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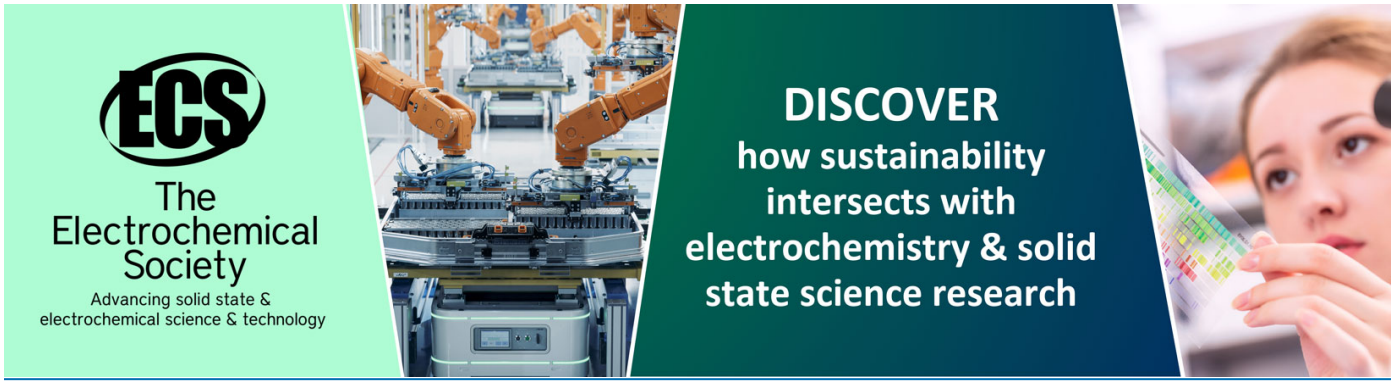

The Role of Autonomous Robots in Fourth Industrial Revolution (4IR) as an Approach of Sustainable Development Goals (SDG9): Industry, Innovation and Infrastructure in Handling the Effect of COVID-19 Outbreak

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Abstract. This research is aimed to discuss the implementation of Autonomous Robot as Fourth Industrial Revolution (4IR) Technology approaches in facing this current epidemic outbreak. The Fourth Industrial Revolution is the current and emerging environment in which technologies has transformed the way we live and work. Since Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure aimed to build resilient infrastructures, promote inclusive and sustainable industrialization and encourage innovation, it is believed that 4IR technology can help to achieve that. World Economic Forum (2017) emphasizes that 4IR innovation can promote system transformation across the environment and natural resource security agenda including enhancing the Risk Reduction agenda Disaster (DRR). A comprehensive solution is needed to prevent or slow down the spread of COVID-19. The objective of the paper is to discuss the implementation of Autonomous Robot as Fourth Industrial Revolution (4IR) Technology approaches in facing this current pandemic outbreak in Malaysia and overseas. The methodology used for this paper is Visual Analysis method. 15 YouTube videos from 12 countries were reviewed. Therefore, gaps determined will help innovators especially in improving the existing function of Autonomous Robots used during COVID-19.

Keywords: Fourth Industrial Revolution (4IR); Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure; COVID-19; Autonomous Robot.

1. Introduction

1.1. Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure

Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure targets to develop resilient infrastructure, drive innovation as well as promote inclusive and sustainable industry [1]. Investment in infrastructure such as irrigation, transport, energy and information and communication

technology are crucial to empower communities as well as to achieve sustainable development goals [1]. According to the United Nations, SDG 9 should improve access to information and communication technology and provide comprehensive and affordable Internet access in less developed countries by 2020 [1]. In addition, technological advances are the key to find sustainable solutions on disaster and economic challenges [1][29]. This is because technological advances are fundamental to efforts on achieving environmental objectives, such as improving energy and resource efficiency [1]. Without innovation and technology, industrialization will not happen, and without industrialization, development will not happen [1].

1.2. Fourth Industrial Revolution (4IR) Technology

The Fourth Industrial Revolution (4IR) is the most recent and evolving environment of technologies and trends such as the Internet of Things (IoT), Virtual Reality (VR), robotics and Artificial Intelligence (AI). The Fourth Industrial Revolution represents a fundamental change on how we work and live. It is a new phase in human evolution, facilitated by the outstanding technology evolution comparable with those of the first, second and third industrial revolutions [2]. The Industrial Revolution 4.0 (4IR) is characterised by; (1) Digitisation, optimisation, and customisation of production, (2) Automation and adaptation; (3) Human machine interaction; (4) Value-added services and businesses, and (5) Automatic data exchange and communication [3]. All in all, there are 9 pillars of 4IR being applied across the globe named as (1) IoT; (2) Big Data; (3) Cloud Computing; (4) Advanced Simulation; (5) Autonomous System; (6) Universal Integration; (7) Augmented Reality; (8) Additive Manufacturing and (9) Cyber Security.

In Malaysia, the first method of readiness assessment for 4IR is published by Ministry of International Trade & Industry in response to the Fourth Industrial Revolution (4IR). On 31st October 2018, the 'Industry4WRD: National Policy on Industry 4.0' was initiated to encourage digital transformation in manufacturing and other related service sectors in Malaysia.

1.3. Autonomous Robot Technology

According to World Economic Forum, robotics is an electro-mechanical, hybrid and biological machines supported by Artificial Intelligence (AI) that computerize, augment or aid human activities, autonomously or according to set instructions [2]. An intelligent robot is a machine set to obtain information from its environment and apply the knowledge about its word to remote safely in a purposeful and significant manner.

