Delivering Super Secure Society through Data Driven Smart Spaces

The places where people travel, work, learn and socialize including airports, stations and entertainment venues are subject to increasing pressure in mature societies. They are often aging, under invested, over-crowded and subject to a range of threats from crime and terrorism to the global COVID-19 pandemic. Hitachi's vision is to make the spaces where people travel, work and meet safe, resilient, efficient, flexible, contactless, trusted and sustainable. This article describes how this vision will be achieved through a combination of sensor and video intelligence, advanced analytics and integrated digital control center solutions.

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1. Introduction

The spaces where people travel, work, learn and socialize including airports, stations, schools, shopping centers and entertainment venues that are central features of civil society have been subject to increasing pressure in mature societies for some years. They are often aging, under invested and over-crowded; in short, not very "smart." These fragilities have been cruelly exposed in recent years. They have become "soft" targets for criminals and terrorists and the attacks on London's transport system in 2005, Brussels Airport in 2016 and Manchester Arena in 2017 are only a few examples. The global COVID-19 pandemic further exposed the fragility of these spaces as potential hot-beds of infection with entertainment and shopping facilities closed; and travelers avoiding public transportation.

Hitachi's vision is to make the spaces where people travel, work and meet safe, resilient, efficient, flexible, contactless, trusted and sustainable. The company believes that it is possible to deliver this vision through a combination of solutions and technologies including; the use of video and sensor intelligence to track risks and threats; advanced modelling and simulation software to enable rapid response including the optimisation of customer flows and deployment of staff and resources; and digital control centers to provide integrated oversight and continuous improvement. This article outlines Hitachi's activities and plans to deliver this vision for "smart spaces."

2. Smart Space Initiatives—Overview

Hitachi's big picture for smart spaces has three key components (see **Figure 1**):

(1) First, image, sound, heat and movement sensors attached to fixed spaces, people or equipment are connected to a sensor intelligence system, such as Hitachi's Multifeature Video Search (MVS) system[(1)], that is able to sense and track risks such as someone leaving an bag unattended; or to dangerous levels of congestion in stations;

(2) Second, advanced analytics using the concept of human, machine, material, and method (4M) is used to simulate, model and optimise the flow of customers as well as the deployment of supporting staff, equipment, and materials – providing a "think and act" capability;

(3) Third, the digital control center provides a single integrated "manage and improve" window on the smart-space, enabling managers to assess risks, plan resources, and respond rapidly to changing pressures and events.

There are a wide range of smart space use cases as shown in **Figure 2**, including:

(1) Assuring citizen safety against criminal and terrorist activity, infection transmission and accidents;

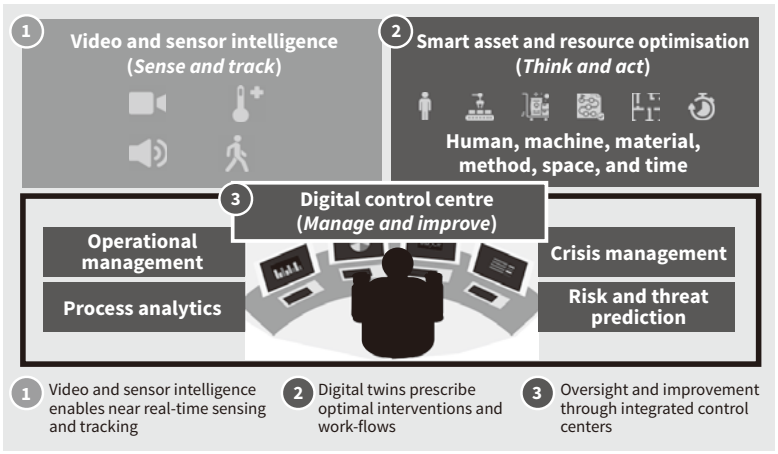
(2) Optimising the flow of customers through smart spaces such as train stations and airports;

(3) Scheduling the deployment of staff and assets, e.g. porters in hospitals or passenger buggies in airports;

(4) Improving worker safety in factories and construction sites;

Figure 1 — Smart Space Solution Components

A smart space has three requirements: a video and sensor intelligence system for sensing and tracking, an analytics simulation function that optimises the allocation of assets and resources, and a digital control centre that manages the entire space in an integrated manner and promotes continuous improvement.



