Recent Research and Development of Information and Communication Technology Division

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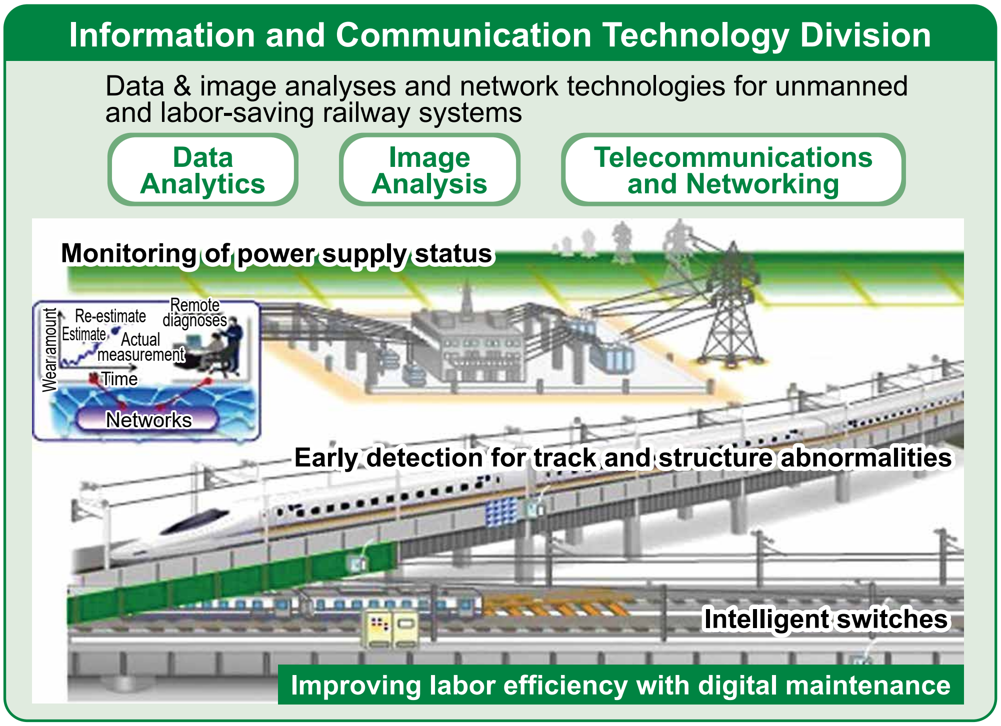
The aim of the Information and Communication Technology Division is "developing innovative railway systems based on digital technologies." Under this policy, we are advancing our research and development (R&D) efforts by developing digital techniques for fields such as data analysis, machine learning, image processing, sensing, and communications networks to improve the labor efficiency in systems like unmanned and labor-saving railway systems. If these techniques are used without any cooperation across disciplinary boundaries, they cannot provide satisfactory results. Therefore, we are working on R&D activities in cooperation with other divisions and research centers. This paper introduces our most recent cross-sectoral efforts.

Introduction

Recent remarkable progress in digital technologies has led to maintenance and service innovations based on digital technologies gaining considerable attention among various industries. The Japanese railway industry is struggling to deal with the impact of the declining working-age population, falling birth rates, and the aging population. Therefore, creating unmanned and labor-saving railway systems in each technical field is essential to maintain and improve the safety and stability in railway transportation.

