International Journal of Nanoelectronics and Materials
Volume 14 (Special Issue) December 2021 [227-236]

Recent Development of Crowd Monitoring Technology Solution for Covid-19 Prevention at Airport Terminal

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ABSTRACT

Public social distancing has been a great concern for the worldwide community as the World Health Organization (WHO) has declared the COVID-19 pandemic as a Public Health Emergency of International Concern (PHEIC). With regards to this global issue, this paper will share the latest commercially available solution and technology on crowd monitoring systems to determine the number of people in confined and crowded spaces at airport terminals which may have the potential for contagious diseases infection. Estimation of crowd dynamics is essential for crowd monitoring to ensure public safety by reducing the possibility of being infected by the COVID-19 virus. In this report a number of commercial and under development crowd monitoring products are reviewed and presented. Research and development of crowd monitoring technology is increasingly demanding to monitor crowds at strategic locations such as entry and exit points of closed areas to ensure public safety and to control the pandemic. In particular for the strategic area at the airport terminal, an efficient crowd monitoring solution is expected to support huge data collection and real time analysis, as well as providing online monitoring of crowds based on non-contact sensors for movement counting to restrain COVID-19 outbreaks.

Keywords: Crowd Monitoring, Covid-19, Machine learning, Thermal Detection, Image Processing.

1. INTRODUCTION

As of August 6, 2021, a new highest daily of 20,889 COVID-19 cases bringing the cumulative number of infections in the country to 1,224,595 cases was recorded [1]. This situation became even more worrying with the emergence of new mutations of SARS-CoV-2 virus [2]. Based on this highest case, one of the active clusters that contribute to the sharp increases of the COVID-19 cases is the economy sector. As it can be seen from the COVID-19 case that was reported on January 23, 2020 which was also the first positive COVID-19 case in Malaysia. This case involved a 63 years old China's citizen who arrived at Kuala Lumpur International Airport (KLIA). He had a slight fever and was treated as an outpatient at a private hospital in Kuala Lumpur on the same day. The next case involves a 41 years old Malaysian's citizen. On February 3, 2020, the first Malaysian who tested positive for COVID-19 was announced. This individual had a history of travelling to a neighbouring nation, Singapore for a business conference, which was also attended by a China's delegation [3]. According to the cases above, consideration of crowd monitoring is not only necessary for managing crowded places to prevent the COVID-19 outbreaks in crowded places, interior places or point-of-interests (POI), particularly at airports in order to avoid the Three Cs which are crowded spaces, close contact settings and confined and enclosed spaces.

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Generally, the crowd related research approaches are classified into two domains based on the literature study namely crowd management and crowd monitoring. The crowd monitoring section can be further expanded into three primary subcategories which are counting, localization and behaviour. The counting section can be divided into two parts, which are the density estimation and people counting. On the other hand, the localization part consists of three main subcategories which are counting and localization, estimation and localization, and anomaly detection and localization. Finally, the behaviour category can be split into three sub categories which are individual behaviour estimation, anomalous behaviour detection and normal and abnormal behaviour detection. The flow chart of crowd related research approaches is shown in Figure 1 [4].

