International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

The Applications of Intelligent System Technologies in Service Processes

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***Abstract:** Intelligent systems are commonly used to perform routine and complex tasks in various environments and create smart environments. These systems combine artificial intelligence and other advanced analytics techniques like machine learning, natural language processing, etc. with other technologies including the internet of things, cyber-physical systems, cloud computing, augmented reality, virtual reality, blockchain, 3D printing, etc. Nevertheless, fewer studies have been reported about the applications of these technologies in service processes unlike in manufacturing processes. The study aims to investigate the common applications of intelligent systems technologies in service processes regarding views of experts from companies in several service areas. Actual data are collected with the semi-structured interviews with experts for the investigation. Respondents were selected from directors, executives, or managers considering the heterogeneity and whether they can give a relevant response about the applications of intelligent system technologies in service processes. The collected data are thematically analyzed. The data were transcribed, reduced, rearranged under technology and service categories, and synthesized for obtaining the related applications. The study presents the findings of applications of intelligent system technologies under the related service and technology categories. The findings are analyzed, and first, the functions of intelligent system technologies in service processes are described and then, the common and rare service processes where intelligent system technologies are given as a result of the analysis. The results can contribute to literature providing a better understanding of applications of intelligent system technologies in service processes for future studies. In practice, the results can help to service companies that need the applications of these technologies to be able to stay competitive.*

Keywords: artificial intelligence, autonomous things, intelligent systems, service processes

I. INTRODUCTION

Intelligent systems "refer broadly to computer embedded or controlled systems, machines and devices that possess a certain degree of intelligence with the capacity to gather and analyze data and communicate with other systems" [1, p. v]. They are commonly used to perform routine and complex tasks in various environments and create smart environments.

Revised Manuscript Received on February 28, 2020.
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These systems combine artificial intelligence (AI) and other advanced analytics techniques like machine learning, natural language processing, etc. with other technologies including the internet of things (IoT), cyber-physical systems (CPSs), cloud computing, augmented reality (AR), virtual reality (VR), blockchain, 3D printing, etc. John McCarthy defined AI in 1955 as "the science and engineering of making intelligent machines" [2]. As the definition, autonomous things such as autonomous vehicles, robots, chatbots, drones, virtual personal assistants, wearable technologies, etc. have been becoming smarter with AI techniques.

Mainly, the applications of intelligent system technologies in manufacturing processes is studied with Industry 4.0, fewer studies have been reported about the applications of these technologies in service processes. Besides, some service areas like professional, scientific, technical, and administrative and support service activities have been rarely studied. Service companies need such applications to be able to stay competitive. In this study, the applications of intelligent systems technologies in service processes are investigated. The study aims to identify common applications of intelligent systems technologies in service processes regarding expert views and to provide a better understanding of the applications for future works.

II. LITERATURE REVIEW

In literature, the applications of intelligent systems has been studied with general technologies scope in specific areas such as electricity supply [3], water supply [4], waste management [5], wholesale and retail services [6], transportation and storage service [7], tourism and hospitality services restaurant service [8]–[12], information and telecommunication service [13], real estate service [14], public service [15], [16], art and entertainment activities [17], [18], education activities [19], [20], and health service [21]–[23]. Moreover, the applications of intelligent systems have been studied with specific technologies in service processes [24]–[27]. Besides, many researchers have investigated the application of the intelligent systems in specific service area regarding only one digital technology such as IoT, CPSs, AI, autonomous vehicles, robotics, drones, chatbots, wearable technologies, sensors, AR, VR, blockchain, etc. Some examples of these different technologies are autonomous vehicles, drones, IoT, blockchain in domestic logistics and delivery services [28]–[36]; IoT, AI, robotics, blockchain and wearable technologies in tourism and hospitality services especially hotels and restaurant services [37]–[44]; IoT, data analytics, robotics and blockchain in information and financial services [45]–[51]; IoT, wearable, autonomous vehicles, robots, governance and public services [52]–[54]; IoT, AR, VR, robotics, wearable, data analytics in education activities [55]–[61]; IoT, AI, AR, VR, robotics, wearable, data analytics in health services [62]–[68]; AR, VR, and wearable in game activities [69].

