CYIENT

THE FUTURE OF YOUR TRACKS: AI-POWERED BUILDING INFORMATION MODELING (BIM)

Unlock the future of rail with AI-driven BIM—streamlining operations, cutting costs, and transforming track design from 2D to powerful 3D models. Discover how this innovation is reshaping the industry.

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Abstract

Building Information Modeling (BIM) is transforming the infrastructure industry by providing a data-rich platform that integrates crucial attributes such as geometry and spatial relationships. The use of AI and computer vision further enhances BIM by automating workflows, reducing human intervention, increasing accuracy, and enabling real-time updates. Traditionally, BIM adoption has been estimated to reduce project costs by 20-30% through better planning and the elimination of rework.

However, **Cyient is pushing these boundaries.** By automating the BIM adoption process, we deliver even greater value—achieving **30-40% cost reductions and up to 60% time savings**. Our advanced solution converts 2D railway track drawings into dynamic, data-rich 3D BIM models, using AI and automation to drastically improve visualization, minimize design errors, and accelerate infrastructure planning.

This innovation revolutionizes rail infrastructure management, driving increased collaboration, regulatory compliance, and sustainability. Cyient's approach positions the industry for a smarter, more resilient future, setting a new standard in BIM-driven solutions.

Introduction

In an era where digital transformation is reshaping industries, the railway sector stands at a critical juncture. For decades, rail infrastructure planning and maintenance have been constrained by traditional 2D drawings, limiting the design efficiency, visualization accuracy, and asset management. Cyient is addressing this challenge with a groundbreaking solution. By leveraging AI, computer vision, and Gen AI we've developed an innovative system that automatically converts 2D railway track drawings into detailed 3D Building Information Modeling (BIM) models. This leap from static schematics to dynamic, data-rich 3D models revolutionizes planning, construction, and maintenance - delivering greater efficiency, reduced costs, and smarter decision-making throughout the rail infrastructure lifecycle.

Problem Definition

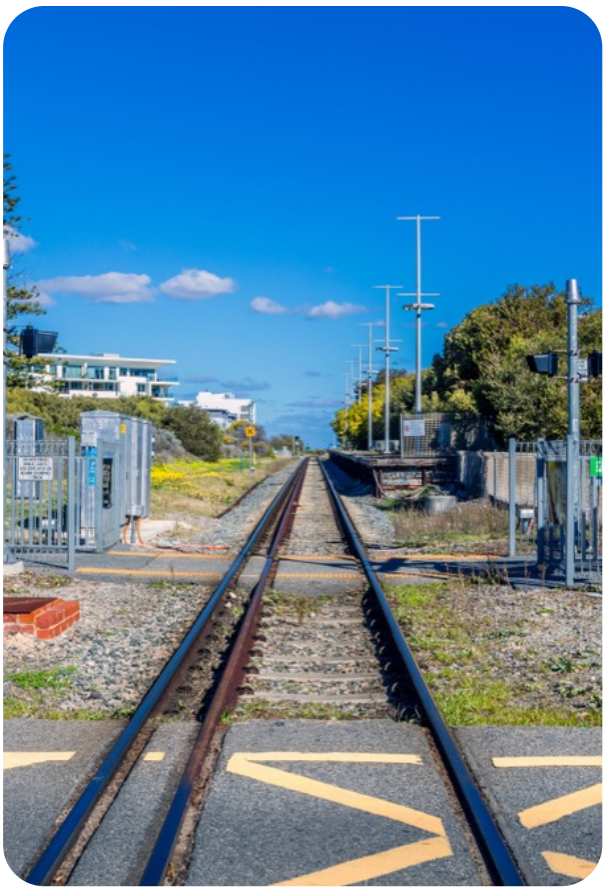
The rail industry faces significant challenges in managing and maintaining infrastructure due to the limitations of traditional 2D track data. These outdated plans hinder precise visualization, complicate planning, and disrupt effective communication among stakeholders. As a result, design clashes often go unnoticed, asset management becomes inefficient, and integrating data across multiple systems proves difficult. These challenges contribute to project delays, increased costs due to rework, and challenges in meeting regulatory requirements. The solution lies in converting 2D track data into 3D BIM models, which enhance accuracy, streamline collaboration, and improve lifecycle management—ultimately driving more efficiency, sustainable rail operations.

What is Building Information Modeling (BIM)?

Building Information Modeling (BIM) is a dynamic, 3D digital process used by architecture, engineering, and construction professionals to represent both the physical and functional aspects of infrastructure. Unlike conventional 2D drawings, BIM offers a comprehensive data-driven platform that encompasses geometry, spatial relationships and other critical details. In the rail industry, BIM enables stakeholders to visualize assets in a 3D environment, identify design issues early, and integrate information from multiple systems. This leads to better decision-making, increased accuracy, improved asset management, and enhanced sustainability throughout the project lifecycle.