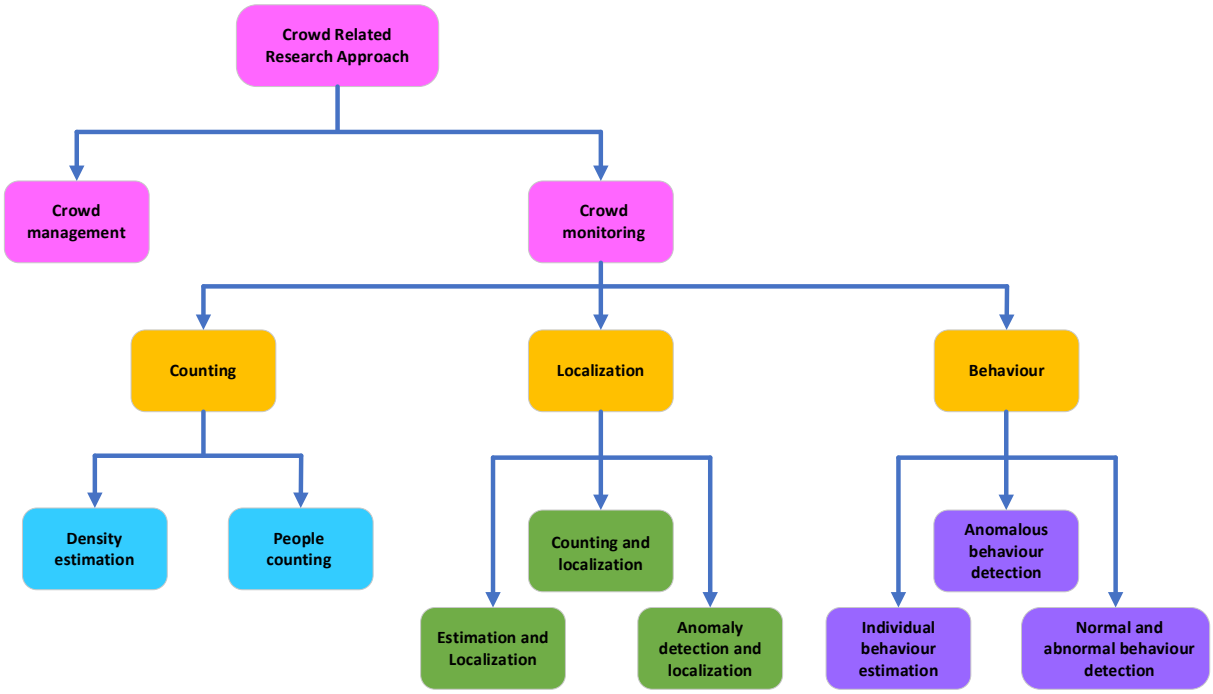

Figure 1. Crowd related research approaches [5].

One of the central objectives of this project is to facilitate and conduct a survey of crowd monitoring systems that will be able to count the number of crowds at the Kuala Lumpur International Airport (KLIA). According to Health director-general Tan Sri Dr Noor Hisham Abdullah's statement, the new variants of Coronavirus that have been classified under the Variant of Concern (VOC) category are include Alpha variant (B.1.1.7), Beta variant (B.1.351) and Delta variant (B.1.617.2). While for the Variant of Interest (VOI) category, the variants are Theta variant (P.3), Eta variant (B.1.525) and Kappa variant (B.1.617.1) [5].

Therefore, the main objectives of this case study are:

1. To survey the crowd monitoring products in certain countries that are available in the market.
2. To survey a potential field area of the crowd monitoring system considering Malaysia's airports as use case study.
3. To conduct a feasibility study on crowd monitoring technology based on non-contact sensors for crowd counting to restrain COVID-19 outbreaks.

2. CROWD MONITORING SOLUTIONS

Crowd monitoring solutions powered by Artificial Intelligence (AI) and Internet of Things (IoT) technologies are becoming increasingly common and has been widely used in many areas such as transportation control and safety management. An effective crowd monitoring system requires a special planning during the operating time and reporting lessons learned for a more reliable system in the future. As technology continuously advanced, the crowd monitoring systems gather wide range of digital sensors such as [6]:

- Automatic counting & flow / speed / density / detection systems
- Wi-Fi & Bluetooth sensors
- GPS trackers and smartphone applications that provide location information
- RFID sensing techniques

Crowd monitoring refers to the capability to guide, monitor and manage large groups of people with an eye towards safety, efficiency and satisfaction [7]. While crowd monitoring system is a system that will combine multiple technologies. These includes image/signal data, storage database, learning and decision support, modelling and analysis. The technologies in the monitoring system manage all aspects of crowd dynamics from detecting and suppressing potential threats to optimizing the flow of human movement, improve safety management and evacuation plans, reduce the queuing times and improve queue management for greater crowd monitoring satisfaction.