III. METHODOLOGY

This study is based on a qualitative research design. Semi-structured interviews were conducted with experts to gather actual data for investigating the applications of intelligent system technologies in service processes. Semi-structured interviews are suitable for gathering comparable data [70].

Purposive sampling technique was used for sample selection. Respondents were selected from directors, executives, or managers considering the heterogeneity and whether they have the ability to give a relevant response about the applications of intelligent system technologies in service processes. Totally, 32 interviews were held.

The instrument includes the main question about the applications of intelligent systems in service processes and the questions for its details. Some respondents preferred a face-to-face interview whereas some of them requested a virtual interview. The consent form was signed by respondents. During the interview, notes were taken. Each interview took about 55 minutes.

The interview data is analyzed according to the steps as follows: the collected data were transcribed, reduced, rearranged under technology and service categories, and synthesized for results [71]. In this study, the applications of intelligent system technologies were handled under the related technology and service categories.

IV. FINDINGS

In this section, the applications of intelligent system technologies are provided for various service processes considering the analysis of interview data.

Administrative and supportive services

In administrative and supportive activities, IoT connects the machines for collecting, sharing and analyzing data, and provides a platform which connects the producer and the customers, and real-time monitoring. AI and data analytics analyze customers for personalization and offer service and support based on customer data. They are used also as software agents. Cloud stores data, provides access, and allows management and sharing. These tasks can be performed everywhere. AR-VR technologies enhance customer engagement. They make visualization and organization of large amounts of data easier and faster. Blockchain connects customers with vendors directly by eliminating the third party and ensure data integrity. Stakeholders monitor processes transparently. Uses of some technologies like CPSs, drones, and 3D printing are not common in this industry.

Education services

In the education area, wearable sensors that detect current behavioral situation like fatigue, and immediately alerts. For example, a pen can check the concentration. Besides, CPSs are used also to keep track of updates and take notifications. IoT based smart boards and pods of smart desks are used to facilitate education. AI and data analytics can be used as virtual advisors of students. Moreover, data are analyzed to assess the study habits and behaviors, personalized training, and feedback, evaluating the curriculum and content, and facilitating personal tutoring. Cloud-based LMS is used to produce and share learning materials and activities for students. In addition, cloud-based tools enable students to engage in research experiences. Robotics can be proxies for teachers, teach students with autism or other disabilities, and even they can attend a class for a student who is too sick. They can be used as learning support tools or an educational subject. Drones engage students in more physical activities and outdoor activities and improve their motor skills and hand-eye coordination. 3D printing materials can be used as a resource in experiments and physical exercise. AR-VR help to create lessons that are fun and engaging for the student, and to increase visual literacy and technology literacy. Virtual classrooms can be developed, and experiments can be run in AR-VR environments. Blockchain helps to manage and monitor information like student records, transcripts, badges, ridesharing, charity, human resources, governance, libraries, publishing, and public assistance.

Health services

CPSs track a wide variety of health indicators, including heart rhythm, blood pressure, amount of oxygenated hemoglobin in the blood, brain waves, blood sugar, respiratory rate, and many more. Wearable devices facilitate the use of these systems. IoT provides connectivity for CPSs to collect data and for analytic systems to predict potential health issues and monitors the health of patients. AI and data analytics provide new insights into diseases and epidemics, predict and prevent them, suggest possible causes for symptoms, and personalize the treatment and medicine. Chatbots can answer simple medical questions, and thereby save time and reduce doctor visits. Cloud provides access to patient and treatment information. It allows more than one doctor a single access point for in order to view test results or inspect notes about patients. Robots can make guidance as patient assistants for examination, test and treatment processes. Drones help to deliver healthcare by transporting blood, blood samples, and other supplies to labs or hospitals. 3D printing outputs can be designed and produced for treatments such as hearing devices, personalized drugs which have unique dosage, and etc. AR-VR technologies are used generally for training and engagement. They allow doctors and doctoral candidates to inspect and interact with patient tissues and organs as if they were real. They provide educational experiences for both patients and doctors to understand current medical conditions. Blockchain allows uniform medical records and provide transparency in workflow, and thereby prevent drug theft and counterfeiting, and resource inefficiency.

