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An overview of the challenges for railway maintenance robots

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***Abstract*— The applications of modern technologies such as robots and AI are yet to be widely deployed in railways. A Railway Inspection and Repair System (RIRS) has been proposed using commercially available Unmanned Ground Vehicles (UGV) and an industrial manipulator for railway track inspection and repair tasks. Using a specially designed trolley enables the on-track and off-track navigation capability of RIRS. The infrastructure in the railway is very diversified and unique in size, shape and remoteness compared to other industries, which creates some unique challenges for the RIRIS. This research investigates these unique challenges to the operation of RIRS imposed by the railway infrastructure.**

Keywords—RIRS, track maintenance, unmanned ground vehicle, manipulators

I. Introduction

The railway has been one of the most prominent modes of transportation for a long time serving the civilizations to grow. The forecast shows a 90% increase in the number of passengers in the UK by the year 2041 compared to the year 2014 [1]. It is vital to reduce the downtime of railway infrastructure by ensuring an optimized inspection and repair technique to meet the demand. Network Rail Limited, owner and infrastructure manager of railway infrastructure (consisting of 20,000 miles of track, 30,000 bridges, and 2500 stations) in the UK, aims to improve efficiency by 17% [2]. Maintenance in the railway industry includes everything such as rolling stocks, tracks, stations, trackside furniture, tunnels, bridges, etc. Among all, track maintenance tasks are vital to ensure the passenger and freight trains.

Most track inspection and repair tasks are conducted by human operators or vehicles with specially equipped tools and sensors. Inspection by a human is very slow, laborious, unsafe and cannot provide concrete information [3], while specially equipped vehicles are efficient in inspection but require human involvement for repair. Due to high operating costs, it is not feasible to use these vehicles for frequent track inspections [4]. As the sensor technologies and computational capabilities have been improved, robots can now replace or assist humans in many 4D (Dangerous, Difficult, Dirty and Dull) tasks [5]. Inspection and repair devices used in the railway can be divided into several groups, such as inspection trolley, TRV (Track Recording Vehicle), RMV (Railway Maintenance Vehicle) etc., as shown in Table 1 [6].

An autonomous ground vehicle, a type of wheeled robots, such as Warthog from Clearpath Robotics, can run in rough terrain. Industrial manipulators, such as the UR10e from Universal Robots, have 6 degrees of freedom and have been used in many industrial applications. The proposed Railway Inspection and Repair System (RIRS), shown in Fig. 1, consists of a mobile manipulator and a trolley, which will perform two tasks: inspection navigation and repair [7], [8], [9] and have both on-track and off-track capability. Compared to other industries, the railway has some unique characteristics in terms of infrastructure. These diversified infrastructures enforce some unique challenges for the movability and limit the navigation capability of the RIRS around the railway track.

TABLE I. Types of maintenance devices in railway

Platforms	*Advantages*	*Limitations*
Inspection Trolley	Easy to transport	Lower speed, only on-track navigation
Self-propelled inspection kart	Easy to transport, multipurpose	Low battery life, only on-track navigation
TRV	High speed, multiple sensors and measurememtns	High cost, only on-track navigation
RMV	Repair task, efficient than human	High cost, only on-track navigation

This paper describes the importance of railway infrastructure asset maintenance to derive the motivation for finding the challenges for the RIRS in the first section. In the later section, unique challenges for the operation of RIRS from the railway infrastructure perspective have been described briefly.

II. Challenges for a RIRS for Railway Infrastructure

Railway infrastructure consists of the track, trackside furniture, stations, platforms, switches and crossings, tunnels, bridges etc. Some of the infrastructures are small such as signal posts or trackside furniture, while some are big such as stations or platforms. Among all the infrastructure, the track is the most critical infrastructure of the railway. Many types of defects can appear in the tracks, and the repair mechanisms are diversified and require different types of tools because of the size, shape, geometry, and materials. Navigating through the track is a challenging task as the rails act as an obstacle of a height of 138mm and uneven trackside areas make it more challenging to navigate. Fig. 2(a) shows the basic track geometry, while Fig. 2(b) shows the capability of RIRS to navigate through the track. Due to the uneven surface, the robot will be exposed to vibration, which will induce noises in the output of the sensors. Railway tracks also have overhead

Fig. 1. Proposed RIRS for railway track maintenance

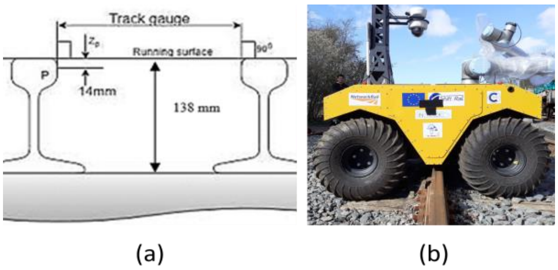

Fig. 2. Movability challenges for a RIRS along the track

electric lines supported by electric poles, which work as a faraday cage for signal blocking. Trackside furniture, point machines, electric motors and heating devices for switches and crossings limit the accessible area of the robot. These objects will work as an obstacle, and RIRS should avoid any collision with these objects for safety. Moreover, RIRS cannot cross over some of these objects as they are very delicate.

Tunnels are confined spaces, have no GPS or cellular signal and dark which imposes additional challenges for the robot. In many old tunnels, the gap between the track and wall is insufficient for off-track navigation. Congested space problems may occur for the railway bridges as well. Platforms are another obstacle which the RIRS cannot overcome. The space between the platform and the adjacent track is not enough for the RIRS, as shown in Fig. 3. RIRS can switch between on-track and off-track navigation with the road-rail conversion process. However, road-rail conversion process requires suitable access points, which are only available in a particular position of the railway track.

The RIRS may get stuck because of all these obstacles and congested space. Due to these challenges, the movability of RIRS is reduced, and off-track navigation becomes challenging, as shown in Fig. 4.

III. Conclusion and Future Work

Some of the conventional railway maintenance tasks are slow, laborious, and hazardous. Robots have good potential to improve the railway track inspection and repair methods because of the improved sensor and computational capabilities. RIRS is a robotic solution for railway track inspection and repair system which has both on-track and off-track capability. Railway infrastructures are very distinct from

Fig. 3. Congested space between the track and platform on the right side

other industrial establishments in terms of size, shape, and remoteness. These unique characteristics of the infrastructures induce some unavoidable circumstances for the RIRS to move along the railway track. Problems become severe when there is no GPS or cellular signal and robot lost communication with the control centre.

The command-and-control centre of RIRS can be designed to keep the safety on mind to overcome all the unique challenges from the railway infrastructures. On-track and off-track navigation capability will help the RIRS to overcome obstacles in congested space as the robot can use the track or trackside area depending on the situation. Moreover, capability of crossing the track extends the area of navigation for RIRS. Loss of GPS and cellular signal can be solved with a proper data budget, data storing capability and local map storing strategies.

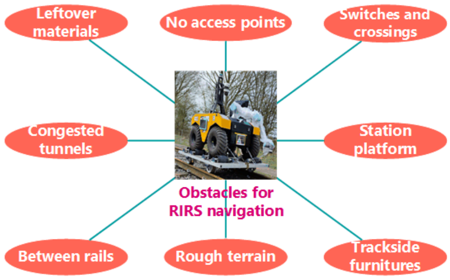

Fig. 4. Obstacles for navigation in the railway track

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