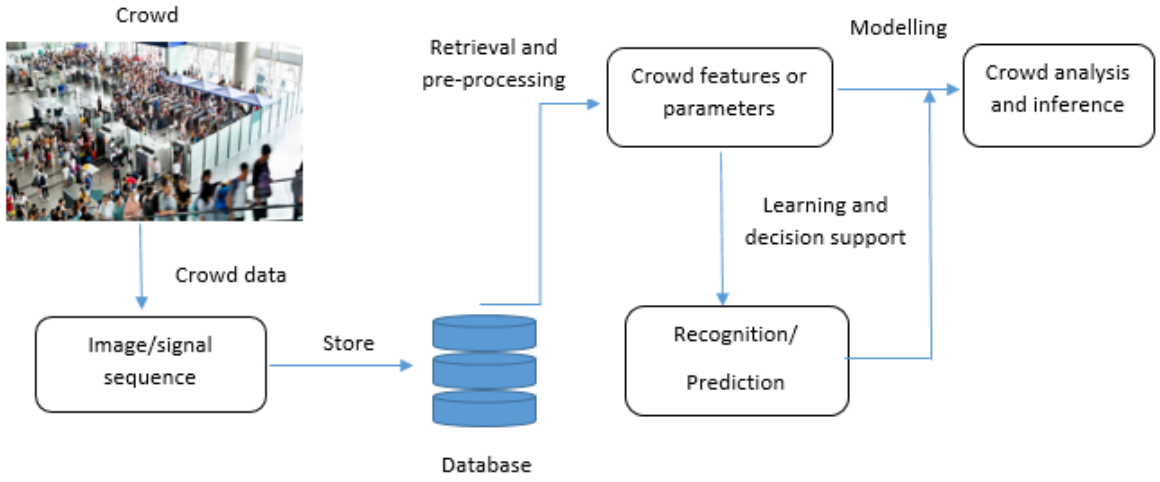

Figure 2. Generalized representational model of a crowd monitoring system.

Figure 2 shows a representational model of a crowd monitoring system. This model starts with a generalized idea of a crowd monitoring system by using image or signal sequence. Then, it is followed by a retrieval of the features and parameters which are useful for crowd characterization. This process comes from the various uses of crowd characterization. Some examples of crowd characterization may include behaviour analysis, ascertaining crowd simulation environments, better event management, personal assistance, and turbulence detection. Crowd parameter is a measurement or estimation that helps to infer crowd dynamics. Whereas a crowd feature can be considered as the distinctive attribute of a crowd which is used to compute crowd parameters. Crowd recognition and tracking is a method for recognizing individuals in a crowd by using sensor detection. Types of sensors may include either thermal imaging, human body sensor, AI facial recognition sensor or others. For instance, a large group of people can be recognized through body temperature. Some examples of crowd recognition

applications may include crowd counting, preparing crowd tie series, forecasting crowd count/density, checking abnormal densities, evacuation, crowd control, crowd modelling, identifying crowd attributes and image labelling [8].

3. CROWD MONITORING METHODS

The term crowd can be defined as the mass gathering of people of any specific reason for example travel and mass gathering [9]. As shown in Figure 3, there are three best methods to handle crowd monitoring which are counting, localization and behaviour analysis. Counting the crowd provides an estimate on the number of people or certain objects without knowing the location. Density maps are computed at various levels with limited accuracy on the location information. On the opposite hand, localization provides accurate information about the location. However, due to its sparse nature, it is comparatively arduous.