2. Research Background

2.1. The role of Fourth Industrial Revolution (4IR) as an approach for Sustainable Development Goals (SDG) 9: Industry, Innovation and Infrastructure in supporting the resiliency of community towards COVID-19 outbreak.

The Hyogo Framework for Disaster Risk Reduction has defined resilience as the ability of a community or society exposed to hazards to resist, absorb, accommodate, and recover during a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management [4]. Besides, the ability of a system, group, or culture to resist or alter in order to achieve an appropriate level of functioning and structure is known as resilience [5]. This is measured by the social system's ability to coordinate itself, as well as its ability to increase its capacity for learning and adaptation, including the ability to recover from disasters [4]. Resilience was also defined as the capacity for bouncing back faster after disaster, enduring greater impact after disaster and being affected less by a given amount of impact [4]. Here, we can conclude that generally the concept of disaster resilience should be associated with that of a community [6]. Also, researchers will use the concept of resilience in relation to disasters.

Meanwhile, World Economic Forum emphasized that 4IR innovations could help to promote the systems revolution across the natural resource and environmental security agenda, including improving the Disaster Risk Reduction (DRR) agenda [2]. In relation to disaster management, it is

important to tackle this Fourth Industrial Revolution to restructure how we manage our shared global environment and help resolve environmental problems.

Hence, these would be in line with one of the SDG's missions, which is to build secure, quality, sustainable, and resilient infrastructure to support economic growth and human well-being, with an emphasis on fair and affordable access for all [7].

3. Research Problem

COVID-19 was declared as pandemic on 11th March 2020 by World Health Organisation. Nearly all regions have been infected by the coronavirus [8]. Most countries are affected by COVID-19 since globalization and increasingly interconnected economies happened [8]. On 30th January 2020, World Health Organisation has classified the novel coronavirus as a global public health emergency. In Malaysia, government has started to imposed Movement Control Order (MCO) from 18th Mac 2020. During the early stage of the lockdown, almost all sectors were closed except those involved in the essential services such as water, energy, electric, transportations, telecommunications, finance, food supply and may more. Other than MCO, the government has also imposed Recovery Movement Control Order (RMCO), Conditional Movement Control Order (CMCO), and Enhanced Movement Control Order (EMCO) depends on the number of cases in a state.

One of the key challenges during the major outbreak is the fact that qualified staff will face tasks with a high risk of exposure [9]. For example, even if the frontline health care practitioners are equipped with protective gear, they will still be exposed to the virus due to direct contact with the patient [9]. Next, lack of qualified personnel to swab patients and process samples [9]. Then, few places do disinfection manually which requires the mobilization of workforce thus increase exposure risk to cleaning workers [9]. From macro to microscale, new robot creations could be built to manage high-risk areas while also sterilising high-touch surfaces [9].

Hence, more research in the field of robotics that focus on the risks of contagious disease is needed [9]. Without continuous research, robots will once again be unprepared for the next event [9].

COVID-19 outbreak has created a new broad field where robotics can make a difference in job continuity and socioeconomic roles [9]. During the event of coronavirus, robots are potentially used to disinfect, deliver food and medicine, diagnose symptoms, and aid border control [9]. Robots are being used to combat the coronavirus everywhere [10]. They are increasingly relying on efficient, fast, and contagion-proof champions to combat the virus [10].

4. Research Questions

This study embarks on the following questions:

(1) What is the implementation of Autonomous Robot as Fourth Industrial Revolution (4IR) Technology approaches in facing this current pandemic outbreak?
(2) How does the function of Autonomous Robot different between Malaysia and overseas?

5. Research Aim

The purpose of the study is to discuss the relationship between the Fourth Industrial Revolution (4IR) technology with Sustainable Development Goals (SDG 9): Industry, Innovation, and Infrastructure in handling the effect of COVID-19. Next, to discuss the implementation of Autonomous Robot as Fourth Industrial Revolution (4IR) Technology approaches in facing this current epidemic outbreak. Then, to discuss the differences in function of Autonomous Robot implemented between Malaysia and overseas.

6. Research Objectives

This study embarks on the following objectives:

(1) To discuss the implementation of Autonomous Robot as Fourth Industrial Revolution (4IR) Technology approaches in facing this current pandemic outbreak.
(2) To discuss the differences in function of Autonomous Robot implemented between Malaysia and overseas.

7. Literature Review

7.1. Autonomous Robots as part of 4IR Technology that has been implemented during pandemic COVID-19 outbreaks.

The potential functions of robotics are getting clear as the pandemic rise [11]. During the 2015 Ebola outbreak, it was discovered at a workshop organised by the White House Office of Science and Technology Policy and the National Science Foundation that there are three (3) broad areas where robotics can make a difference; (1) clinical care, such as telemedicine and decontamination; (2) logistics, such as delivery and waste handling; and (3) reconnaissance, such as surveillance activity (Yang et al., 2020). However, the COVID-19 outbreak has introduced a new area (fourth area) which is: job continuity and socioeconomic roles [11].

During the event of coronavirus, robots are potentially used to disinfect, deliver food and medicine, diagnose symptoms, and aid border control [11]. From Thailand to Israel, robots are being used to combat the coronavirus everywhere [10]. They are increasingly relying on efficient, fast, and contagion-proof champions to combat the virus [10].

7.2. The relationship between Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure and Fourth Industrial Revolution (4IR) Technology.

During the launching of 'Industry4WRD: National Policy on Industry 4.0' on 31st October 2018, YAB Tun Dr. Mahathir bin Mohamad has mentioned this readiness assessment would enable Malaysia's manufacturing sector to shift to Industry 4.0 and contribute to the country's commitment to the United Nations' Sustainable Development Goals (SDGs).

