Disruptive Technologies and
Digital Transformations for Society 5.0

Amit Kumar Tyagi
Niladhuri Sreenath

Intelligent Transportation Systems: Theory and Practice

Springer

Disruptive Technologies and Digital Transformations for Society 5.0

Disruptive technologies and digital transformations for Society 5.0 aims to report innovations to enable a futuristic society in which new values and services are created continuously, making people's lives more conformable and sustainable. It aims to present how problems can be solved in different areas, including mobility, health, agriculture, food, manufacturing, disaster prevention, and energy to name a few. Society 5.0 framework is based on data captured by real-world sensors and sent to the virtual cloud world for Artificial intelligence (AI)-based analysis, which in turn will return to the real world in physical form through robots, machines, and motor vehicles. People, objects, and systems are all connected in Society 5.0 and converge in cyber and physical space to collect a large amount of data from a variety of sources using sensors and devices. In Society 5.0, new values created by social innovation eliminate regional, age, gender, and language disparities and enable the delivery of personalized products and services that meet many individuals and potential needs. Digital transformation marks a radical rethinking of how an organization uses technology, people, and processes to fundamentally change business performance. Disruptive technologies including AI, affective computing, Blockchain, biological computing, cloud computing, emotion theory, human-computer interaction, Internet of Things (IoT) predictive analysis, probabilistic methods, swarm intelligence, socio-cognitive neuroscience, quantum computing, web intelligence have monumental roles to play in digital reality and Society 5.0. These technologies are shifting the economic landscape and the time has come to imbibe these technologies and empower organizations to exploit them now and in the future. The Series accepts research monographs, introductory and advanced textbooks, professional books, and reference works.

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- Special focus on AI, affective computing, Blockchain, biological computing, cloud computing, cognitive intelligence, digital business transformation, decision sciences, e-health services, emotion theory, Futuristic digital society, habitat Innovation, human-computer interaction, Internet of Things (IoT), Internet of Humans (IoH), IoT-oriented Infrastructure, mobile computing, neural computing, predictive analysis, probabilistic methods, resilience in cyber-physical systems, robotics and automation for futuristic applications, swarm intelligence, synergies, and tradeoffs of food, energy, and water (F-E-W) nexus, socio-cognitive neuroscience, smart homes, and smart buildings, smart mobility and transportation, smart factories, embedded devices, quantum computing, and web intelligence to name a few.

Amit Kumar Tyagi · Niladhuri Sreenath

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Amit Kumar Tyagi
Department of Fashion Technology
National Institute of Fashion Technology
New Delhi, Delhi, India

Niladhuri Sreenath
Department of Computer Science
and Engineering
Puducherry Technological University
Puducherry, India

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Preface

Since nineteenth century, we have seen major development in vehicular technology, but still ITS is in growing phase, enhancing safety, energy and fuel efficiency, comfort, and economic growth. ITS with high-level automated driving (and vision) over road is called as connected vehicle. Vehicle connectivity and information exchange over the road is an essential requirement for other users in future with automated driving/for driverless cars. Each vehicle can connect with another vehicle and can get situation about further routes. Note that ITS use information and communication technologies (ICTs) to deliver transport improvements instead of extending physical infrastructure, thereby saving money and reducing environmental impact. This book will be used to understand ad hoc network structure from nineteenth century to twenty-first century, i.e., from man-based controlled vehicles to intelligent transportation system/unmanned vehicle. Note that VANET (intelligent transportation system is a type of VANET) will be discussed in detail like research work done by scientific community toward VANET, issues, and challenges. Autonomous intelligent vehicles (AIVs) (vehicles which use intelligence and automation to control themselves) pose unique challenges in robotics that encompass issues of environment perception and modeling, localization and map building, path planning and decision-making, and motion control. At last, several applications of vehicles with Internet of Things (IoTs) will be discussed like health care, logistics/supply chain management, etc.