High-Level Solution

This solution automates the conversion of large-scale 2D railway track diagrams into detailed 3D BIMs. By harnessing advanced technologies like computer vision and generative AI, it extracts and organizes critical information from 2D drawings, transforming them into accurate 3D representations essential for modern rail infrastructure management. This automated process boosts efficiency, minimizes human error, and enhances asset management, design coordination, and lifecycle planning, making it a vital tool for rail infrastructure modernization.



Solution Details

Key Steps in the Solution:

Data Ingestion and Segmentation

The process begins by breaking down large-scale 2D track drawings, often spanning hundreds of kilometers, into smaller, manageable sections. This segmentation enables more precise and focused analysis, making it easier for AI models to detect and interpret individual assets and their locations within the track layout.

1

Text and Object Extraction

Advanced computer vision models are used to extract key information from the 2D drawings, such as asset names, identification numbers, kilometer markers, and other textual data. Simultaneously, object detection models identify various track-side assets, such as signals, track equipment, and stations, with their coordinates referenced to the segmented images.

2

Data Correlation and Structuring

After asset and textual data extraction, the information is correlated to form a unified representation of the entire track. Each asset's coordinates and kilometer markers are mapped to correspond to their physical locations. This enriched data is then organized in a structured format that reflects the original 2D drawing but now contains enriched data, making it ready for 3D modeling.

3

3D Model Generation

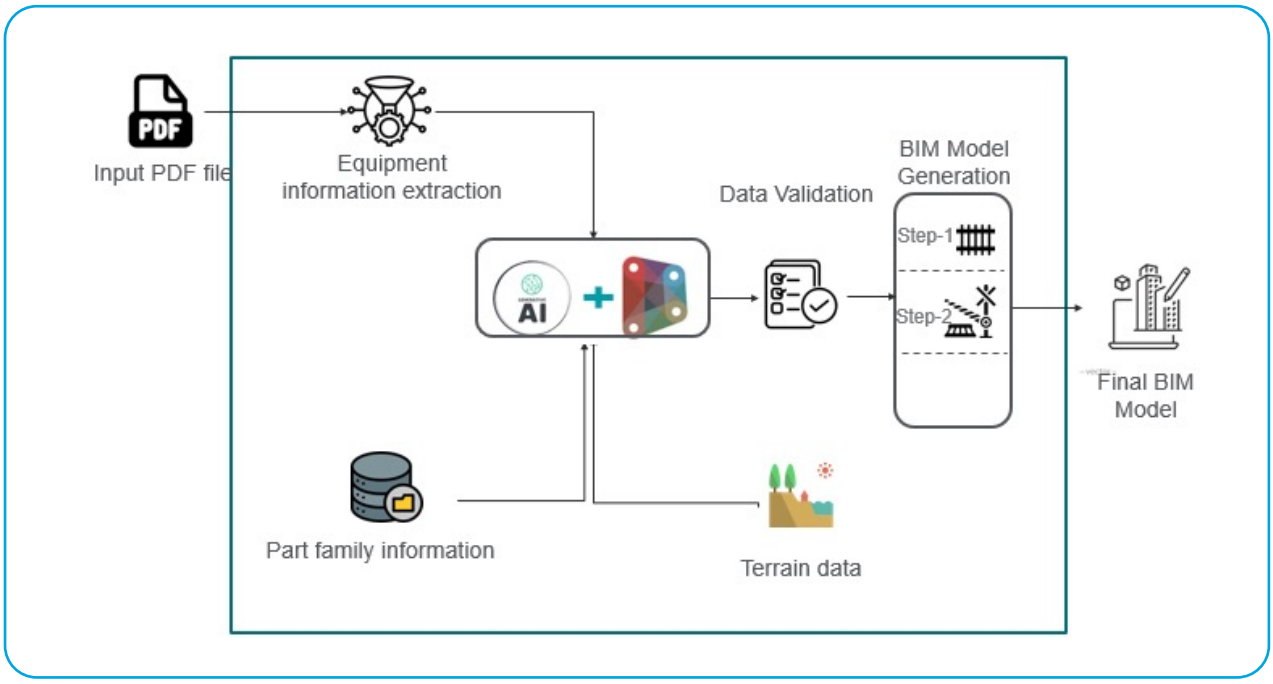
Using the extracted data, the system automates the process of creating the 3D BIM model. Generative AI, access in placing the identified assets and track features into a virtual 3D space based on the calculated coordinates and kilometer markers. The resulting BIM model provides an accurate and detailed visual representation of the track and its surrounding assets, supporting better decision-making in rail design, maintenance, and operations.

4

Human-in-the-Loop for Verification

While the AI-driven process offers significant automation, a human-in-the-loop mechanism ensures accuracy and reliability. Confidence levels are assigned to each extracted asset, and if the AI's confidence falls below a set threshold (e.g., 80%), the data is flagged for manual review. Users can filter and review flagged sections, validating or correcting information before the final 3D BIM model is approved, ensuring high accuracy and minimal errors.