(5) Remote asset inspection using drones.

These use cases can be applied to multiple environments from traditional "smart spaces" such as stations, airports, and entertainment venues; to other sectors such as manufacturing and construction. The following sections describe Hitachi's work across the three areas outlined above.

2. 1
Video and Sensor Intelligence

Hitachi has developed artificial intelligence (AI) technology that can track people and objects in near-real time using video surveillance systems. This is done using an analytics engine that is able to search through a large number of images, captured across multiple video cameras, at high-speed to identify people and objects that have similar visual characteristics (for example, hair and clothing color) to those within a specified image. This technology is used within the MVS system to identify and track potentially suspicious objects and behaviour in public spaces including the detection of left baggage that has become a significant security concern in recent years. For example, more than 1,000 operations were carried out in the first nine months of 2017 to deal with unattended luggage at Paris-Charles de Gaulle airport causing more than 400 flights to be delayed[(2)].

Hitachi's application, developed through collaborative creation (co-creation) with a European airport, alerts

Figure 2 — Smart Space Use Cases

Smart spaces have a wide range of uses, such as confidence against infection, security for public facilities, and ensuring safety at production sites.

Use cases	Trains and stations	Airports and seaports	Entertainment venues	Shopping malls	Factories	Construction sites	Smart cities	Example solutions
Confidence against infection	●	●	●	●	●		●	Dirty surface visualisation, face mask detection, social distancing
Protection against terrorism	●	●	●	●			●	People tracking, left baggage detection, suspicious behaviour identification
Accident prevention (customer)	●	●	●	●		●	●	Suspicious and anomalous behaviour detection
Speedy customer flow	●	●	●				●	Smart parking, passenger flow optimisation
Optimised flows and resourcing	●	●			●		●	Dynamic train scheduling, smart asset and resource optimisation
Improved worker safety	●	●			●	●	●	Worker activity and posture analysis, protective clothing compliance, secure zones
Intelligent asset maintenance	●	●	●		●		●	Sensor (including drone) enabled asset diagnostics

security staff in the event that bags are left unattended; then identifies the distinguishing features of the person who left the bag; and enables people with those features to be tracked through the airport so that security staff can intervene or take appropriate counter measures. This has the potential to reduce security costs as well as avoiding unnecessary suspension of airport services.

Hitachi also participated in a railway security project in Germany, in which the MVS system was extended to cover further safety and security use cases such as the identification of people lying down on the platform. A further use case was developed in collaboration with the German Research Center for Artificial Intelligence (DFKI) to use sensor intelligence to detect patterns of worker movement and posture to improve safety and productivity.

As the pandemic hit Europe in March 2020, Hitachi innovated rapidly to deliver a suite of COVID-19 solutions to identify high-touch surfaces conveying the risk of cross-infection; social distancing risk; as well as breaches of face mask rules.

Europe has strict laws and regulations on the use of personally identifiable data including the General Data Protection Regulation (GDPR); and the use of video and sensor data is a particularly sensitive issue. Consequently, Hitachi is developing a privacy platform that enables the insights from video and sensor data to be exploited without compromising citizen's rights to privacy (see **Figure 3**).

2. 2
Smart Asset and Resource Optimisation

Significant opportunities exist to combine sensor and video intelligence technologies solutions with digital twins that simulate, model, and optimise customer and staff workflows and the deployment of resources. This is critical not only to making these spaces safer, but also more resilient and better able to counter issues of over-crowding and congestion. Hitachi's work here extends the "4M" concept, initially developed for manufacturing, to optimise smart spaces across six key dimensions – human (customers and staff); machine (assets and equipment); material (consumables); method (workflows and assignments); space (e.g. airport check-in) and time.