In near future, AIV will face many requirements like online data storage, online communication, online maintenance, and fault tolerance. All such requirements belong to dynamic and will change frequently. This book provides fundamental principles of ITS with a comprehensive insight and state of the art of normal vehicles, vehicular technology, connecting vehicles, and intelligent vehicles/ autonomous intelligent vehicles. Many students/readers (newcomers) to this era face several difficulties in understanding this topic and feel so difficulty in grabbing the concept of ITS. This book will help such readers and will provide an in-depth understanding about vehicles, its internal structure, types, and its related fundamental principles. This book will leave readers/researchers at future vehicles like autonomous vehicles, hybrid vehicles, AIV (i.e., in the necessity of future transportation), and autonomous decentralized systems (ADS). With an emphasis on both high-level concepts and practical

detail, the text links theory, case sties with real-world scenarios, algorithms, and issues of hardware and software implementation in autonomous intelligent vehicle research. This book gives a boost for new researchers/young researchers to do their research with complete information about network technologies/or finding a problem for their research work (with respect to vehicular network).

New Delhi, India — Amit Kumar Tyagi
Puducherry, India — Niladhuri Sreenath

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Dr. Amit Kumar Tyagi
Dr. Niladhuri Sreenath

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About the Authors

Amit Kumar Tyagi is working as an Assistant Professor in National Institute of Fashion Technology, New Delhi, India. He has worked as an Assistant Professor (Senior Grade) and Senior Researcher at Vellore Institute of Technology (VIT), Chennai, India (the period of 2019–2022). He received his Ph.D. Degree from Pondicherry Central University, India. He is a Member of the IEEE society. His current research focuses on machine learning with big data, blockchain technology, data science, cyber-physical systems, smart and secure computing, and privacy. He has contributed to several projects such as "AARIN" and "P3-Block" to address some of the open issues related to privacy breaches in vehicular applications (such as parking) and medical cyber-physical systems.

Niladhuri Sreenath is a Senior Professor in the Department of Computer Science and Engineering at Puducherry Technological University, Puducherry India. His primary research interests are WDM optical networks, privacy, and trust. He obtained his Ph.D. in Computer Science from the Indian Institute of Technology, Madras, India.

Chapter 1
Introduction to Intelligent Transportation System

Abstract This chapter provides an overview of wired, wireless, and vehicular technology, information on intelligent transportation technologies, how wired, wireless, and vehicular technology has evolved, and how wireless communication works. In addition, this chapter briefly discusses wireless communication, the future of intelligent transportation systems and smart cities, a cooperative system on the road, and intelligent transportation. Aside from that, the chapter analyzes intelligent cities and related artificial intelligence techniques and contemporary concerns and challenges in wired, wireless, and vehicle technologies. It's impossible to ignore the importance of transportation in today's society. Onboard computers are becoming increasingly common in automobiles and trucks. Businesses and individuals desire cars that can connect to the Internet. Even though this should cover most of the country, technology is not universally available. In automobiles, sensors are used in more ways than ever before. Allowing movement between vehicles so that one terror can use the information provided by researchers to figure out where the cars are coming from can be beneficial. These are the most efficient methods for ensuring that people do not make any mistakes in the shortest time possible. In recent years, the automobile industry and academics have shown a strong interest in intelligent transportation systems, which improve road safety and traffic management. Because intelligent transportation systems use wireless communication, people must be concerned about security and privacy.

Keywords Intelligent transportation system (ITS) · Information and communications technologies (ICTs) · (PDAs) · (DSRC) · Internet of Things (IoT)

1.1 Introduction

The population has grown over time, which has led to cities growing and developing. This has required the construction of new infrastructures to provide citizens with new transportation systems and meet their transportation needs, which has led to cities growing and developing over time. People should drive their cars down the road [1]. It's also bad if too many people use it simultaneously, which slows down

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transportation systems, increases travel times, air pollution, and fuel use. Public infrastructure safety and efficiency are becoming more and more critical, and this is making people think about the idea of ITS. New technologies will be integrated into the transportation infrastructure to get around safer and more efficiently. This will also make transportation more environmentally friendly and profitable for people. It has been long since information and communication technologies (ICTs) have developed new intelligent transportation apps. A lot of work has been done on cooperative driving [2]. In this idea, everyone in the transportation system can work together to avoid accidents and make drivers safer. They can do this by exchanging real-time information and making the roads less dangerous. It also has essential information about how to run infrastructures.