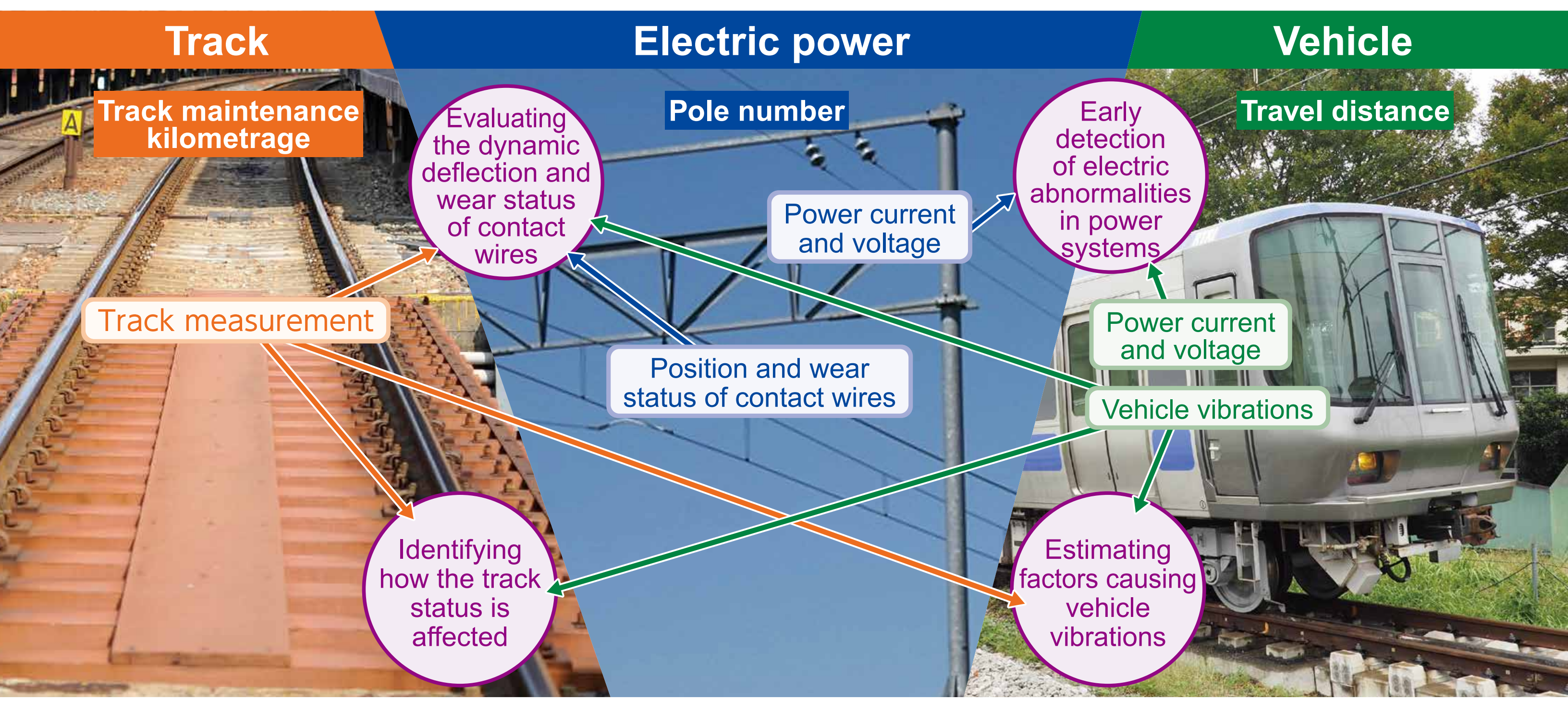
On April 1, 2022, the Information and Communication Technology Division was newly established as a research hub in the organizational reform section of the Railway Technical Research Institute (RTRI) for promoting the cross-sectoral use of digital technologies and developing unmanned and labor-saving railway systems (*Technical fields targeted by the Information and Communication Technology Division*)[1]. We shall briefly overview our subdivisions: Data Analytics, Image Analysis, and Telecommunications and Networking laboratories. The Data Analytics Laboratory carries out R&D related to efficient and sophisticated data analyses, machine learning, demand forecasts, and decision-making to save labor in performing maintenance for tasks such as diagnosing system conditions. The Image Analysis Laboratory is developing safety-enhancement systems and unmanned and labor-saving systems for railway inspection and monitoring with the support of sensing techniques that employ



Technical fields targeted by the Information and Communication Technology Division

cameras and LiDAR(light detection and ranging) sensors along with image processing and machine learning techniques. The Telecommunications and Networking Laboratory is working on applying innovative communication technologies, such as 5G technology, to railway systems and building a shared information infrastructure to support safe and stable railway operations.

Herein, we report recent examples of R&D related to platforms for cross-sectoral data analyses, maintenance data analyses based on machine learning results, safety check support systems at station platforms, and integrated communication networks.