Hotel services

In hotel services, CPSs alert for unexpected situations.

They notify about conditions such as when rooms are ready for cleaning. CPSs prepare the environment for guests such as heating the room before the guests come. Control secure access to rooms and facilities. IoT allows to self-check-in and it provides connection among CPSs. AI and data analytics techniques are used to provide personalization in service, to make a recommendation based on customers' physical location, to answer routine questions in a call center and information desk, to recognize hazardous conditions, and to contribute to predictive maintenance. Robotics are used for some hotel services such as housekeeping service pool service, and product delivery service, and in self-service contact centers. AR-VR route customers can use AR-VR technologies as a personal touristic guide. They also show realistic, virtual representations of hotel activities. Cloud manages databases, client's requirements online from one single place to anywhere in the world, and stores information about door keys thanks to cloud and customers may use this technology as 3D printing files. Clients' requirements can be managed online from anywhere in the world with the cloud. Blockchain provides secure tracking points for stakeholders. Drone use is assessed as an ethical problem in this industry.

Logistic services

In logistic service activities, CPSs provide feed information between stock tags and signal readers, and thereby provide stock visibility and transparency; monitor driving speed, fuel consumption, brakes, and loading rate of the vehicle; track maintenance time; and controls temperature. CPSs and IoT help to asset and inventory tracking, warehouse management, and fleet management. They are used for tracking transportation goods and inventory movement, enabling to respond to disrupt or hinder the supply chain, sharing speed, and position or direction information among trucks, communicating with all stakeholders in real-time, and matching vehicles and nearest empty containers via "uberization". AI and data analytics techniques provide advice about shipping orders, stock transfer, and inventory; optimize driving speed for travel time and fuel consumption; anticipate maintenance and predict the risk of malfunctions; optimize the movement of cargo and resources usage, and analyze data to identify customer trends and market insights patterns. Robotics are more efficient ways of order picking, inventory location detection, delivery of shipments, and providing information to the entire supply chain. Besides, autonomous vehicle reduces accidents due to human error, and adapts its driving behavior according to environmental factors and thereby optimizes of travel times. Drones are used in barcode scanning, cataloging inventory, stacking of stocks, last-mile delivery, traffic monitoring, etc. AR-VR technologies show exactly where items should fit on carts during picking orders and thereby improve the process by making it faster and less prone to error. They make the delivery process safer and more efficient in difficult conditions; control the processes whether are running as planned; reflect important information such as package weight, contents, and navigation instructions; allow identity verification with a picture; support warehouse redesign and planning; and are used intensively on the job training. Cloud store up-to-date information and provide data sharing among stakeholders without inconsistency and time problems. Blockchain ensures that processes are running as planned by providing transparent tracking.

Real estate services

In real estate activities, CPSs are used for monitoring variables such as temperature, humidity, climate, and occupancy, and collecting data. They help to identify failures before they happen. IoT allows people to buy, sell or invest in property online, and to interact with stakeholders with one another. DA & AI are used as an agent that guides the consumer about house prices and availability. They identify trends that will affect occupancy in the building and pricing such as the graduation of a college student, flooding into the area, etc. Cloud perform data sharing and data storage, provide mobility, security, cost efficiency, and scalability for the professional, and improve communication and workflow. Drones are used for surveillance and delivery. AR-VR provides a virtual tour of a potential estate and visualizes an empty house as though it has furniture inside. Blockchain ensures the data integrity, make a record for every property, provide smart asset transfer and smart contracts, reduce the security risk, and allow customers to access much more data on individual properties and owners.