- **Wired Technology**

People who work with computers use "wired" to separate wireless connections from those using wires. Some wires move data between different devices and computer systems in a wired setup. There are many different types of wired networks out there [3]. Most wired networks use Ethernet cables to move data between the connected PCs. If only a few people are in a wired network, a single router may be enough to connect them all. Many routers or switches join many more extensive networks than small ones. Other things may also be "wired." Now, there are a lot of keyboards and mice that don't need to be wired to work. It isn't common to call things like monitors and external hard drives wired devices because wireless options aren't widespread, so it isn't general to call them that. There is wired technology in the intelligent transportation system shown in Fig. 1.1.

- **Wireless Technology**

Many things, like two-way radios and cell phones and personal digital assistants and wireless networking, are part of this category [4]. It can also be used in GPS

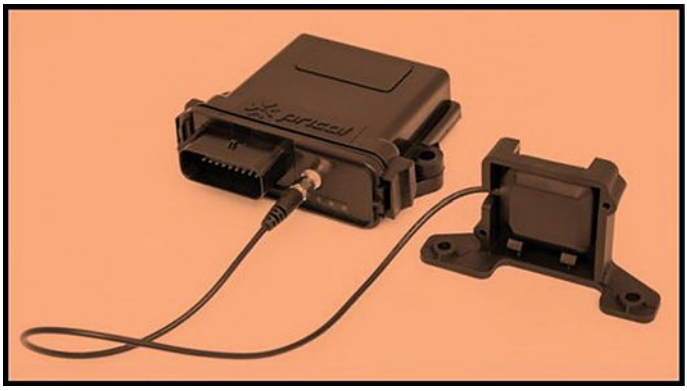

Fig. 1.1 Wired technology in intelligent transportation system

units, garage door openers, wireless computer mice and keyboards, headphones and radio receivers, satellite TV, broadcast TV, cordless phones, and many other things that use radio. Light, magnetic, or electric fields can get wireless communication. Each time, it meant something different. Before 1920, the word "radio" was used to describe the first radio technology to send and receive. There were radios in the UK called "wireless sets" even though they couldn't be moved [5]. The term was used again in the 1980s and 1990s, primarily to separate digital devices that don't need wires or cables from those that do.

When new technologies like Wi-Fi and Bluetooth came out, this became its primary use in the 2000s. There are some things that wireless operations can be used for those wires can't or won't be used for, like mobile and interplanetary communications. "Energy-based" is a term that people in the telecommunications field use to describe telecommunications systems that don't need wires to send and receive information. These systems don't need wires to send and receive news. They use radio waves, acoustic energy, or other types of fuel to send and receive information. Across both short and long distances, data is transmitted in this way. Figure 1.2 shows how wireless technology is used in the intelligent transportation system.

