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Employing of Object Tracking System in Public Surveillance Cameras to Enforce Quarantine and Social Distancing Using Parallel Machine Learning Techniques

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Abstract

Like many countries, Jordan has resorted to lockdown in an attempt to contain the outbreak of Coronavirus (Covid-19). A set of precautions such as quarantines, isolations, and social distancing were taken in order to tackle its rapid spread of Covid-19. However, the authorities were facing a serious issue with enforcing quarantine instructions and social distancing among its people. In this paper, a social distancing mentoring system has been designed to alert the authorities if any of the citizens violated the quarantine instructions and to detect the crowds and measure their social distancing using an object tracking technique that works in real-time base. This system utilises the widespread surveillance cameras that already exist in public places and outside many residential buildings. To ensure the effectiveness of this approach, the system uses cameras deployed on the campus of Al-Zaytoonah University of Jordan. The results showed

the efficiency of this system in tracking people and determining the distances between them in accordance with public safety instructions. This work is the first approach to handle the classification challenges for moving objects using a shared-memory model of multicore techniques.

Keywords: *Covid-19, Parallel computing, Risk management, Social distancing, Tracking system.*

1 Introduction

Among the many precautionary measures taken worldwide to limit the rapid spread of the Coronavirus, social distancing is one of the most effective measures. Social distancing is designed to reduce interactions between people in a broader community, in which individuals may be infected but have not yet been hence identified. As diseases transmitted by respiratory droplets require certain proximity of people, the social distancing of persons will reduce transmission of the virus. Social distancing is particularly useful in settings where community transmission is believed to have occurred but where the linkages between cases are unclear, and restrictions placed only on persons known to have been exposed is considered insufficient to prevent further transmission [1].

Policies aimed to increase physical distancing have been implemented in all public and private places to reduce Coronavirus transmission. The spread of the epidemic has disrupted various economic and social sectors worldwide, and education is among the highest directly affected sectors by the pandemic. The Covid-19 has a significant effect on resuming the campus's traditional educational process (face-face teaching and learning processes). Therefore, it was a compulsory act for all educational institutions to take precautionary measures to prevent the spread of infection among students and staff to return to work from the institutional campus. These precautionary measures have been tested and announced by the public health authorities in Jordan and supported by World Health Organization (WHO) announcements. According to the WHO guidance [2], physical distancing helps limit the spread of Covid-19, keeping a distance of at least 1m from each other and avoiding spending time in crowded places or groups will break the chain of Covid-19 transmission. This paper aims to present an Object Tracking System (OTS) to help Al-Zaytoonah University of Jordan implement the precautionary measures that prevent the spread of Covid-19 among students and staff to return to work from the campus. This will make Al-Zaytoonah University among the pioneer institutions that use an automated "social distancing" system as a part of its risk management plan.

This system measures the distances between people, whether they are moving, standing or sitting, and sends an alert to the concerned authorities if there is a violation of the assumed social distances. The system utilities Parallel Computing and Machine Learning techniques that play a critical role in many application areas, especially those requiring processing a large amount of data, such as automatic detection of moving objects and image processing [12]. On the other hand, the system will overcome the problems of cost, speed and time consuming for higher-level processing and decreases computation time considerably. Moreover, this system can be used to enforce the law in many other applications.

In parallel computing architecture, all involved nodes (memory or distributed memory) should be connected to set up a parallel environment. In general, communications are also implementing the process in parallel computation. Thus, many message-passing libraries have been developed to send and receive data between processors to initiate and configure the messaging environment in parallel computing communications. The most popular message-passing libraries are Parallel Virtual Machine (PVM) and Message Passing Interface (MPI), whereby POSIX Thread and OpenMP are considered as the most famous routines in shared address space paradigms [12].

On the other hand, the elapsed time between the beginning and the ending of execution processing on a sequential machine is defined as a serial runtime of a program (Ts). The elapsed time specified from the moment a parallel computation starts to the moment of finishing the last processing is defined as the Parallel run time (Tp).