An example of Hitachi's current social innovation focuses on optimising passenger flows through congested spaces such as railway stations (see **Figure 4**). The solution uses sensor intelligence and advanced optimisation to address three problem scenarios including:

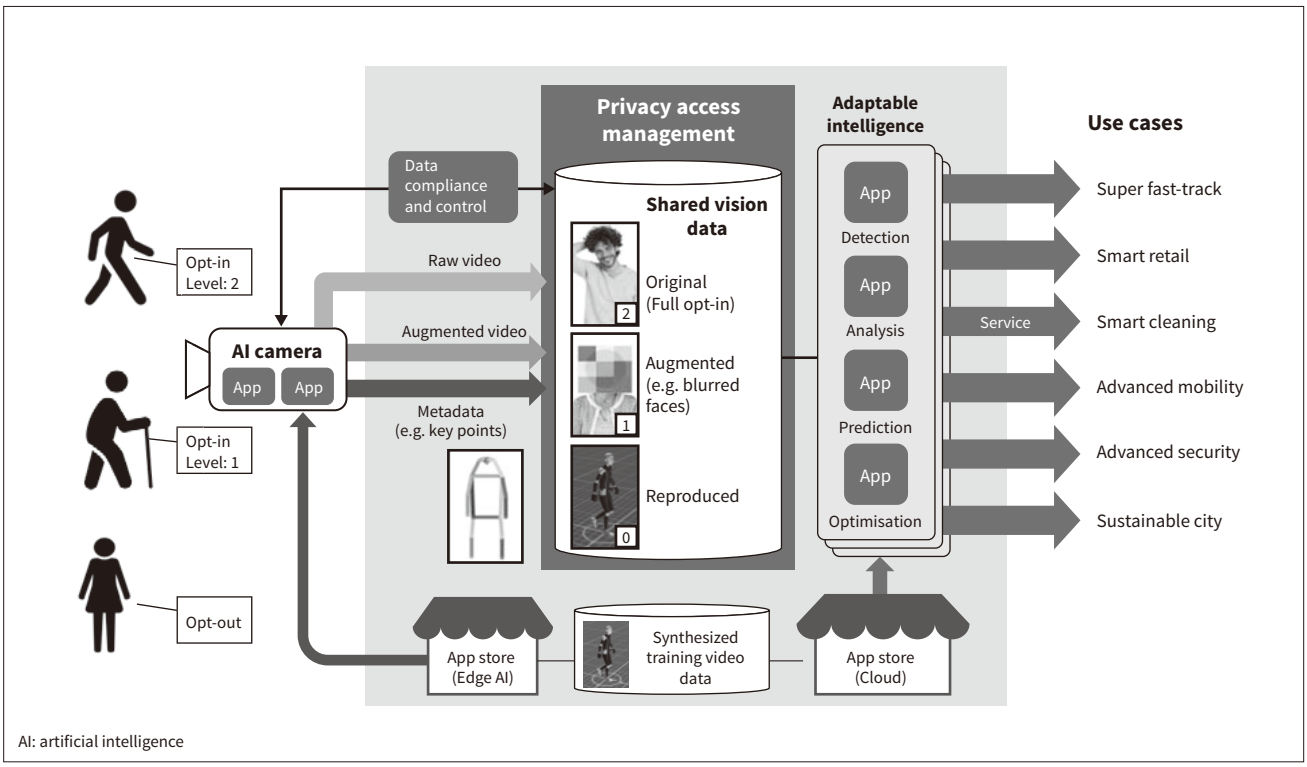
(1) Crossflows: Passengers with different destinations reduce mobility and make it difficult to avoid close contact.

(2) Congestion points: Large volumes of people accessing or leaving platforms causes congestion at gates, escalators, and stairways.

(3) Contraflows: The movement of people in opposite directions in corridors and staircases reduces capacity and increases the possibility of viral transmission.