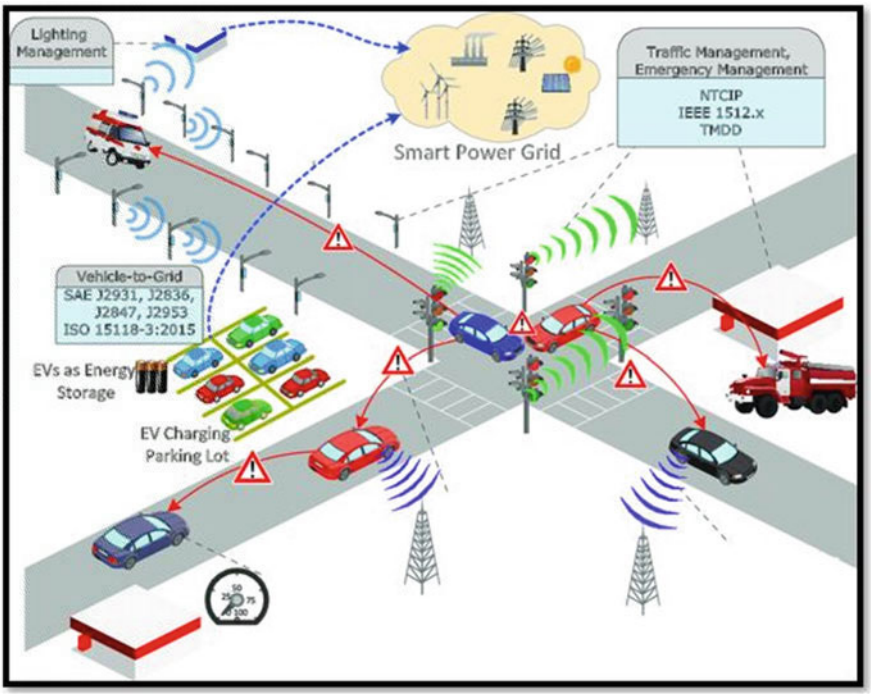

Fig. 1.2 Wireless technology in intelligent transportation system [6]

- **Vehicular Technology**

It's like a computer network, but instead of cars talking to each other, they talk through roadside units. They talk to each other about things like safety warnings and traffic. They can help keep accidents and traffic jams from happening and help people find their way. DSRC devices can be found in both types of nodes [7]. Many different words have been used to talk about how cars communicate. Transport safety and flexibility are better when advanced public relations technology is used in moving support and vehicles. There is a lot of extra work done by putting these technologies together. It is a transportation method that will be used in the future. It has high-tech information and telecommunications for both the road and the cars. Electronics divide, communication, and high-tech sensors are used in intelligence transportation [8]. This app gives passengers important information and makes the transportation system run more smoothly. ITS isn't just for cars on the highway. It also helps people and is used in navigation, air, water, and rail systems.

As more people use it, transportation systems need to be built to help people get around. In the intelligent transportation system, there are a lot of different kinds of things. In Europe, it is known as "Prometheus." In the USA, it is called "ITS." Traffic management systems, information systems, vehicle control systems, commercial vehicle operations, and public transportation are critical. They all want to improve these things at the same time. These are digital maps, computers, path planning, human factors, sensors, communications, vehicle control, and traffic control, to name a few things [9]. Figure 1.3 shows how vehicles work in intelligent transportation systems.

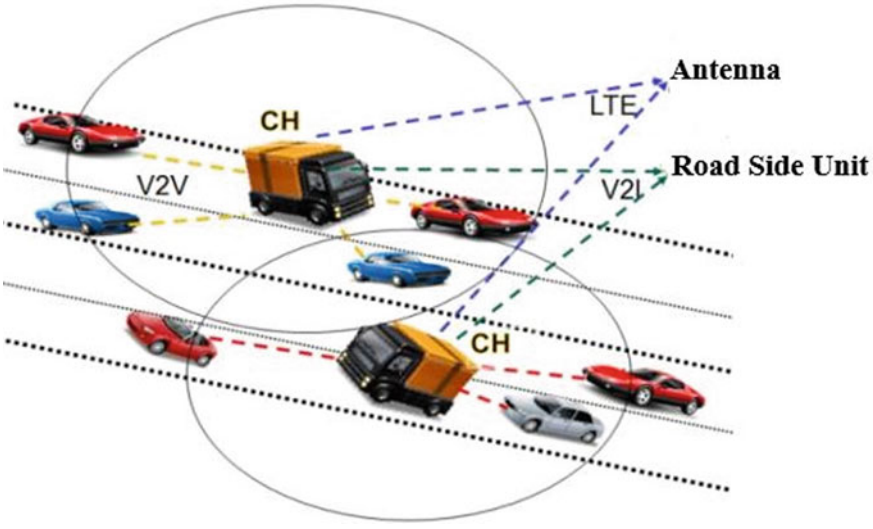

Fig. 1.3 Vehicular technology in intelligent transportation system [10]