5



High level Diagram

Technology Comparison

AI-driven automation and BIM modeling offer a significant advantage over traditional manual methods in terms of speed, accuracy, and scalability. Manual CAD-based drafting, for example, lacks the ability to automatically extract data, enable real-time collaboration, and integrate comprehensive asset information within the model. In contrast, this automated solution harnesses AI to eliminate manual errors, detect design conflicts early, and improve asset management through a unified, data-driven platform —ultimately enhancing project efficiency and decision-making.

Benefits

In manual operations, this process typically takes approximately 2 hours per 20Km of track, according to experimental data. However, an automation experiment showcased the remarkable potential of computer vision and generative AI to drastically reduce both time and costs. the automated solution delivered a 40% cost reduction per 20Km of track and while cutting the time spent by more than 60%. This highlights the transformative efficiency that AI-driven automation brings to railway infrastructure management.

Enhanced Visualization

BIM offers precise 3D visualizations, minimizing design errors.

Improved Collaboration

It facilitates seamless coordination among stakeholders.

Lifecycle Management

BIM supports asset management throughout the infrastructure lifecycle.

Regulatory Compliance

Ensures that all designs adhere to industry regulations and standards.

Sustainability

Assists in planning environmentally sustainable and resilient infrastructure.

Stakeholder Communication

Enhances communication through data rich, visually engaging models.

Future Adaptability

BIM models can be easily updated to accommodate future modifications.

Conclusion

The transition from 2D drawings to 3D Building Information Modeling (BIM) marks a crucial advancement in addressing critical challenges in railway infrastructure management. Cyient's innovative solution, powered by AI, computer vision, and generative AI, creates a seamless, automated process that vastly enhances accuracy, efficiency, and collaboration. Unlike traditional methods, which face issues such as data loss, complex geometry, and time-intensive manual interventions, this AI-driven approach significantly minimizes those challenges. Compared to outdated CAD-based drafting, which lacks the precision and adaptability of modern BIM systems, AI-powered automation streamlines the workflows, allowing rail networks to be managed and visualized more effectively.

Supporting Technologies & Industry Impact:

Industry experts emphasize that BIM adoption can reduce infrastructure project costs, thanks to improved planning, minimized rework, and early detection of design clashes. Cyient's solution goes even further, offering a **30-40% reduction in costs** and saving over **60% time**, showcasing the tangible benefits of integrating AI into BIM workflows.

Addressing the Competition:

Traditional tools and manual 2D-to-3D conversion methods are no longer scalable in today's fast-moving, regulation-heavy environment. Competing technologies require more time, effort, and prone to human errors during asset extraction and placement. In contrast, AI-driven automation not only enhances accuracy but also offers flexibility to adapt to future needs. Cyient's automated system, equipped with human-in-the-loop verification, ensures high-confidence, data-rich BIM models are delivered with greater speed and reliability than traditional methods.

THE CYIENT THOUGHT BOARD

What is the main problem addressed?

Traditional 2D rail track data limits visualization, causes design errors, delays projects, and increases costs.

How does Cyient's solution improve rail infrastructure?

Converts 2D tracks to dynamic 3D BIM models.

What technologies power this solution?

AI, computer vision, and generative AI automate workflows.

What are the key benefits of this transformation?

60%-time savings, 30-40% cost reductions, better collaboration.

How does it impact project lifecycle and sustainability?

Enhances asset management, regulatory compliance, and adaptability.

About the Authors

Hitesh Palamada is a Practice Lead - Data Science & Data Engineering at Cyient, where he supports clients across industries such as aerospace, medical devices, mining, healthcare, telecom, and utilities in their digital transformation journey. With over 11 years of experience, Hitesh leverages his expertise in data engineering, AI, machine learning, and statistical techniques to drive innovative solutions for customers. His passion for harnessing data to unlock business value has been instrumental in helping organizations streamline operations and enhance decision-making. Hitesh holds a strong background in applying cutting-edge technologies to complex industry challenges and is based in India.

Shyla Kumar Thadikamala serves as the Head of Data Engineering, Analytics, and GenAI at Cyient, with over 24 years of extensive experience leading large-scale IT transformation projects across diverse industries, including Engineering, Industrial, Manufacturing, Banking, and Smart Cities. As a senior executive, Shyla excels in steering strategic initiatives, managing global teams, and overseeing multi-million-dollar transformation efforts. With deep expertise in artificial intelligence, machine learning, and cloud technologies, Shyla is committed to driving operational efficiency and integrating advanced technology solutions to deliver impactful business outcomes.

About Cyient

Cyient (Estd: 1991, NSE: CYIENT) partners with over 300 customers, including 40% of the top 100 global innovators of 2023, to deliver intelligent engineering and technology solutions for creating a digital, autonomous, and sustainable future. As a company, Cyient is committed to designing a culturally inclusive, socially responsible, and environmentally sustainable Tomorrow Together with our stakeholders.

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