Fourth Industrial Revolution (4IR) technology was discovered to play a vital role for Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure [12]. According to Celine Herweijer, Partner and Global Innovation and Sustainability Leader of PwC UK, there is a large untapped area for utilising new technologies to accelerate progress on the Global Goals. According to United Nations Development Programme (UNDP), technological progress is also essential in finding permanent solutions to both economic and environmental challenges, such as fostering energy efficiency and providing new jobs [13]. Therefore, in order to facilitate sustainable development, it is important to promote sustainable industries and investments in scientific research and innovation [13].

7.3. Coronavirus disease 2019 (COVID-19) outbreak as a new disaster.

This virus has a single-stranded RNA genome and is surrounded by a positive sense [14]. The first cases were discovered in a large Chinese city, namely Wuhan [15]. Coronavirus is pathogens that mainly aims for respiratory system of human [15]. Coronavirus (CoV) outbreaks have already occurred, including the Severe Acute Respiratory Syndrome (SARS)-CoV and the Middle East Respiratory Syndrome (SARS)-CoV, all of which pose a significant public health risk [16]. Coronaviruses (CoVs) usually cause mild illness, but they have sometimes, in recent years, led to major outbreaks of human disease [17]. COVID-19 has recently been declared a global pandemic by the World Health Organization on year 2020. In order to avoid or slow down its rapid spread, it is suggested that worldwide solutions are needed until successful control mechanisms have been developed and implemented [18].

According to Associate Prof Dr Rafdzah Ahmad Zaki, an associate professor and lecturer in epidemiology at the Department of Social and Preventive Medicine, Malaysia's COVID-19 pattern of infections are different from other countries where the disease spread more quickly. The majority of the cases in early March were related to a 'tabligh' convention held at the Sri Petaling mosque. Figures below shows the daily increase (**Figure 1**) and growth in number of cases (**Figure 2**) as of this writing

(21 April 2020). According to Ministry of Health (2020), there are 57 new cases, 54 recovered cases, and 3 deaths in Malaysia on this date.

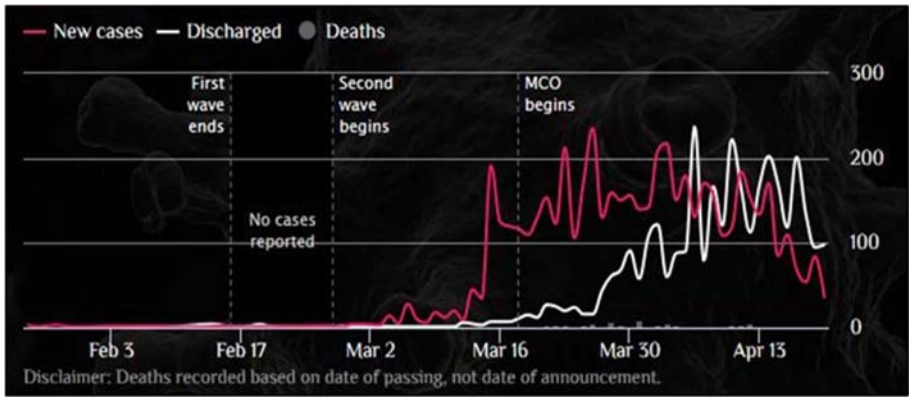

Figure 1. Malaysia daily increase in COVID-19 cases
Source: Malaysiakini (2020)

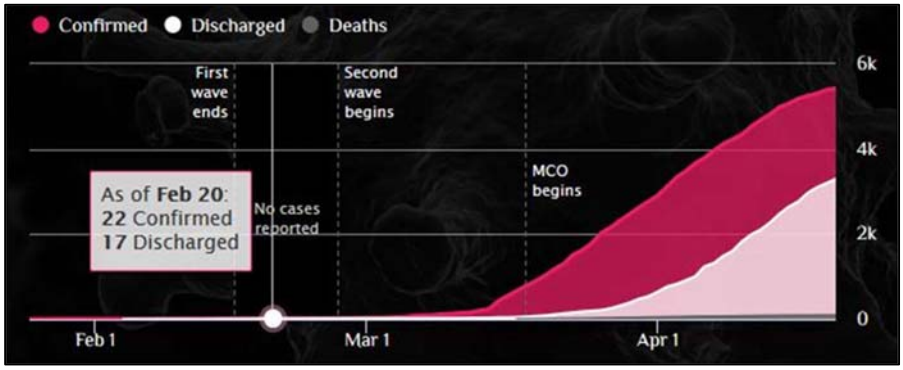

Figure 2. Malaysia growth in number COVID-19 cases
Source: Malaysiakini (2020)

8. Methodology

The objective of the paper is to discuss the implementation of Autonomous Robot as Fourth Industrial Revolution (4IR) Technology approach in facing this current epidemic outbreak. In order to achieve this objective, the researcher selected 15 YouTube videos with the following keywords:

(1) Robotics;
(2) Robotics and COVID-19;
(3) Autonomous Robots; and
(4) Robotics and Pandemic

The methodology used in this paper is purely qualitative by employing visual method as the method for this paper. The applications of Robotics technology during the outbreak of COVID-19 in Malaysia and 10 other countries has been identified through 15 latest and most relevant YouTube videos as listed in Table 1 below. After the analysis of the YouTube videos, few technologies of Autonomous Robot that has been proposed and applied in handling the effect of COVID-19 has been determined. Therefore, in this paper, the applications of Autonomous Robots during COVID-19 and

how these applications would be strategically important to the development of new applications of Autonomous Robots in the field of disaster are described.