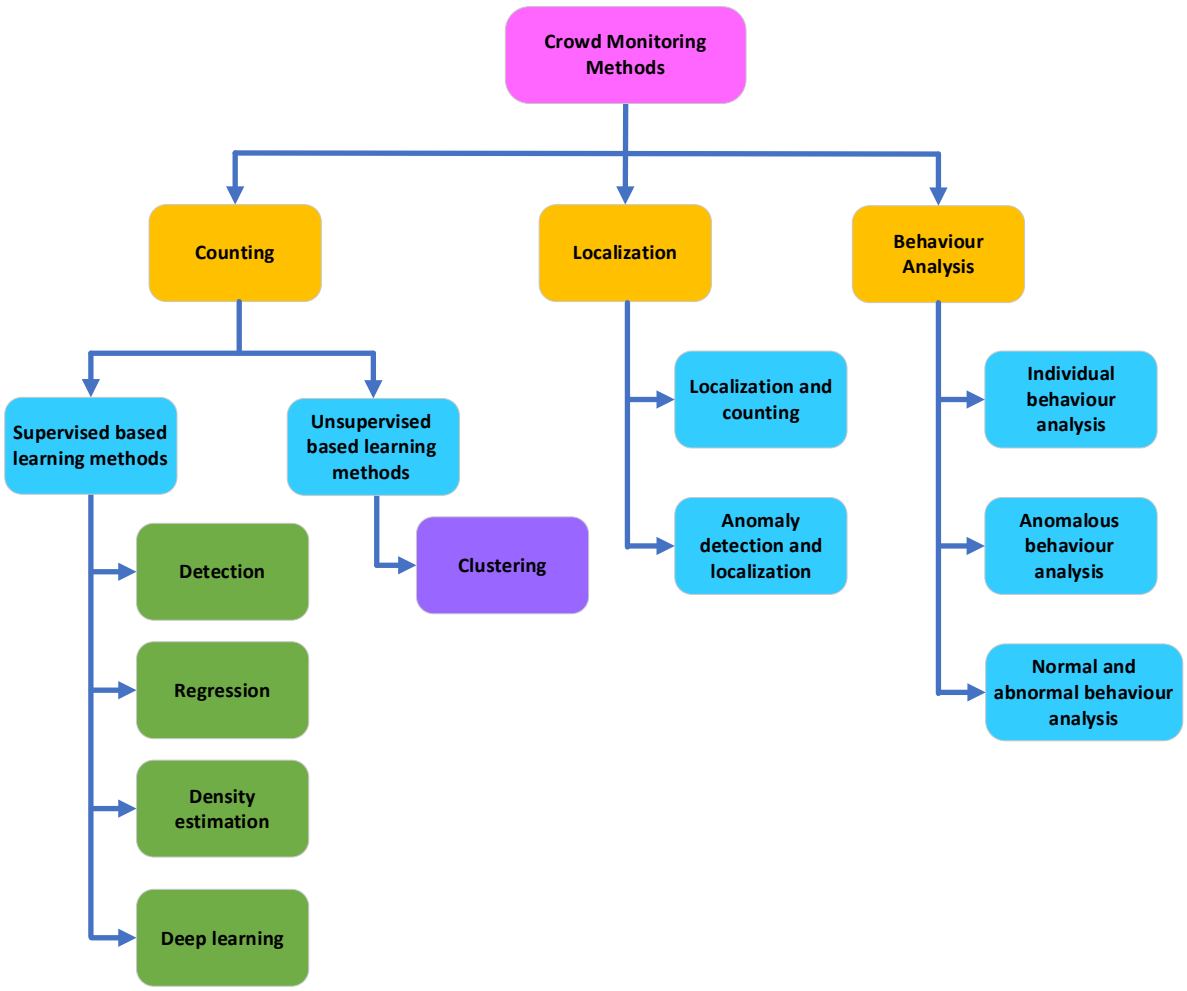

Figure 3. Crowd monitoring methods reported in literature.

Crowd counting, which is the key topic in this survey, can be estimated from the number of people by measuring body temperature, breathing rate (BR), heart rate (HR) and image processing technique or detect vital signs is video camera imaging technology. There are two types of counting which are controlled and uncontrolled counting. For the controlled counting, the input data is normally labelled and uses machine learning as a tool for prediction. For the uncontrolled counting, the input data is unable to be obtained and therefore could not be labelled [10]. As mentioned previously, the case study is an airport, hence it can be classified as the controlled counting crowd based on the identified indoor parameters.

Hence, in this project, we will study and develop deployment strategy for Malaysia Airport transformation to maintain social distance in crowded places. A series of surveys and findings will be included in this paper by starting with surveys of the existing crowd monitoring products in certain countries that are available in the market to fully understand the type of crowd data acquired by a particular device. Following with the survey on Malaysia's airport terminal to implement the crowd monitoring system and lastly survey on crowd counting models by statistics regression methods using sample data captured by existing cameras at the facilities.

4. TECHNOLOGY AND PRODUCT CASE STUDY

Survey on crowd monitoring products, potential application field and crowd monitoring technology will be presenting in the following:

4.1 Survey the Crowd Monitoring Products in International Market

In crowd monitoring, there are variety of technologies have been used, with vision-based devices being the most common. The monitoring approach and underlying mathematical models depend on the choice of device. Therefore, it is necessary to fully understand the type of crowd data acquired by a particular device.

Countries that have been selected for this survey are Malaysia, China, Korea, Japan and Europe. The coverage that is emphasized for this product survey are measurement principle and use cases in monitoring. The description specified for coverage is given where most approaches reside. A high-level comparison between the capabilities of some monitoring devices is shown in Table 1.