Recycling services

In recycling activities, CPSs provide the real-time tracking of drivers and measurement of the content of containers with sensors and radiofrequency for avoiding unnecessary trips identification. IoT provides a connection for real-time monitoring and feedback about trucks and optimizing the truck route. Therefore, it reduces operating costs and environmental impacts. Waste information is analyzed, and the logistical collection chain is optimized with AI and data analytics techniques. They enhance operations efficiency and optimize task planning. Chatbots guide citizens for recycling and waste. Cloud delivers quick and consistent information and update information easily and deliver to stakeholders. Robotic recycling plants check recyclables, and waste sorting machines separate mixed waste. Besides, driverless garbage trucks are also used. Drone collect recyclables; monitor landfills and reduce overfills; identify abandoned garbage and collect; monitor illegal waste activities. AR-VR is used for helping to make maintenance with data visualization and remote expert interaction, training employees with animations and drawings, planning of recycling and waste treatment plants, and visualizing the impact of dangerous materials. 3D printing is used for recycling plastics. Blockchain facilitates trading with recording and tracking of the recycling production at each level as a transaction, gives a unique identity to the product, and provides transparency about product information such as responsible company for its production.

Restaurant services

In restaurant services, CPSs the optimization of food safety measures and monitor temperature, cooking times, and inventory levels to order. Therefore, with the IoT support, they increase efficiency in the use of inventory and equipment, ensure ongoing compliance, and enhance health, safety, and end-customer satisfaction. With the AI and data analytics, customer waiting time is reduced, the customer ordering experience is enhanced, and menus are customized based on preferences. Robotics help food preparation and delivery greet of guests and booking and purchasing by providing menu details and menu recommendations. AR-VR technologies make 360-degree tours of the facility for customers. These technologies are used also to monitor employees and test their skills and train them with simulation games.

Blockchain brings transparency to supply chains and makes tracking points less expensive and more secure. Some technologies are not commonly used but they are also used in the foodservice industry. 3D printing can prepare and serve foods, and thereby more fresh food is served faster than traditional foodservice. Drones take a role in the delivery of food and beverages, whereas the cloud provides data consistency and control.

Telecommunication and financial services

In communication services, CPSs are used for location-based communication, and face and image recognition in activities. CPSs measure risk-sensitive parameters, and provide a smarter alarm, and thereby reduce the cost of insurance, etc. IoT provides machine connectivity for collecting, sharing and analyzing data. IoT gets real-time and accurate data and ensures immediate support. It tracks audiences, monitors traders' activities, and adjust their policies accordingly. AI and data analytics provide customer-specific services, complex problem-solving, and decision-making, and support customer via chatbots. Virtual agents/brokers who have a high degree of cognitive computing for efficiency and quality. They analyze customer and service data to provide real-time and customized assistance to customers, offer client-specific insurance, and develop fraud indicators. Cloud is used to store and share data and to backup. Robotics support repetitive administrative tasks. Drones are generally used for inspection and control. They are used in hard-to-reach areas to record and evaluate loss and damages. 3D printing meets specific material needs quickly. AR-VR is an efficient way of training, maintenance, audit, and customer engagement. They provide a virtual trading experience with virtual reality workstations and virtual branches, and thereby ensure the secure customer experience. They provide navigation to customers for the nearest branch and train employees. Blockchain improves workflow and collaboration, provide transparency in the supply chain, and provide trustworthy agreement with smart contracts and digital identities.