Table 1. Sources of Evidence from Visual Method
Source: The Researcher (2021)

No.	**Countries**	**Name of the Robots**	**Name of Provider**	**Visual Method (Youtube Link)**
1.	Malaysia	MediBot V1-U	International Islamic University Malaysia's (UIAM)	https://www.youtube.com/watch?v=bJrmHO-xSwA
		'Makcik Kiah 19' (MCK19)	Universiti Teknologi Malaysia (UTM), and DF Automation & Robotics Sdn Bhd (DF)	https://www.youtube.com/watch?v=oDp8hOQwbQg
2.	Israel	CoRobot	Technion-Israel Institute of Technology researchers, Faculty of Aerospace Engineering, Faculty of Architecture and Town Planning together with students from the FIRST Robotics Group	https://www.youtube.com/watch?v=Ty1ycHzjVps
3.	Italy	Tommy The Robot Nurse		1.https://www.youtube.com/watch?v=2NWcQ27ZZYo 2.https://www.youtube.com/watch?v=6_SUaupcLe8
4.	China	Foodom (Cooking), TMIRob	Startup Gosuncn	https://www.youtube.com/watch?v=JzthGASSxxM
5.	Rwanda	Akazuma, Urumuri and Ngabo	ZORA Robots Team	https://www.youtube.com/watch?v=A_wPwJLide4
6.	India	Mitra Robot		1.https://www.youtube.com/watch?v=pv24_19CVT4 2.https://www.youtube.com/watch?v=GOO_wPI2J8o
7.	Washington, D.C, USA	Starship	Self-Driving Robots	https://www.youtube.com/watch?v=yEmjGo72a7g
8.	Belgium	1. James 2.Ultraviolet Lights Robot	ZoraBots	https://www.youtube.com/watch?v=8kQwL0NYUz8
9.	Taiwan	Nasal Swab Robot	Brain Navi	https://www.youtube.com/watch?v=1u8VFZzaqyA
10.	Korea	Sterilization Robot	Seoul Digital Foundation	https://www.youtube.com/watch?v=BKgkmWzyefE
11.	Mumbai	Gollar		https://www.youtube.com/watch?v=RpbYZ2eIjug

9. Discussions and Analysis

In order to analyse the obtained evidence, the researcher used Content Analysis by identifying themes known as (1) Functions, (2) Benefits, (3) How it works; (4) Outcome and (5) Issues and Challenges based on 11 countries. This information can be found in **Table 2** below.

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Table 2. The Applications of Autonomous Robots Technology in Few Countries
Source: The Researcher (2021)

No.	Countries	Name of the Robots	Name of Provider	Visual Method (YouTube Link)	Functions	Benefits	How it Works	Outcome	Issues and Challenges
1.	Malaysia	MediBot V1-U	International Islamic University Malaysia's (UIAM)	https://www.youtube.com/watch?v=bJrmHO-xSwA	1. Reduce health workers' risk of infections. 2. Thermal system to detect patient's temperature and an alarm system to notify high temperature 3. Disinfectant spray system	1. Can reduce health workers' risk of infection 2. Can help in disinfectant activity 3. Reduce the burden of the medical staff worker	1. This robot can check patients' temperature remotely by social distancing. 2. Thermal system is used to detect patient's temperature 3. Alarm system is used to notify if patient's temperature is high 4. Embedded with disinfectant spray system	Through the application of this robot, the diagnose of patient can be done. The number of PPE used can be reduced. This robot will be placed in Kuantan UIAM Medical Centre for the next development process.	Future development needs to be done since there are some features of the robot need to be upgraded.
		'Makcik Kiah 19' (MCK19)	Universiti Teknologi Malaysia (UTM), and DF Automation & Robotics Sdn Bhd (DF)	https://www.youtube.com/watch?v=oDp8hOQwbQg	1. Help to deliver medicines and food to COVID-19 patients. 2. Provide services to the COVID-19 patients.	Can minimise healthcare workers' exposure to Patients Under Investigation (PUI)	1. Zalpha is a DF commercial robot that can hold weights of up to 300 kg in its shelves, allowing doctors and nurses to assist in delivering food or medicine to a patient's room. 2. The robot has LCD screen that display an animated face, making the robot more human friendly. It can be used for teleconference between doctors with patients from two (2) 2.different places. 3. IoT robot can be accessed by any phones, tablets, or PC allowing	This robot prototype is the first delivery robot developed in Malaysia, officiated by the Prime Minister. At first, this automation system was developed to replace the front liners delivering foods to the Category 1 & 2 COVID-19 patients which are healthy and only have mild Symptom. Clinical tests were done in Hospital Canselor Tuanku Mukhriz (HCTM).	It is now still under planning to produce a function that can detect the temperature, blood pressure and can perform disinfectant activity inside the wards.