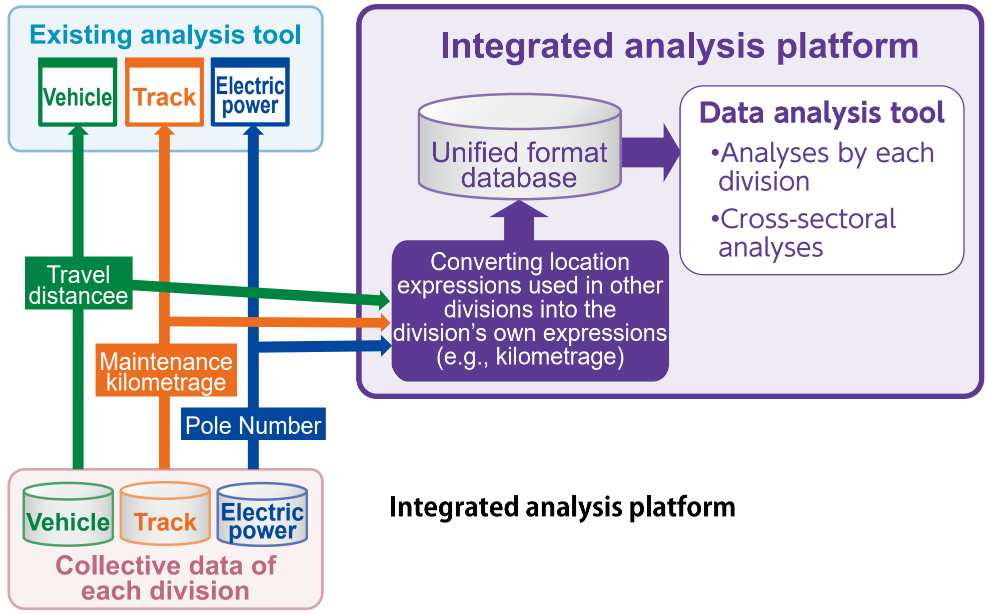


Interaction of mutual technical fields

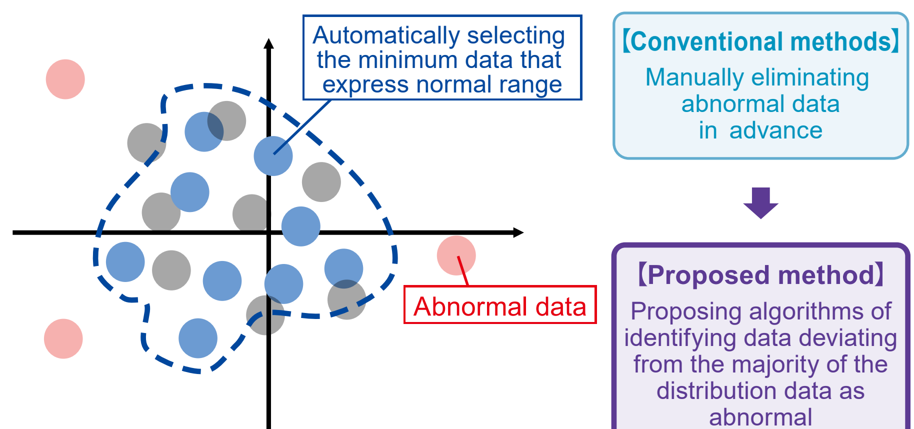
Development of a Platform for Cross-Sectoral Data Analyses

Currently, each technical field have independently acquired and accumulated railway maintenance data and put their heads together to find the best method for analyzing and utilizing these data. Since the railway is a complex system consisting of various interacting components, such as vehicles, tracks, structures, and electric power systems (*Interaction of mutual technical fields*), the underlying factors for any issues may vary across components. Tracks and structures can cause vehicle vibrations, which may further affect overhead contact line systems, including contact wires. The independent analyses conducted in each field showed only one aspect of such complex railway system behaviors. However, if analyzed in a cross-sectoral manner with reference to data from other fields, events that have never been analyzed, such as signs of abnormalities, can be detected.

Considering these demands, we are proposing to develop an "integrated analysis platform" where multiple-field maintenance data can be consolidated and used for cross-sectoral analyses (*Integrated analysis platform*). In this platform, the interconversion of location expressions (e.g., kilometers), which differ depending on the division, enables a division to analyze the data of other divisions using its own expressions. Currently, we have built an integrated analysis platform for test tracks[2]. The data measured in the running tests on the test tracks at the RTRI can be automatically consolidated on a server; we plan to verify cross-sectoral analyses using the consolidated data.