Organization of this Chapter: This chapter is divided into 11 subsections; this is the first section of Chap. 1; it gives an overview of wired, wireless, and vehicular technology. Section 1.2 talks about how wired, wireless, and vehicular technology has been used in the past. Section 1.3 talks about intelligent transportation technologies, how wired, wireless, and vehicular technology changed over time, and how wireless communication works. Section 1.4 talks about wireless communication, and Sect. 1.5 talks about the future of intelligent transportation systems and smart cities. Section 1.6 talks about a cooperative system on the road, and Sect. 1.7 talks about smart transportation shortly. Section 1.8 describes intelligent cities and related artificial intelligence techniques reviews; Sect. 1.9 describes critical issues and challenges in the intelligent transportation system. Section 1.10 describes current issues and challenges in wired, wireless, and vehicular technology. Section 1.11 summarizes the chapter in the form of a conclusion.

1.2 Background/Literature Review

Wired—As a result, some people still prefer to use wired peripherals even though many of them are now wireless. They have a few advantages over wireless ones. In this case, there isn't a lot of signal interference that can slow down Wi-Fi connections with Ethernet connections, so they work well. Wired connections are usually faster than wireless ones, with speedier data transfer rates [11]. This is another thing to keep in mind. It's also a good idea to use wired peripherals because they don't need to change their batteries very often. People who play games like to use wired keyboards and mice because they have less latency and can be backlit because they get power from the USB connection, which means they can be colored. Wired communication is when data is sent over a wire-based method of communication, like by text message or by phone call. Another name for this type of communication is "wireline communication." Most wired networks use Ethernet cables to move data between the PCs connected. A wired line called a waveguide (electromagnetics) can be used for very high-power applications—people who live or work in the same area use residential and business telephone networks. Today, many networks use fiber-optic communication technology to make sure that both inbound and outbound transmissions are clear, which is essential. There will be fewer copper wire transmissions and more fiber-optic transmissions. More signals can be sent through fiber optics than through copper wire, but fiber optics can keep the signal's integrity over longer distances [12]. They're thought to be slower and less reliable than wired communication technologies.

Goswami et al. [13] WSNs will be used in the future to connect all the devices in the Internet of Things paradigm. People who use WSNs put sensors in all things to make them work together. In the upper layer of the OSI model, it's hard to make WSN routing protocols that use less energy. People who use IoT applications can help with multi-access edge computing (MEC). Another important thing about 6G is that it makes it easier for sensors to talk to each other. These two things significantly

impact how intelligent transportation systems are made in the future (ITS). Here, the proposed work explains how to use neural networks to make distributed AI (DAI) work in a way that is both energy efficient and quick for communication between the nodes in a cluster. There are some problems that ITS has to deal with, and this helps to solve some of them. It doesn't matter that there have already been a lot of studies about the intercluster energy-efficient network because our work proposes a new way to use DAI and self-organizing maps together (SOM) [13].

Nencioni et al. [14] people who live in a "smart city" use electronic methods and sensors to get information about things in the city. As a result of using information and communication technologies (ICTs), "smart cities" try to make their service better by managing public resources and putting a lot of focus on things like comfort and sustainability. It's possible to connect everyone and everything to a new communication network thanks to the fifth generation (5G) of wireless mobile communication. There is a "mesh" network in this new network. 5G will significantly impact the economy and society because it will provide the communication infrastructure needed for many new city apps. Many innovative city applications can be made with 5G technology. This is one of them. ITS is just one of them. It will talk about how 5G will affect and affect ITS in many different ways. The report that comes before this gives an overview of the benefits of 5G in both technology and money. There is also a lot of talk about how a smart city will change things like energy, health care, manufacturing, entertainment, and transportation [14].