							users to communicate with the robot even if the users are not at the hospital's premise. 4. This robot can be accessed by authorised admin only since it has security feature.		
2.	Israel	CoRobot	Technion-Israel Institue of Technology researchers, Faculty of Aerospace Engineering, Faculty of Architecture and Town Planning together with students from the FIRST Robtics Group	https://www.youtube.com/watch?v=Ty1ycHzjVps	Deliver medication, food and medical equipment	1. Can reduce the risk to the medical staff 2. Maximise movement in the crowded hospital space since it travels on four (4) wheels 3. It has battery that can support for hours	1. It travels on four (4) wheels so it can turn on its axis at the robot's centre allowing for maximal movement in the crowded hospital space 2. This robot has a camera that give a 170-degree field of view. 3. It has two (2) trays; upper tray and lower tray which you can put all sort of things and the upper tray for holding a tablet. 4. It supports a wide range of remote controls.	The risk of infections towards COVID-19 virus to the healthcare workers of Rambam Health Care Campus are reduced through applications of this robot. Simple tasks such as delivering medications, food and medical equipment are replaced by the robot.	One of the challenges is to keep the robot as compact as possible while maintaining the necessary surfaces that allow robot to move freely in the hospital while protecting the robot from the virus and make it easy to wash and sterilize
3.	Italy	Tommy The Robot Nurse		1. *https://www.youtube.com/watch?v=2NWcQ27ZZYo* 2. *https://www.youtube.com/watch?v=6_SUaupcLe8* 3. *https://www.youtube.com/watch?v=GOO_wPI2J8o*	1. Helping the frontliners during coronavirus by taking care of patients. 2. Help medical staff monitor patients with COVID-19 3. Assist in the remote transmission of	1. Can avoid and minimise risk of infection. 2. Lowers the frequency of direct contact between medical professionals and patients 3. Minimizes the use of scarce resources, like masks & gowns	1. Equipped with touchscreen faces that allow patients and doctors to interact with each other without physical contact. 2. Reduce the chances of the infection by avoiding direct contact with patients. 3. Allows the medical staff to use less protective clothing.	This robot is currently being used in Varese, Italy, in the most infectious wards. While in Lombardi's northern region, which accounts for the majority of known coronavirus cases in Italy, the robots relay the vital information between doctors and the patients remotely.	Future development need to be done since there are some features of the robot need to be upgraded

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					critical information between patients and doctors. 4. Assist in the monitoring of some clinical parameters for the patient.	4. Ease the burden of isolated patients 5. Only requires a quick recharge when batteries are running low			
4.	China	Foodom, TMIRob	Startup Gosuncn	https://www.youtube.com/watch?v=JzthGASSxxM	1. Grocery delivery – pick up goods at the company's warehouse and travel to designated points to drop off purchases 2. Meal delivery – deliver meals to Beijing, Shenzhen and Guangzhou Hopital staff 3. Cooking (Foodom) – cooking at Wuhan quarantine facility 4. Cleaning (TMIRob) – do disinfection job more efficiently at hospital in Wuhan and other cities 5. Patrolling – developed by	1. Meal delivery robot can deliver up to 50 lunch sets in each round, can reduce human contact 2. Cooking – Foodom can make 120 servings of clay pot rice per hour, which is enough to feed the medical staff who are on duty. The robot also use disposable containers to ensure hygiene 3. Patrolling robots can reduce the time officers spend outside	1. Grocery delivery – pick up goods at the company's warehouse and travel to designated points to drop off purchases 2. Meal delivery – deliver meals to Beijing, Shenzhen and Guangzhou Hopital staff 3. Foodom – workers scan a code to collect their meals anytime, to ensure that the food is always served hot 4. TMIRob release hydrogen peroxide and UV light to kill germs, and able to map own route through the hospital. Before entering a room, it will warn people inside to leave and automatically connect to charging stations when its out of power 5. Patrolling – detect fever from five (5) metres away, able to recognize	These robots currently provide services in some Beijing districts. This technology or robots seems to make the lives of many group of people become easier during the pandemic outbreak and reducing the risks of infections.	The grocery delivery robots need to be disinfected multiple times a day since it travels to many places.

				Startup Gosuncn can detect fever from five (5) metres away, able to recognize if people are wearing mask or potentially ill, police can also broadcast messages through the droids		if people are wearing mask or potentially ill, police can also broadcast messages through the droids		
5.	The Robotic Arms on Wheel	China's Tsinghua University	https://www.youtube.com/watch?v=VFkvCWFoBa0	1. The robotic arm on wheels can check temperature. 2. This robot can collect mouth swabs to test the samples. 3. Perform ultrasounds (sounds made by a patient's organs). 4. Deliver medicine to patients and can be observed by doctors through the robot's cameras. Actions can also be controlled remotely by doctors.	Help protect medical workers from getting infected by COVID-19.	The machine consists of a robotic arm on wheels that can perform ultrasounds, take mouth swabs and listen to sounds made by a patient's organs.	This innovation help protect medical workers from getting infected by COVID-19 and lessen their burden of work.	The pandemic in South Korea was worsening during that time. Thus, the developemnt of the robots that can carry out certain crucial tasks during the pandemic is needed. However, there are still few features need to be improved for a better functioning.

6.	Rwanda	Akazuma, Urumuri and Ngabo	ZORA Robots Team	https://www.youtube.com/watch?v=A_wPwJLide4	1. Screen 50 to 150 people per minute, deliver food and medications to patients rooms, capture data and notify working officers about detected abnormalities. 2. Temperature screening, facial recognition, patient's status monitoring and patient's medical records keeping.	1. Reducing contact of the medical staff with the COVID-19 patients thus minimizing the risks of infection 2. Opportunities for the medical staff to focus on another tasks.	1. The robots can screen 50 to 150 people per minute. 2. Deliver food and medications to patients rooms. 3. Capture data and notify officers on duty about any abnormalities that are discovered.	The United Nations Development Programmed (UNDP) Rwanda has donated five (5)obots to be used in Rwanda's treatment of COVID-19. This can help doctors and other medical staff to reduce the risks of infections towards COVID-19.	The major challenge was to get the robots to Rwanda because of the lockdown in many countries.
7.	India	Mitra Robot		*1. https://www.youtube.com/watch?v=pv24_19CVT4* *2. https://www.youtube.com/watch?v=GOO_wPI2J8o*	1. Screening body temperature for everyone who enter the building of Fortiss Hospital 2. Delivering vital supplies 3. Giving foods and medicine to patients	Get the visitors notified about their body temperature thus precautions can be taken	1. Robots will screen everyone who enter the Fortiss Hopital. 2. If the temperature is high, visitors will be connected to the doctor for the supervisions of symptoms.	Mitra robot has been introduced for COVID-19 screening to protect the healthcare workers and intensify the screening process. This technology can help doctors and other medical staff to reduce the risks of infections towards COVID-19.	Future development needs to be done since there are some features of the robot need to be upgraded.
8.	Washington, D.C, United States of America	Starship	Self-Driving Robots	https://www.youtube.com/watch?v=yEmjGo72a7g	Local business use self-driving robots to stay open during the pandemic and provide contactless	Make the activity of buying becomes easier.	This robot can travel within a 4-mile radius from their starting location and are monitored via smartphone.	There are 10 robots running depends on their availability.	Some people don't prefer to rely on robots since they prefer to have a normal shopping.

