Smart AI-based Waste Management in Stations

DETAILS
SECTOR | Transport
STAGE | Operations and Maintenance
TECHNOLOGIES | Artificial Intelligence (AI), Robots, Sensors

SUMMARY
Artificial Intelligence (AI) is technology that can perform tasks that require human intelligence, such as speech recognition, decision making and visual perception. AI technology can be used in a wide range of different applications including waste management, recycling and cleaning. The introduction of AI powered waste management is becoming more common place in public infrastructure such as train stations, as it provides a more efficient method for the collection and sorting of waste. Specifically, the AI used for this purpose includes ‘bin-bots’, that are mobile robot bins that can move through a defined area within the station, to detect waste on the floor and people wanting to dispose of waste. These bin-bots contain systems that can measure the amount of waste in their compartments and will automatically transport the waste to the station bin collection centre when the compartment is full.

An alternative means of conducting waste management and cleaning in stations is through automatic robots that spray cleaning chemicals (e.g. hydrogen peroxide) onto furniture and surfaces. This spray is atomised to a specific concentration, ensuring that the disinfectant can penetrate small gaps, which are difficult to reach otherwise.

The concept of AI was introduced during the early 19th century in science fiction books. In the 1950s, researchers studied AI in order to understand how machines could think and problem solve like humans. Today, our use of AI is largely related to “big data” across multiple industries. Waste management bin-bots are the next stage of this AI development, with functional cleaning capabilities proving them to be efficient and cost-saving additions to the cleaning workforce.

AI waste management solutions provide a more efficient and automated system for ensuring that station environments are kept clean and litter free. This is essential to provide an attractive and comfortable environment for passengers, that will help ensure they continue to use public transportation (see also the Smart Stations use case) and is also key to keeping shared spaces hygienic, particularly in response to biohazards and disease outbreaks.

Robot waste disposal can eliminate the need for cleaning staff to transport waste throughout the station to the main waste unit. Traditional operations would involve staff checking all the fixed location bins in a station at fixed time intervals. They would need to check if the bins are full, even if they are not. As the robots transport waste from the bins to the main waste collection area, staff no longer need to check the bins. Furthermore, the robot will only transport the waste to the collection area when it is full. Therefore, eliminating any unnecessary trips. This can provide a time saving for stations, allowing staff to concentrate on other tasks.
Due to their mobile nature and sensors, robots can identify when a passenger has waste to dispose of and can travel to that person to enable disposal. In large stations, passengers may be unable to find the fixed bins, or choose not to look for them. Therefore, waste is left in the public space, making the station look unkept and increasing the risk of injury from tripping on waste, pests being attracted to the waste and - if left for considerable time - damage or staining of the station and/or its furniture.

AI cleaning robots can be developed to complete more complex tasks such as mopping of floors, cleaning of bathrooms, cleaning of windows and furniture etc. They could also develop more interactive capabilities enabling them to move around more complex areas or throughout the station precinct.

VALUE CREATED

Improving efficiency and reducing costs:

- Improve efficiency of cleaning activities by optimizing trips to/from main waste collection points.
- Reduce staff cost by replacing with AI robots, or enable staff to be utilized on other often neglected tasks.

Enhancing economic, social and environmental value:

- Enhance the station environment and user comfort by ensuring waste is collected and reduce the risk of slips, trips and falls caused by litter.
- Improve commuter convenience by enabling bins to travel to people when they need to dispose of litter.
- Improve sanitation at stations by enabling continuous cleaning and therefore reduce the risk of disease spreading.

POLICY TOOLS AND LEVERS

Legislation and regulation: Legislation regarding the data security and safety standards of bin-bots and other waste management AI need to be determined, to ensure passenger safety within the vicinity of the technology.

Transition of workforce capabilities: Train station managers and employees should be informed of the methods for cleaning and repairing the bin-bots, to ensure they function correctly. In the case of a technical malfunction, a response plan should be developed to ensure that staff can reduce the environmental impact and hazard, repair the machinery and report the incident.
**IMPLEMENTATION**

**Ease of Implementation**
The station managers and technology providers need to collaborate to ensure the bin-bots are developed to meet the specific station needs, including familiarizing the robots with the station layout, enabling them to detect hazards (e.g. stairways, escalators). Technical developments of the bin-bots to enable additional functionality and service provisions should be investigated. Waste management plans, including recycling, should be incorporated into the system to enable separation of waste by type. This would minimize the need for sorting later in the process. Additionally, a plan for implementation should be developed that addresses where the technologies should be trialled, and where they should be later rolled out, to enable passengers to become familiar with their presence.

**Cost**
The capital investment in these robots is substantial, particularly when done on a large scale. Each robot can cost between USD 10,000 and USD 50,000 depending on the model and its functionalities. They can replace the need for alternative machinery (e.g. commercial floor cleaning machines) and eliminate the need for a human operator. They can reduce the cost of utilities by using water and power more efficiently. They can ensure consistent and efficient operations that reduce ongoing operations costs.