Integrated analysis platform



Method of automatically eliminating abnormal data

Analyses of Maintenance Data Based on Machine Learning Results

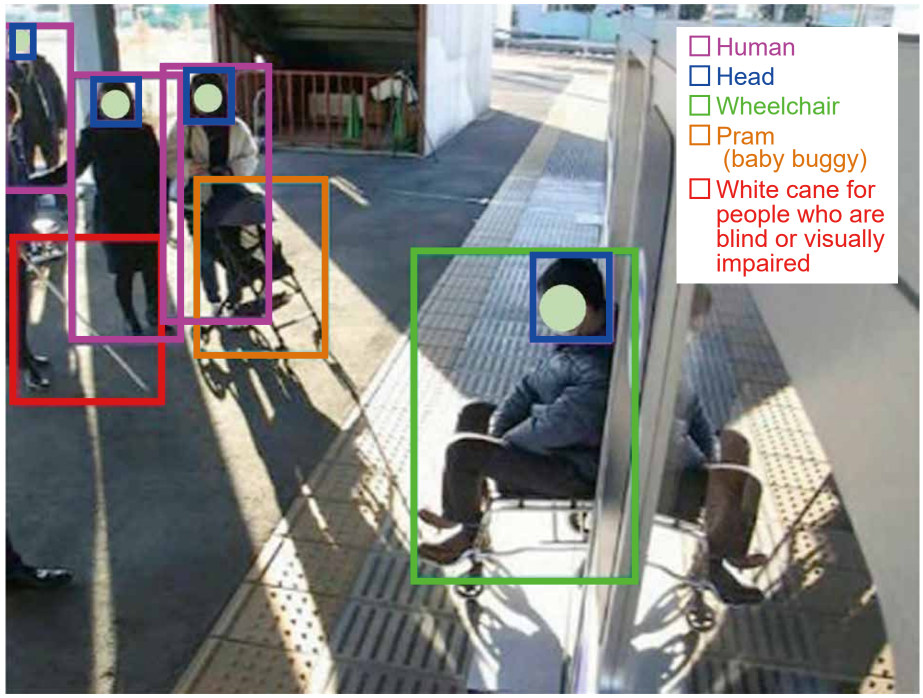
Proactively applying machine learning in analyses of maintenance data can produce benefits, such as promptly detecting abnormal signs. Ensuring successful results in machine learning necessitates plenty of labor such as preparing abundant learning data, manually eliminating abnormal data, and labeling data, which can be barriers to its application. The RTRI has developed machine learning-based methods to detect abnormalities using the vibration data of a vehicle system. Disadvantageously, these methods require manual labor to eliminate abnormal data.

As a countermeasure, we developed a method to automatically eliminate abnormal data in the machine learning process (*Method of automatically eliminating abnormal data*). This method can complete the learning process while identifying and automatically eliminating abnormal data i.e., data that deviate from most of the distribution data. We implemented this method using a commercially available general analysis tool to enable engineers without specialized knowledge in machine learning or programming to analyze maintenance data using machine learning.

Development of Safety Check Support Device for Driver Using Side Camera on Rolling Stock

The safety of passengers on the platform, mainly at departure time, can be visually confirmed by the train crew. In some one-man operation sections, platform safety can be monitored from the cab of a train operator with photographic images captured by cameras installed on the sides of the vehicles; however, the crew is still required to perform visual inspection. To support the inspection, we developed a safety check supporting system[3] that automatically detects passengers approaching vehicles using photographic images captured by cameras installed on the sides of vehicles and notifies the crew thereof. Humans, heads, wheelchairs, perambulators, and white canes for visually impaired people can be detected separately by applying AI models trained on our own data to an algorithm that detects approaching passengers (*AI-based detection of individual detection*).

Through our efforts to improve the high-speed operation and implementation methods specifically designed for each station environment, we developed a system that enables real-time performance with just a CPU, removing the need for an expensive GPU that also generates plenty of heat. Additionally, we downsized the system (to 360 × 260 × 70 mm). If cameras are already installed on the sides of vehicles, the crew can be notified of approaching passengers through this system.