					delivery .				
9.	Belgium	James	ZoraBots	https://www.youtube.com/watch?v=8kQwL0NYUz8	'James' help the elderly keep in touch with their families by replacing physical contact	1. 'James' help the elderly to stay connected with their family and friends 2. Can help reduce the spread of COVID-19 among the vulnerable community	1. These robots help the elderly keep in touch with their families in the midst of social distancing & COVID-19 concerns. 2. Each one is connected to Facebook Messenger so nursing home residents can call their friends and family while continuing to social distance. 3. These robots have the software which enables them to communicate froma distance.	Approximately 60 robots are being used in Belgium. This can fight loneliness during the phase among the vulnerable community.	The issues is that the government there has banned outside visitors from nursing homes in order to curb the spread of COVID-19. Thus, through the development and applications of this robot at the nursing home, the elderly will not feel lonely anymore.
		Ultraviolet Lights Robot	UVD Robots	https://www.youtube.com/watch?v=GOO_wPI2J8o	'Ultraviolet Lights Robot' help disinfect wards to keep patients safe	1. Help disinfect hard-to-reach areas 2. Can minimes the risk of infection	These robots will drive themselves to the room and disinfect hard-to-reach areas to minimize the risk of infection. The machines ultraviolet light quickly kill the bacteria.	The surface of the wards will become clean thus the rate of infections will become lower.	People need to leave the room and close the door while the robots disinfect the wards. Future development need to be done so peple don't have to leave the room when the disinfection activity is taking place.
10.	Taiwan	Nasal Swab Robot	Brain Navi	https://www.youtube.com/watch?v=1u8VFZzaqyA	Taking nasal swab tests	1. Reduce the risk of exposure towards the infection. 2. Reduce the workload of healthcare workers.	1. A nasal clip is worn by the patient, and the system uses it to orient itself. They'll then put their heads in a metal bracket that looks like the ones used for eye exams.	This robot is the first COVID-19 testing robots, invented by Taiwan, helping the medical staff in taking the nasal swab tests.	The slowness and inevitability of the robot's movements feel like an implicit threat, and the entire operation has the vibe of an alien lobotomy. However,

							2. A depth-sensing camera scans their faces and measures the distance between their nostrils and ear canals. Brain Navi claims it is a reliable proxy for the nasal cavity depth, and helps the robot to safely navigating inside you. 3. The robot then retrieves a cotton swab from its base and approaches patient slowly. 4. It inserts the swab, twirls it, and then withdraws the sample, which is then placed in a sterile tube for transport and analysis.		a depth-sensing camera scans their face and measures the distance from nostril to ear canal, which Brain Navi claims is a reliable proxy for the depth of the nasal cavity and assists the robot in safely navigating inside you. The robot also has pressure sensors to detect when it is accidentally pushing into flesh, as well as imaging to provide accurate and safe guidance.
11.	Korea	Strelization Robot	Seoul Digital Foundation	https://www.youtube.com/watch?v=BKgkmWzyefE	1. Measuring body temperature 2. Sterilize negative-pressure wards by using ultraviolet light to prevent room-to-room contamination. 3. Collect medical waste such as hospital gowns and move medical devices	1. Can prevent cross-contamination at a city-run medical center 2. Can prevent room-to-room contamination. 3. Minimize the risk of infections among medical staff. 4. Can help prevent the overloading of medical professionals	1. Measuring body temperature 2. Sterilize negative-pressure wards by using ultraviolet light to prevent room-to-room contamination 3. Collect medical waste such as hospital gowns and move medical devices	The risks of infections among medical staffs are minimized through this application of technology.	Future development need to be done since there are some features of the robot need to be upgraded.

12.	Mumbai	Gollar		https://www.youtube.com/watch?v=RpbYZ2eIjug	Deliver food and medicines for COVID-19 patients in Mumbai Podar Hospital	Can minimize physical contact thus reduce the risk of infection among medical staff who are treating patients infected by COVID-19	In Mumbai Podar Hospital, 'Gollar Robot' deliver food and medicines for COVID-19 patients. This robotic trolley will help to prevent the physical contact and reduce the risk among medical staff.	This robot has been applied in Mumbai Podar Hospital to serve food and water to COVID-19 patients.	The robot still need to be disinfected. Thus, future development need to be done since there are some features of the robot that needs to be upgraded.

