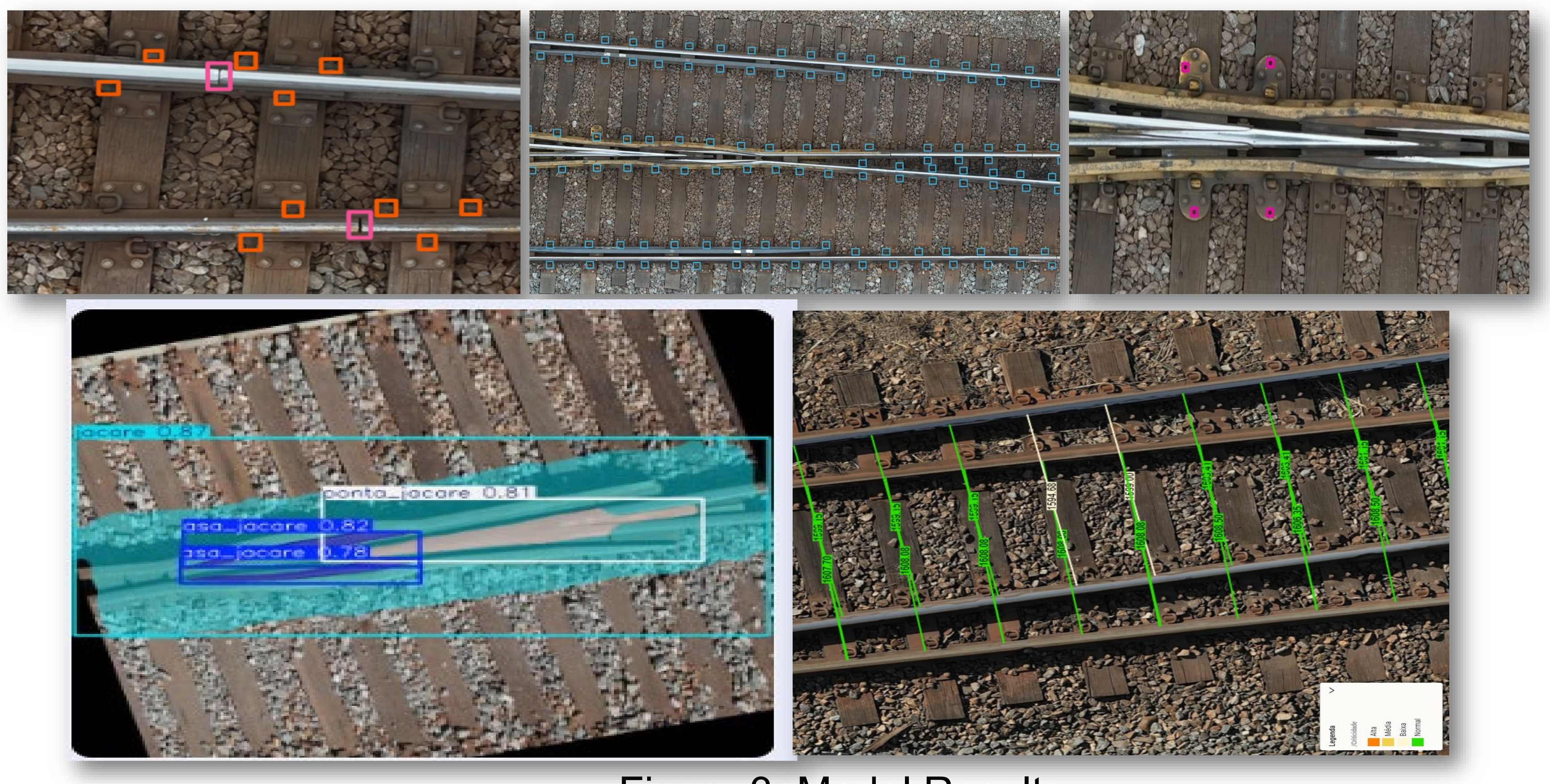

Figure 3: Model Results

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