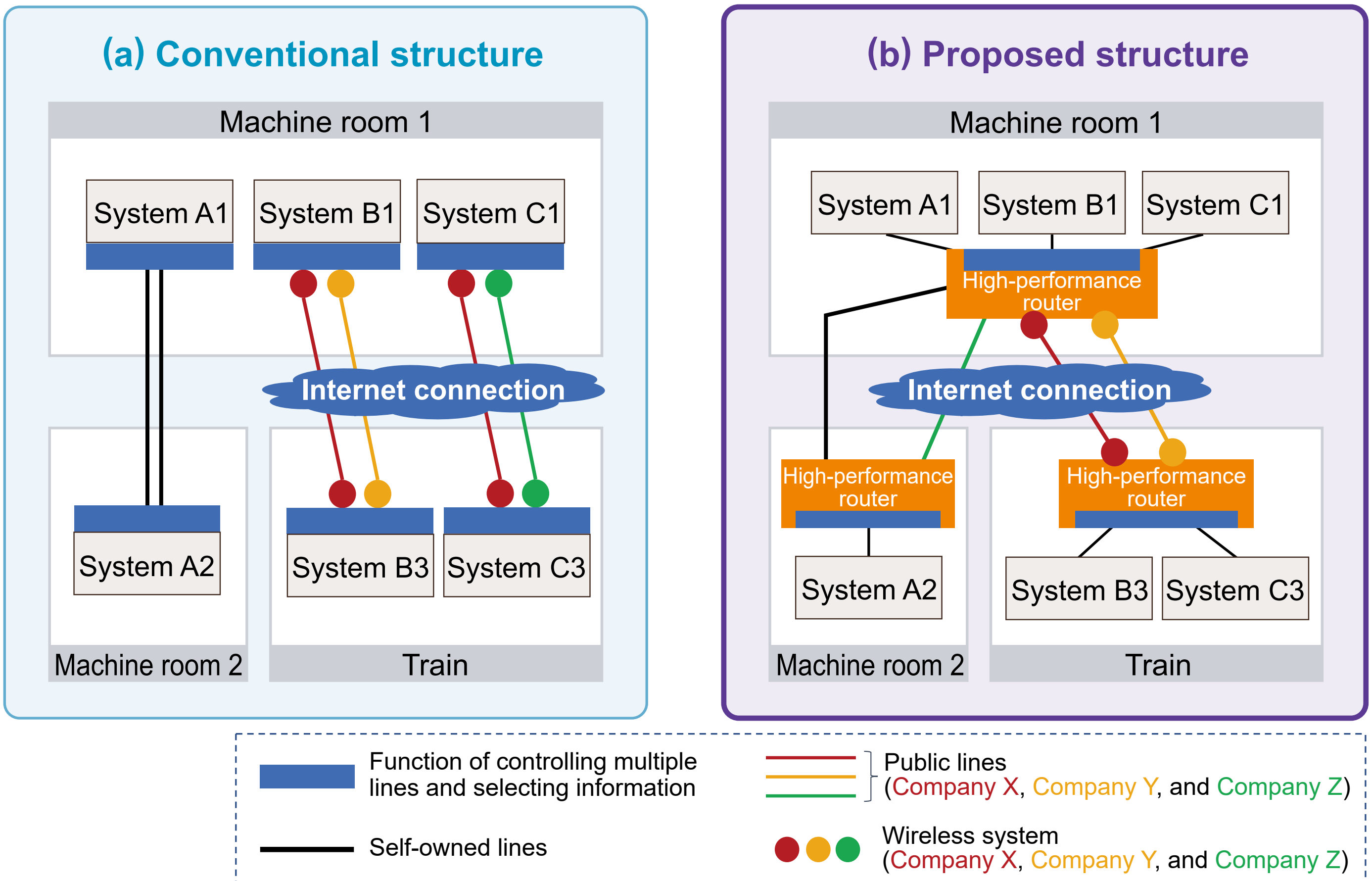


AI-based detection of individual detection

Improving Facility-Saving Strategies and Communication Quality Through an Integrated Communication Network

Many railway-related systems communicate information over networks, most of which are independent and self-constructed (*Method of integrating communication networks*, left). Safety-critical systems often incorporate redundancies by using multiple lines. Redundancy is becoming increasingly important, particularly in systems that use cellular phone networks[4]. Considering the growing use of network-based communications in the future, many wireless systems and communication cables need to be installed in machine rooms and vehicles. Moreover, each system is required to implement control functions that determine the information to be selected from redundant lines, which can impede the efficiency of the procedures.

To help resolve these issues, we have proposed a method of integrating communication networks and switching communication lines depending on factors such as level of importance, priority or network traffic conditions[5] (*Method of integrating communication networks*, right). We performed running tests on the test tracks at the RTRI, in which multiple lines had been combined, and we confirmed that the communication quality of even congested communication networks could be improved. This router mainly consists of a general-purpose router with a function of controlling multiple lines and selecting information added thereto. The general-



Method of integrating communication networks

purpose router can be updated to produce continuous enhancements in the security features.

Conclusions

In this report, we covered relating to maintenance data analyses, as well as applying still image-based methods and the other related to communications networks. For more information on our other research achievements, please refer to the official RTRI website (https://www.rtri.or.jp/rd/division/rd62/).

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