9.1. The role of Autonomous Robots in combatting COVID-19 in Overseas

9.1.1 Israel
'CoRobot' was developed by Technion-Israel Institute of Technology researchers, Faculty of Aerospace Engineering, Faculty of Architecture and Town Planning together with students from the FIRST Robotics Group. CoRobot helps to deliver medications, food and medical equipment. It travels on four (4) wheels so it can turn on its axis at the robot's centre allowing for maximal movement in the crowded hospital space. This robot has camera that give a 170-degree field of view. It has two (2) trays; upper tray and lower tray, the upper tray allows you to put all sort of things and the upper tray will hold a tablet and supports a wide range of remote controls.

9.1.2 Italy
'Tommy the Robot Nurse' helps the frontliners during coronavirus outbreak by taking care patients and help medical staff monitor patients with COVID-19. This robot is equipped with touchscreen faces that allow patients and doctors to interact with each other without physical contact.

9.1.3 China
In China, there are five (5) current functions of robot which are currently being use during the COVID-19 outbreak:

- Grocery delivery – Pick up items from the company's warehouse and deliver them to specified drop-off locations.
- Meal delivery – deliver meals to Beijing, Shenzhen and Guangzhou Hospital staff.
- Cooking (Foodom) – cooking at Wuhan quarantine facility where workers scan a code to collect their meals anytime, to ensure that the food is always served hot.
- Cleaning (TMIRob) - do disinfection job more efficiently at hospital in Wuhan and other cities. It releases hydrogen peroxide and UV light to kill germs, and able to map own route through the hospital. Before entering a room, it will warn people inside to leave and automatically connect to charging stations when it is out of power.
- Patrolling – detect fever from five (5) metres away, able to recognize if people are wearing mask or potentially ill, police can also broadcast messages through the droids.

Temperature tests, mouth swabs, ultrasounds, and medication delivery are all possible with the 'Robotic Arm on Wheels.' Doctors can monitor and manage the procedures using the robot's cameras.

9.1.4 Rwanda
ZORA Robots Team has developed robots that can perform screening to 50 until 150 people per minute, deliver food and medications to patient's rooms, capture data and notify officers on duty about abnormalities found. This robot will perform facial recognition, temperature screening, monitoring patients' status and keep medical records of the patients.

9.1.5 India
In India, MITRA robot is used to screen body temperature for everyone who enter the building of Fortiss Hospital. It also delivers vital supplies and giving foods and medicine to patients. If the temperature is high, visitors will be connected to the doctor for the supervisions of symptoms.

9.1.6 Washington D.C, United States of America
Starship has developed 'Self-Driving Robots' that can travel within a 4-mile radius from their starting location and are monitored via smartphone. Local business uses self-driving robots to stay open during the pandemic and provide contactless delivery.

9.1.7 Belgium
The 'Ultraviolet Light Robots' by UVD Robots will drive itself to the room and disinfect hard-to-reach areas to minimize the risk of infection. The machines ultraviolet light can quickly kill the bacteria.

9.1.8 Taiwan
In Taiwan, Nasal Swab Robot was developed by Brain Navi to reduce the risk of exposure towards the infection and reduce the workload of healthcare workers. This robot will take nasal swab of patients. A depth-sensing camera scans their faces and measures the distance between their nostrils and ear canals. The robot then retrieves a cotton swab from its base and approaches patient slowly. It inserts the swab, twirls it, and then withdraws the sample, which is then placed in a sterile tube for transport and analysis.

9.1.9 Korea
Sterilization Robot by Seoul Digital Foundation measure body temperature and sterilize negative-pressure wards by using ultraviolet light to prevent room-to-room contamination. They collect medical waste such as hospital gowns and move medical devices.

9.1.10 Mumbai
The 'Gollar Robot' deliver food and medicines for COVID-19 patients in Mumbai Podar Hospital. This robotic trolley will help to eliminate the physical contact and reduce the risk among medical staff who treat COVID-19 patients.

9.2 The role of Autonomous Robots in combatting COVID-19 in Malaysia
In Malaysia, MediBot V1-U is currently being developed [10]. MediBot is a 1.5-metre-tall white barrel-shaped robot on wheels with a camera and screen that allows patients to communicate with medics remotely [10]. MediBot is an invention by International Islamic University Malaysia's scientist with a purpose of reducing health workers' risk of infection [10]. This can be achieved through frequent check on COVID-19 patients since this invention also fitted with device to check patients' temperature remotely by social distancing [10]. However, it cost about RM15,000 (US$3,500) to develop, and the university intends to test it in their own private hospital, which does not treat virus patients, soon [11]. If that is successful, the scientists hope it can be used in government hospitals where people with COVID-19 are admitted [11].

We have also used Hospital Delivery Robot called 'Makcik Kiah 19' (MCK19) in assisting healthcare frontliners [19]. 'Makcik Kiah 19', or MCK19 is the First Malaysian Made Delivery Robot for hospitals developed by DF Automation & Robotics Sdn Bhd (DF), Hospital Canselor Tuanku Mukhriz (HCTM), and Universiti Teknologi Malaysia (UTM) [19]. This significant collaboration aimed to assist healthcare frontliners in delivering healthcare to COVID-19 patients. The first advantage of using this robot in the hospital is that it can reduce the exposure of healthcare professionals and frontliners to patients under investigation (PUI) who may be highly contagious and require isolation [19]. Exposure can be reduced by limiting contact through robot-assisted delivery of medicines and food, also teleconference between doctors with patients [19]. This is as been advised by World Health Organisation (WHO) for people around the world to practice physical distancing thus COVID-19 transmission should be avoided at the community level.