Table 1 Comparison between some commonly used monitoring devices.

Device/Technology		Measurement Principal	Use Cases in Monitoring	Camera View
Country	Product Name			
Malaysia [11]	Non-Contact Face Access Control (PB03GYW)	-Thermal imaging -Image metrology	-Facial recognition -Mask recognition -Detection, tracking	Single cam-view
China [12]	Thermal Imaging Human Body Temperature Monitoring System	-Thermal imaging -Image metrology	-Detection, tracking -Mask recognition	Multi cam-view
Korea [13]	Security Camera with Siren PTZ Surveillance System with Facial Recognition	-Image recognition	-Facial recognition, detection, tracking, surveillance	Multi cam-view
Japan [14]	Crowd People Counter for Milestone XProtect Version 1.0	-Image recognition	-Detection, tracking	Multi cam-view
Europe [15],[16]	TSCAN-750 (Temperature Scanning Entry System)	-Thermal imaging -Image metrology	-Detection, tracking -Facial recognition	Single cam-view

4.2 Crowd Monitoring System Considering Malaysia's Airports as a Case Study

After several surveys and discussions, Kuala Lumpur International Airport (KLIA), Sepang, Selangor was the best potential field area for this case study. The reason Kuala Lumpur International Airport (KLIA) has been chosen as the case study area is because the airport, also called air terminal, is a point-of-interest (POI) area and domestic field that is frequently used for international and intercontinental flying travel and constantly crowded with people. The physical structure of the airport which is capable of accommodating hundreds of thousands of people and has high potential to be a congested area is also one of the factors the place was chosen.

The huge impact of the COVID-19 pandemic has had a profound effect on the airline industry. This has led many airlines to implement a massive capacity reduction approach such as reducing manpower and lowering operating costs. Therefore, a crowd monitoring system has been studied as the best solution to be implemented at Kuala Lumpur International Airport (KLIA) to monitor the number of people in enclosed areas to reduce the Three Cs which are crowded spaces, close contact settings and confined and enclosed spaces probability of COVID-19 infection. It is because KLIA is a place where the COVID-19 infection begins which involving a 63-year-old Chinese man from Wuhan, China who arrived at Kuala Lumpur International Airport (KLIA) on 18 January 2020 which was reported by Health Minister Datuk Seri Dr Dzulkefly Ahmad during a press conference on the latest situation of 2019 Novel Coronavirus (2019-nCoV) infection at the Ministry of Health [17]. This can be an effective solution to reduce capacity on a large scale, including lowering operating costs for airport staff services and controlling crowd limits.

Thus, in this project, a survey on potential areas for the crowd monitoring case study at Kuala Lumpur International Airport (KLIA) will be conducted to emulate the digital future airport initiative. This crowd monitor case study can be beneficial to help in assessing how effective the crowd safety precautions during this coronavirus pandemic. The selected site for our survey has been identified at Kuala Lumpur International Airport (KLIA), Sepang, Selangor as depicted in Figure 4 below.

Figure 4. Kuala Lumpur International Airport (KLIA), Sepang, Selangor indicating area for the proposed surveillance for crowd monitoring system.

4.3 Crowd Monitoring Technology Based on Non-Contact Sensors

The physical distance between a person and the other is the one of important aspects needed to seriously take care of to help limit the spread of COVID-19. To reduce the risk of infection, it is required to keep at least 1-meter distance between persons when they cough, sneeze, or speak. Maintain even greater distance between others when indoors [18]. Non-contact sensor that refers to ones that have the ability to function without the need to physically touch the object being monitored [19] is very important at this moment in time to avoid direct contact with another person. In this case study, crowd monitoring by counting the number of crowds in closed areas is important. There are many ways to detect the number of crowds, for example, by measuring their vital signs such as body temperature. In addition, vital signs can also be measured in various methods by using several technologies