Thangavel et al. [15] IoT isn't just crucial for industry 4.0. It's also essential for many other things, like making cars. It can also make oil transportation through a pipeline system more efficient too. The start of the Internet of Things has been an enormous success in using wireless sensor networks and ubiquitous computing to make things brighter. There are a lot of wireless sensor networks used in the oil business to make sure that pipeline transportation is smooth, accident-free, and long range. Because there are problems with interoperability and heterogeneity, this is why this is the case. There is not yet a small, integrated IoT module for wireless networks in the oil industry that can power and use less energy. That's what this research work talking about. It shows how to make a new, unique, small, intelligent IoT module that can save money by replacing commercial data loggers and sensors that need to be controlled and storing data that need to be run by a specific piece of software. People who buy commercial solutions usually have limited sensors that can't be expanded; maintenance is limited to the manufacturer, and extended cable communication distances make it hard to fix things. IoT module: The intelligent module runs on free software that lets it be spread out and communicate with a cloud server over Wi-Fi through message queuing and telemetry transport (MQTT) and the hypertext transfer protocol (HTTP) for efficient data exchange [15].

Sun et al. [16] this research work talks about how to plan a transportation system that is smart in the age of artificial intelligence. Yunnan is the province where people are the happiest with the intelligent transportation system, and that's why. China should be at the top of the world's list of things to do. Finally, the construction industry should be more important, the traffic information platform should be better,

data management should be better, and technological innovation should be better [16].

Wireless—They came up with the photophone, a phone that could send audio over a beam of light, in 1880. Alexander Graham Bell and Charles Sumner Tainted came up with it. There had to be enough sunlight for the photophone to work, as well as a clear line of sight between the transmitter and the receiver for it to work [17]. These things made the photophone less useful in any real-world way, so it was not worth having. At first, the photophone was only used for military communications and later for fiber-optic communications. It took a long time for its principles to be put into practice. There were many ways to send electricity through water and the ground using electrostatic and electromagnetic induction in the late nineteenth century when radio systems were not widely used. Thomas Edison came up with a telegraph to connect to wires running next to the tracks during the train's journey. System messages could be sent across bodies of water thanks to a William Peerce induction telegraph [18]. There were also several operational and planned systems for telegraphing and voice earth conduction. It all began in the 1990s when digital wireless networks were first made. As a result, there was a social revolution and a shift from wired to wireless technology, which led to the rise of commercial wireless technologies like cell phones, wireless telephony, pagers, and wireless computer networks. Laptops and handheld computers with wireless connections also became more common, as did their use. This is because of new research in radio frequency engineering and how radio waves work. This has led to a massive rise in voice traffic and digital data delivery like text messages, images, and streaming media. In the end, this led to the wireless revolution [19].

Boukerche et al. [19] ITS, part of smart cities, sends traffic management plans based on real-time traffic conditions to everyone in the transportation system. It uses a lot of traffic monitoring equipment and technology called the Internet of Vehicles. A lot can be done to make transportation more efficient and safer. Many AI-assisted data transmission methods are being worked on to ensure that ITS can work properly. In this letter, people who want to learn more about how artificial intelligence can help the VNE send data should read it. Two types of AI can help VNE send data faster: predicting traffic flow-assisted data routing protocols and predictive handover/precaching algorithms are used [20].

Moazzami et al. [21] the Internet of Things (IoT) is a new idea that has been around for a while now. This idea has been a big hit with many different types of technology worldwide. The Internet of Things (IoT) is a technology that many businesses, organizations, and other groups are interested in because it can help develop new ideas in many different fields. There are many important ways IoT can be used, but smart cities are one of the most important. This makes it easier for people to get many different services. A lot hasn't been done yet to look into the architecture of IoT in intelligent transportation [21].

Asghar et al. [22] there is more and more Internet of Things applications, and people want self-driving cars all the time. People worldwide are expected to use different transportation systems because of these changes. UAVs are an essential part