Doctors and nurses can be aided in bringing food or medication to a patient's room by using Zalpha, a DF commercial robot that can handle weights up to 300 kg in its [19]. Thus, its ability to accommodate up to 300 kg weight instead of remote autonomously will reduce health workers' risk of infection [19]. Next, the robot has an LCD screen that displays an animated face to make it more human-like, and it will soon be used for teleconferences between doctors with patients from his room or office, hence doctors does not have to visit patients' room [19]. This robot is also an Internet of Things (IoT) robot, which means it can be accessed from any PC, tablet, or phone, allowing users to communicate with it even if they are not at the hospital [19]. There is also a security feature that only allows licenced admins to access the system [19].

In addition, Malaysia has also focused on the third area on which robotics can make a difference: logistics. For example, delivery and disposal of contaminated waste. A group of students from Universiti Teknologi Mara (UiTM) has produced two (2) types of robots to help them to do their daily tasks [20]. These two (2) robots since six (6) months ago has been fully used in UiTM Sungai Buloh Hospital wards and laboratory [20]. Chief executive officer of Sailcott (M) International Sdn Bhd, Shaifull Naim Othman said it not only reduced contact between people at the hospital but also provide pleasure while on duty [20]. This robot act as assistants to their clinical support services while reducing contact of employees with clinical waste, especially COVID-19 residues [20]. At UiTM Sungai Buloh, there is a laboratory where they perform screening for this COVID-19 virus [20]. It is hoped by implementing this robot, the contact of the workers with COVID-19's residues can be reduced [20]. In addition, with the use of these robots, they have also been able to reduce the use of personal protective equipment (PPE) [20]. If the clinical waste were taken manually, the PPE they use will have to be thrown away every time their employees go to one place [20]. And when they went elsewhere, they had to apply for new PPE and had to get rid of it after they left [20]. Thus, the use of these existing robots will reduce PPE disposal at this critical time [20].

Hence, by reducing the contact between healthcare workers and patient, the need for PPEs can be reduced [20]. Healthcare workers are facing a shortage of supplies, including face masks as the novel coronavirus disease, COVID-19 continues to spread worldwide [21]. Since everyone has started to realise and become aware of the pandemic effect, there are shortages of supplies like masks, ventilators, intensive care unit (ICU) capacity [22]. Besides, the increasing number of patients has also caused shortages of masks and other protective equipment [22]. Hence, medical staff are at high risk or vulnerable when shortages of testing and protective equipment happened. For example, 9% of Covid-19 cases in Italy are comprised of medical staffs [23]. In Spain, the figure is 14% [24]. Same goes to United States which has a significant rate of infection among medical staffs [24]. Meanwhile, on 3 April 2020, the number of medical staff infected with Covid-19 in Malaysia has increased by more than two-thirds to 138, from 80 recorded as at March 26 [25].

Figure 3. The team involved in the development of 'MCK19'.
Source: UTM News (2020)

Figure 4. A user is with 'MCK19'.
Source: UTM News (2020)

Figure 5. Left picture: Customizable compartment shelves. Right Top picture: The LCD screen displays an animated friendly face. Bottom Right Picture: Graphical User Interface (GUI).
Source: UTM News (2020)

10. Discussions and Analysis

Instead of performing tasks like disinfecting surfaces, taking people's temperatures in public places or at ports of entry, and providing social support for quarantined patients. It is also hoped that the robot would be able to gather nasal and throat samples for testing, as well as enable people to virtually attend conferences and exhibitions [9]. However, there are still none of these specific functional robots in Malaysia that are able to collect nasal and throat samples for testing. Even if we have, there are still some features or functions need to be enhanced. Besides, the existing robots can be enhanced by using other countries as an example.

In China, an intelligent robot has been developed to perform throat swab sampling for coronavirus diagnosis to reduce the risk of cross-infection among medical personnel [26]. The robot was created in collaboration between the Chinese Academy of Sciences' Shenyang Institute of Automation and the Guangzhou Institute of Respiratory Health [26]. The robot is made up of a binocular endoscope, a snake-shaped mechanical arm, a human-computer interaction terminal, and wireless transmission equipment [26]. Since it operates in the pharyngeal region, the snake-like arm is considered efficient and precise [27]. Doctors can see high-definition 3D anatomical views with the binocular endoscope [27]. The robot will finish sampling quickly and gently using remote man-machine collaboration [28].

Meanwhile, some analysts have pointed out that during conventional throat swab screening, medical personnel are in close proximity to the patient, increasing the risk of cross-infection [27]. Furthermore, the accuracy and quality of throat swab results are affected by the working

skills and psychological states of medical personnel [27]. According to the expert, the robot is helpful in reducing the risk of infection among medical personnel since it interacts directly with patients [27].

Since the COVID-19 outbreak has added a fourth field (where robotics can make a difference in a disease outbreak): job continuity and socioeconomic functions, further research into remote operation for a wide range of applications involving dexterous manipulation would be needed, from manufacturing to remotely operating power or waste treatment plants [9]. In robotics, there are extensive developments as well as possibilities to be explored [9]. In terms of clinical care, areas of particular importance include disease prevention, diagnosis, and screening, as well as patient care and disease management, which should be investigated further [9]. Seeing as the hospital's innovation industry is bright, it expects more collaboration between the university and the Ministry of Science, Technology and Innovation (MOSTI) not only in medical equipment but in hospital support services.

In conclusion, Malaysia is already 'on the track' of implementing Fourth Industrial Revolution (4IR) as an approach of Sustainable Development Goals (SDG 9): Industry, Innovation and Infrastructure in handling the effect of COVID-19 together with other countries. It is hoped that 'lack' in some features or functions on the existing robots that were determined will help innovators especially in improving the existing function of Autonomous Robots used in Malaysia during COVID-19.

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