Figure 3 — Privacy First Cloud Concept

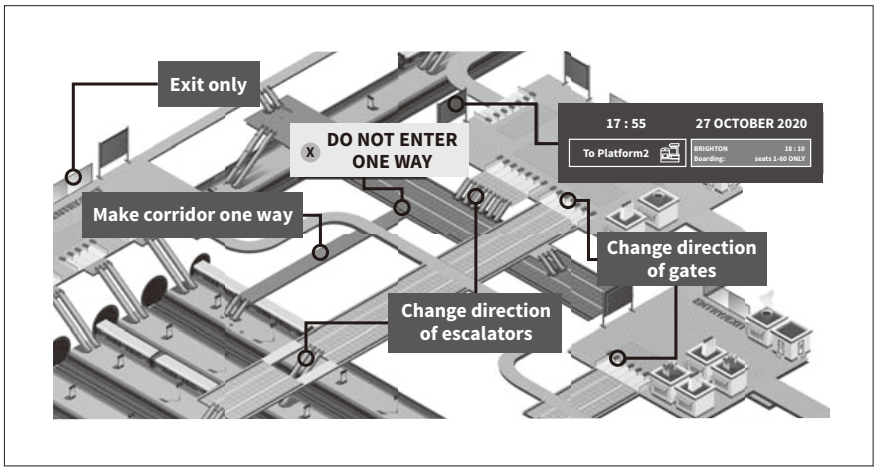
Privacy protection is important when utilizing security camera images. Hitachi's privacy platform can utilize video data without infringing on the privacy rights of the people captured by the camera.



AI: artificial intelligence

Figure 4 — Example of Opportunities to Optimise Passenger Flows in Rail Stations

The configured infrastructure and digital signage work in concert to create a smooth flow of people by optimising the paths of all travellers to reduce congestion, enable physical distancing, and minimize transit times.



The solution aims to minimize crossflows, congestion points, and contraflows by limiting passenger volumes entering the station; dynamic switching of gate and escalator direction; and electronic route signage including one-way designation of corridors and staircases. As passenger volumes and routes change throughout the day, the system will automatically adjust to ensure optimal passenger flow. The solution employs mathematical programming in combination with machine learning in order to calculate the configuration of resources that optimally satisfies weighted objective functions determined by the smart space operator. Objectives may for example represent total travel distance or time and/or total number of passengers affected by congestion. Objectives are optimised respecting physical constraints of the infrastructure e.g. escalator capacity and availability of resources; and the results are communicated directly to equipment and staff devices.

Other use cases for combining video and sensor intelligence to optimise the deployment of assets and resources in smart spaces include directing cleaning activities to target and prioritize high-touch surfaces in airports and train stations.

2. 3
Integrated Digital Control Center

The digital control center provides a single integrated window on the smart-space; connecting sensor technology, operational systems, and advanced analytics; enabling managers to assess risks, plan resources, and respond rapidly to changing pressures and events. For example, a large UK hospital trust needed to improve operational delivery; better respond to fluctuations in demand; and optimise the use of its resources and assets. The digital control center, implemented by Hitachi will provide staff with the information they need, in a timely and visual manner, to better match resources to patient needs, including the allocation of beds, operating theatres, and equipment, resulting in reduced waiting times and optimised pathways for patients.

3. Conclusions

Hitachi has developed a number of smart space solutions aimed at protecting citizens from terrorist threats and viral infection. As a next step, the company will use advanced analytics to simulate, model and optimise the deployment of staff, resources, and customer flows. It believes that this work is essential to building back better after the global pandemic; ensuring that the transport, entertainment, work, and community spaces and services that are essential to our civil society are safe, trusted, convenient, and efficient. Hitachi sees the opportunity to leverage these solutions globally into wider smart city applications such as dynamic traffic and mass transportation optimisation.

References

1) H. Okita et al., "AI-based Video Analysis Solution for Creating Safe and Secure Society," Hitachi Review, 69, pp. 687–693 (Sep. 2020).

2) T. Otley, "Paris Aeroport Launches Campaign on Unattended Luggage," Business Traveller (Nov. 2017).

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Current work and research: Leading Hitachi's social innovation in smart spaces and digital trust.