Professional services

Companies in this sector give consulting services on the selection of technological devices such as sensors, data analytics techniques, and tools like mobile applications, and data security and privacy as professional services. IoT-based and mobile technologies are used for collaboration and expertise sharing in the digital workplace among professionals. AI and data analytics techniques are generally used as a software agent and to analyze customer data, and thereby offer service based on the analysis. They support trend analysis, risk assessment, scoping, and judgments. AR-VR make faster the processes like exploring and assessing design choices, and remedial work. They minimize on-site changes thanks to virtualization, and thereby save time and money. Blockchain allows stakeholders to interact without a third party. Cloud stores data and shares data with stakeholders. Drones are used for inspection, and 3D printers are used to meet technical needs.

Public services

Various technologies are used in public services. CPSs provide information and manage and control processes. They sense the environment by monitoring cyber and physical indicators and modify the environment with actuators dynamically. For example, they provide a real-time monitor the traffic, control traffic lights to prevent traffic congestion; provide better information on waiting times of buses by real-time monitoring of them; send emergency alerts; monitor pollution levels; help to earthquake measurements; and identify abnormality in infrastructure such as potential sources of fire, leakage in water pipes, etc. IoT has an important role to access information from CPSs and manage and share that information with other devices or users. For example, it updates citizen identity information and citizen's process information, parking and traffic information, etc. AI and data analytics predict provide greater insight into a problem. They are used in crime prevention and investigations, city planning, pollution and congestion prevention, environmental damage prevention, and waste minimization. Robotics take tasks for dangerous work situations like military operations. Fully automated machines are used for landscaping, garbage collection, park-street cleaning, garden maintenance, and transportation. Drones are used for security inspection. They identify security issues and report them. 3D printing technology supports key resource supply. AR-VR technologies are generally used for planning, control, guiding and training. 360 panoramic tours, simulations for disaster management and employee training, and ground analysis and city planning tools are some examples of AR-VR applications in public services. Because of the security and privacy issues, the cloud is used for storing and sharing data only which does not include personal and private information. Blockchain provides trustworthy and secure integrated workflows.

Utility supply services

Various technologies are used for electricity, gas, steam and air conditioning supply. CPSs monitor and collect data safely from the operational environment, alert for unexpected conditions in real-time to be able to predict failures before they happen, or to react at the right time after they occur. Supervisory control and data acquisition and advanced metering infrastructure are important technologies to auditing and measuring especially for the electricity and gas supply industry. With the CPSs technologies, the water pipe network is monitored for online water quality, and early detection and prediction on sewage conditions are performed with remote sensing. IoT provides accessibility to the data collected via sensors. IoT provides the connection of the system for real-time monitor and control in planning and operational processes. It provides access also to consumption data.

All these data can be analyzed with data analytics and AI techniques to understand customer consumption behavior, and predict potential breakdowns and malfunction, and thereby improve efficiency and help to make maintenance. Data analytics and AI techniques operationalize and analyze data for optimization and prediction in future automation, use and service, and asset failure and management. Therefore, an efficient investment plan can be proposed, and network problems can be prevented with a systematic condition assessment.

Customer data also are analyzed, and customer satisfaction is improved with the analysis. Robotics are used generally for repair and maintenance works. Chatbots provide the connection with customers. Drone inspect quality or level of water. Another important technology for this industry is AR/VR. These technologies visualize underground assets or complex components, diagnose and identify problems, and reduce accidents thereby provide also worker safety. AR-VR technologies help utility staff in training. They help in the training of employees and assist them in working remotely. 3D printing technology reduces assembly time and improves stock and replace processes, and thereby limits downtime. 3D printing materials are used for maintenance and as operational materials such as a conduit for sensors to monitor online water quality. Cloud technologies are used to store, access and share information among stakeholders. Blockchain is used to provide trusted information sharing among stakeholders. It builds trust in sharing information about utility operations, such as service disruption, service quality, and customer information.