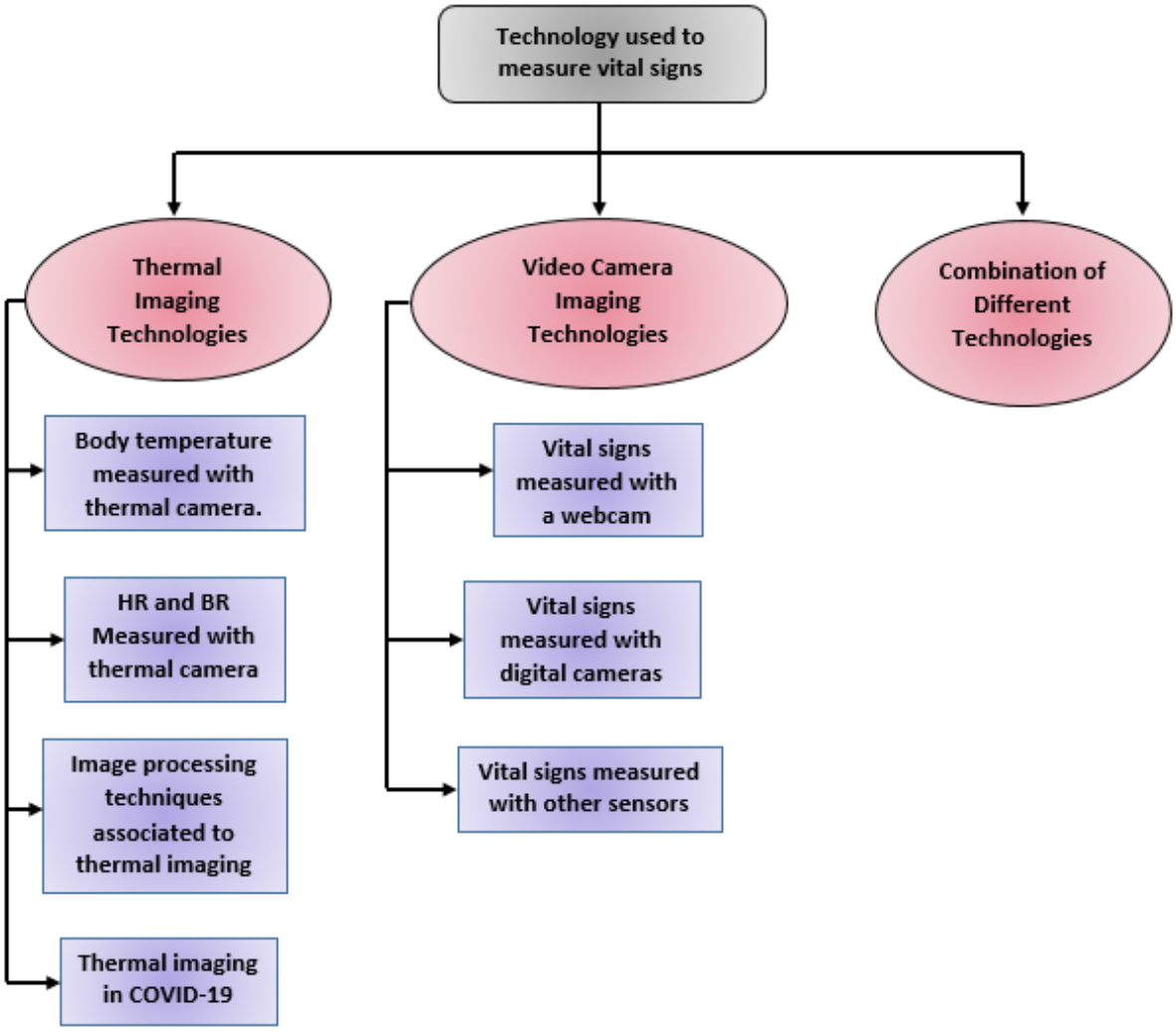

Figure 5. The technologies to measure vital signs.

Based on Figure 5, 2 methods were chosen to detect vital signs, namely Thermal Imaging Technology and Video Camera Imaging technology. Thermal imaging technology is a method to detect the number of people by measuring body temperature, breathing rate (BR), heart rate (HR) and image processing technique [20]. The internal parameters of temperature and cardiorespiratory rates which can be measured using noncontact sensing technology are the focus of this review. This case study, on the other hand, has chosen to focus solely on the internal parameter of temperature factor. Next method to detect vital signs is video camera imaging technology. Video camera imaging technology is a non-contact and passive modality that can be

delivered from a variety of video data including fixed and hand-held video cameras, smartphones, webcams, or from sensor platforms such as robots and unmanned aerial vehicles (UAV). Video analysis of vital signs actually relies on two phenomena. The first phenomenon is known as imaging photoplethysmography (iPPG) or colour-based methods depending on skin colour variations caused by cardiorespiratory activity. motion based methods which is a second phenomenon, depends on cyclic body motion such as the motion of head movements, arterial pulse or movements within the thoracic and abdominal regions due to cardiorespiratory activity [21]. The second phenomenon which is a motion-based method by detecting head movement using Microsoft Kinect was chosen for this study. Then, combinations of different technologies are required to enhance the performance of monitoring vital signs where different technologies can be combined. For example, by combining RGB camera, thermal camera and a monochrome camera with colour filter [22].