**Country Readiness**
Today, most of the implementations of these robots have occurred in more developed countries like France, Japan and Hong Kong. This is in part a result of the higher labour costs in these countries, therefore making robots a cost-effective solution. Transport and station operators will need to take an innovative view of reassessing their operations and the place for these technologies. Implementations will be most successful in communities that are likely to react in a positive and accepting way to the robots, where their novelty is appreciated.

**Technological Maturity**
Bin-bots and other robot cleaning machines contain camera and 3D lidar sensors to detect obstacles and are reliant on batteries to enable them to move around the station freely. Today, these sensors are mature and are used in other applications across sectors. They continue to advance as autonomous vehicle technology is developed. Today’s batteries can give them approximately 4-10 hours of operation depending on the specific machine. As battery capacity continues to improve, this will extend their hours of operations.

**RISKS AND MITIGATIONS**

**Implementation risk**
Risk: Technological risks related to sensor malfunctions or robot collision may occur, which could result in hazardous situations for passengers or damage to the robot or other station assets. The bin-bots run on battery power, which, if not charged regularly, could result in breakdowns throughout the day.

Mitigation: In order to mitigate the risk of technological malfunctions, maintenance and repairs need to be undertaken and continuous development of the technology must occur. Furthermore, to avoid AI cleaners running out of power, a regular system for charging needs to be implemented e.g. automatic return to a power station when low charge is detected.

**Social risk**
Risk: There is a risk of commuters being disrespectful towards the technology, for example undertaking vandalism and causing damage, which would result in financial loss. There is also a risk of travellers colliding with the AI waste collectors, if they are rushing through the station and/or are unaware of the robot’s presence.
Mitigation: Video surveillance should be used to ensure that any individuals damaging the bin-bots are held accountable, and warnings should be displayed around the station. Furthermore, it is important to gradually integrate this technology into stations, so that users become familiar with their presence. Station managers can opt to initially have the cleaning robots working during quieter times of the day to minimize accidental collision with passengers.

**Safety and (Cyber)security risk**

**Risk:** The AI technology could potentially be hacked by external sources, resulting in technological and safety issues such as collisions with passengers or using the camera for surveillance. Additionally, hacking could result in sensitive information such as video footage and station information being acquired by malicious third parties.

Mitigation: The technology developers and providers need to ensure that their AI is cyber secure, and continual development and maintenance needs to take place to ensure this.

**EXAMPLES**

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<th>Example</th>
<th>Implementation</th>
<th>Cost</th>
<th>Timeframe</th>
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<td>Whiz Cleaning Robot, Japan</td>
<td>The robot vacuum using LiDAR sensors to detect objects. It can clean for 3 hours on a single charge and cover up to 15,000 sq. feet at a time.</td>
<td>USD $499 per month from Japanese tech giant SoftBank. Can be deployed at offices, stations etc.</td>
<td>Central Japan Railway Co. has been using cleaning robots at its stations since 2016.</td>
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<td>‘BARYL’ Smart Waste Bin, SNCF, France</td>
<td>The robot embeds LiDAR technology and cameras and uses beeps and flashing LEDs to interact with users. A probe analyses its fill level and controls the return of the bin to its base for cleaning. Station operators find the waste bin robot both unobtrusive and convenient.</td>
<td>It cost more than EUR 10,000 to develop BARYL.</td>
<td>The development of the robot was completed in 6 months (in 2016) and was then put on trial in Paris Gare de Lyon station for one week during peak hours. It was then trialled across 25+ stations in France through 2017.</td>
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<td>Deep Cleaning Robots, Hong Kong</td>
<td>Deep cleaning robots which spray vapourised Hydrogen Peroxide into the air, is being used in Hong Kong to improve train hygiene standards during COVID-19.</td>
<td>The robots cost HK 1 million each (USD 129,000). Hong Kong’s Mass Transit Railway deployed a fleet of 20 to decontaminate areas where confirmed COVID-19 patients had been.</td>
<td>The transport agency began using this technology in 2020 in response to the COVID-19 pandemic.</td>
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<td>Neo Floor Cleaning Robot</td>
<td>A commercial floor cleaning robot by Avidbots that is used across several sectors including airports, warehousing, facilities management etc.</td>
<td>Neo costs around USD 50,000 and a typical service plan costs USD 500 per month, adding another USD 6,000 a year. A ride-on floor cleaning machine would cost USD 15,000 and the labour cost could be USD 27,000. Therefore, the initial investment in Neo is paid off in two years.</td>
<td>Avidbots was founded in 2014 and has since expanded its operations to serve many major clients across multiple industries.</td>
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