Wholesale and retail trade services

CPSs enhance inventory management providing updated inventory data and alerting to restock. They monitor temperatures and vibrations during transport with track and trace systems. IoT provides mobilization and connectedness for CPSs, offers immediate and consistent online support for customers. AI and data analytics techniques predict customer needs based upon past and present activity and predict sales and thereby help to manage inventory. They also support to customers via chatbots. They help to identify inefficiencies in operational procedures and provide alternative options. AR-VR technologies improve consumer engagement by allowing interaction with products or services, reduce time and material use by decreasing sample rounds, provide getting consumer feedback by using 3D prototypes, provide better insight into inventory movement, and help training employees. Cloud stores valuable information ensures quick and consistent information access and provides secure sharing among stakeholders. Blockchain provides secure business transactions and quick supply chain activities, and efficient information and asset management. Some digital technologies are used rarely in this industry. Robotics is used as a channel thanks to smart vending machines. Drones help delivery.

V. RESULTS

In this section, the findings are analyzed, and the analysis results are presented. First, the intelligent system technologies and their application functions in service processes are presented in Table-I.

Table- I: Functions of intelligent system technologies

Intelligent System Technologies	Functions in Service Processes
AI and Data Analytics	process and analyze collected data, and convert into useful information
AR and VR	provide a visual representation for resources and activities
Autonomous Things	interact with humans or other machines to perform activities without human direction
Blockchain	provides transparent and secure business transactions and direct communication
Cloud	provides flexibility and mobility for storing, accessing, updating, managing, and sharing data
CPSs	sense the environment, detect situations and modify the environment or alert
IoT	provides real-time connectivity for machines to collect, share and analyze data
3D Printing	provides customized material to support resources

Table- II: Common and rare service processes where intelligent system technologies are applied

Intelligent System Technologies	Common Processes in Service Areas	Rare Processes in Service Areas
AI and Data Analytics	customer relation customer support data management marketing planning process optimization risk management	value enhancement in administrative and supportive, financial, health, telecommunication, and real estate services
AR and VR	customer engagement employee training maintenance operation planning process optimization R&D planning	value enhancement in education and hotel services
Autonomous Things	customer relation customer support maintenance operation execution supply chain management process optimization	value delivery in the logistic, recycling, and education services
Blockchain	customer relation partnership management process optimization risk management supply chain management	quality control and compliance, and counterfeit management in hotel and restauranr services
Cloud	customer relation data management resource management partnership management	value creation in software, infrastructure, and platform services

CPSs and IoT	communication operation controlling operation execution resource management risk management	customer engagement in education, health, and public administration services value enhancement in education, health, hotel, professional services
3D Printing	customer relation maintenance resource management R&D planning supply chain management	recycling revenue in wholesale and retail, transportation and storage, finance and insurance, real estate, administrative and support services, and professional services industries

Usually, AI techniques and data analytics methods are used together with other technologies like CPSs, IoT, AR-VR, autonomous things, blockchain, cloud, 3D printing, etc. for applications of intelligent systems in service processes, however, their functions are analyzed separately.

Moreover, the common and rare service processes where intelligent system technologies are applied are shown in Table- II. According to the results, some technologies like blockchain and cloud are used for the same processes in all service areas whereas the uses of others may vary by service areas as shown in Table- II.

VI. DISCUSSION AND CONCLUSION

This study mainly focuses on providing expert views on the applications of intelligent system technologies in various service processes. According to findings, these technologies are used in all service areas; however, there are some differences in their uses. IoT and CPSs have a crucial role, especially for utility supply, hotel, and logistic activities. Wearable technologies and AR and VR are important for education, and health service areas whereas chatbots are used commonly in administrative and supportive services, and financial services. Autonomous things like drones, robots, autonomous vehicles are actively used in public services, and recycling and logistic activities. Blockchain technology is important for wholesale and retail trade activities. According to the analysis results, although intelligent system technologies are applied for similar processes, they may vary by the service areas. The results can contribute to literature providing a better understanding of applications of intelligent system technologies in service processes for future studies. In practice, the results can help to service companies that need the applications of these technologies to be able to stay competitive. In future studies, the number of interviews with experts can be increased for data saturation, and the potential technologies also can be investigated in addition to common technologies.

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