This case study concentrates mostly on using thermal imaging as crowd counting for COVID-19 prevention. These technologies are important and receiving increasingly more interest nowadays. Thermal screening for body temperature measurement is non-invasive, meaning it could not spread virus through contact or harm the body's organs and tissues when applied with appropriate application [23]. Other than that, it is also fast, cost effective and accurate to identify people that are potentially infected by the novel coronavirus [24]. This thermal imaging using a telethermographic system. When combined with software programmes that can recognise face features such as the nose, eyes, and mouth, telethermographic systems capable of determining skin-surface temperature at a reference body point such as the oral, tympanic membrane, and inner canthus. The resulting value can be used to estimate core body temperature. One advantage of using telethermographic systems for initial temperature assessment is that they can be used in high-throughput places like airports, business, warehouses, and factories, as well as in situations where other temperature assessment products are in short supply [25]. This feature was utilised to take photos of people and perform social distancing measurements as well as density-based thermal imaging. Various organizations and workplaces are looking for ways to prevent the virus from spreading while ensuring the safety of its staff and consumers.

This paper highlights more on vital signs measured with a Microsoft Kinect camera. Microsoft Kinect camera provided a real-time people counting algorithm by the depth photos obtained from the camera that is positioned vertically such that the camera points toward the ground as shown in Figure 6. People counting using depth images might make it easier to design algorithms in which several issues such as occlusion, illumination variation and scene clutter are easier to tackle. According to Figure 6, the depth images for people counting algorithms are actually provided by Kinect sensors released by Microsoft. The Kinect device produces two types of images based on the structure light technique: RGB and depth images [26]. The main challenge is the view of the sensor is limited. The Microsoft Kinect sensor has a difficulty to cover more large area [27]. The goal in this paper is to provide an overview on the methods to identify and track the number of crowds in confined areas. The consideration place is more focused on the indoor area due to the lack of ventilation and poses higher risk than outdoor area.

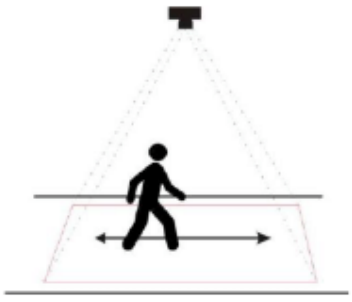

Figure 6. Kinect camera placement of vertical Kinect.

5. CONCLUSION

In this paper, we present the case study of crowd monitoring by focusing on crowd counting in closed areas to prevent the spread of COVID-19 virus. This report could be useful for researchers who are interested in crowd monitoring product surveys. There are 3 methods available for crowd monitoring which are counting method, localization method and behaviour analysis method. The comparison between products from several countries such as Malaysia, China, Korea, Japan and Europe also have been reported in this paper. One of the potential locations to implement the crowd monitoring system is the Kuala Lumpur International Airport (KLIA), Sepang, Selangor. The study on crowd monitoring technology based on non-contact sensors was conducted. There are 3 methods in determining the vital signs by using several technologies such as thermal imaging technologies, video camera imaging technologies and combination of different technologies. Thermal imaging technology and video camera imaging technology are used for this case study as non-contact sensors for public monitoring. This includes measuring body temperature as an internal parameter to detect vital signs using thermal imaging technology and a Microsoft Kinect camera as a tool for counting people. From the continuously growing number of exciting new publications on crowd counting to prevent crowded places and the spread of coronavirus in public and closed areas. It can be concluded that crowd monitoring has become more important than ever and more development works are required to further improve the system to meet the current needs.

ACKNOWLEDGEMENTS

We wish to acknowledge for the financial support received under The Industry-International Incentive Grant Vot 02M86 from Universiti Teknologi Malaysia.

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