This paper is organized as follows: In Section 2, brief literature on social distancing systems is presented. The methodologies of this work are introduced in section 3, and section 4 discusses the experimental results of this project. Finally, the conclusion and recommendations for future improvements on the current work are presented in Section 5.

2 Related Work

Social distancing policies implemented around the world resulted in meaningful behavioural change. Many researchers reported a practical impact of social distancing in reducing the spread of the virus and preventing the transmission of droplets between people. [3] observed a 35% increase in objective social distancing using an American national dataset that assessed social distancing through GPS positioning and collected the related information about the transmission of covid-19. Through their results, [3] found that the state policies of staying at home successfully reduced the spread of the disease.

Such outcomes are consistent with emerging evidence using a different social distancing methodology such as Google Human Mobility Indicators which was tested by [4]. Their results showed that state policies reduced mobility by 37% within approximately two weeks after their implementation. [5] demonstrated in their study the effectiveness of following the precautionary instructions in various American states that state policies were associated with a 5–10% increase in the prevalence of residents staying at home full-time.

In a comprehensive study [6] that analysed the relationships between key parameters characterising the Covid-19 epidemiology and social distancing efforts of nine European countries, the results showed signs of substantially increasing the disease's death toll when social distancing efforts are weak. Therefore, increasing social distancing is considered a key public health measure to reduce the fast spread of coronavirus disease. In order to provide an effective social distancing monitoring system, many research studies that utilise different technological techniques were conducted.

According to statistical research introduced by [7], India, South Korea, and Singapore are taking benefit from CCTV footage to monitor the recently visited places of Covid-19 patients to track down the infected people. [7] also found that China utilises AI-powered thermal cameras to identify those people in the crowd having the temperature. Such inventions in this drastic situation might help to flatten the curve, but at the same time, it results in a threat to personal information.

A framework for automating the task of monitoring social distancing using surveillance video was presented by [8]. This framework utilises the YOLO v3 object detection model to segregate humans from the background, and Deepsort approach to track the identified people with the help of bounding boxes and assigned IDs.

[9] provided a night-time human detection system that uses a single image captured at night on a visible light camera to detect humans in various environments based on a convolutional neural network. Another detection system introduced by [10], where a detector for standing and moving people in videos with possibly moving cameras and backgrounds, has been developed. [10] studied various motion coding schemes but found that although there are considerable performance differences between them when motion features alone are used, the differences are significantly reduced when the features are used in combination with static appearance descriptors. Despite the recent advancements in this field, the implementation of intelligent human detection and tracking systems is still a very challenging problem due to the objects' motion, the camera and the background, the variations in pose, appearance, clothing, and illumination. In this work, the gap in the existing studies will be overcome by focusing on human detection methods, tracking and measuring the physical distance between humans regardless of the lighting conditions of the studied environments (indoor /outdoor) and whether the object is close or far away. Moreover, the utilisation of a parallel computing approach will reduce the processing time for video-based images.

3 Methodology

This research aims to construct a powerful parallel computing system using a multicore programming model that implements data of real-time moving objects to provide an adequate social distance monitoring solution. The proposed system will overcome the problems of cost, speed and time consuming for different object detection and tracking applications. This section proposes a parallel social distancing system combining three techniques: object detection, object tracking, and distance measurement on a real-time basis for multiple cameras.

The YOLO algorithm (You Only Look Once), which employs a convolutional neural network, is used for the detection process. This algorithm is already trained on the Common Objects in Context dataset (COCO dataset) [11]. This dataset consists of 80 labels where the “PERSON” class is used to recognize humans from other objects in the scene. Tracking the mapped bounding boxes and determining the distance between moving/unmoving people are the following stages to ensure no violation of the assumed physical distance. Fig. 1*: The flowchart of the proposed social distancing system*shows the flowchart of the proposed model.

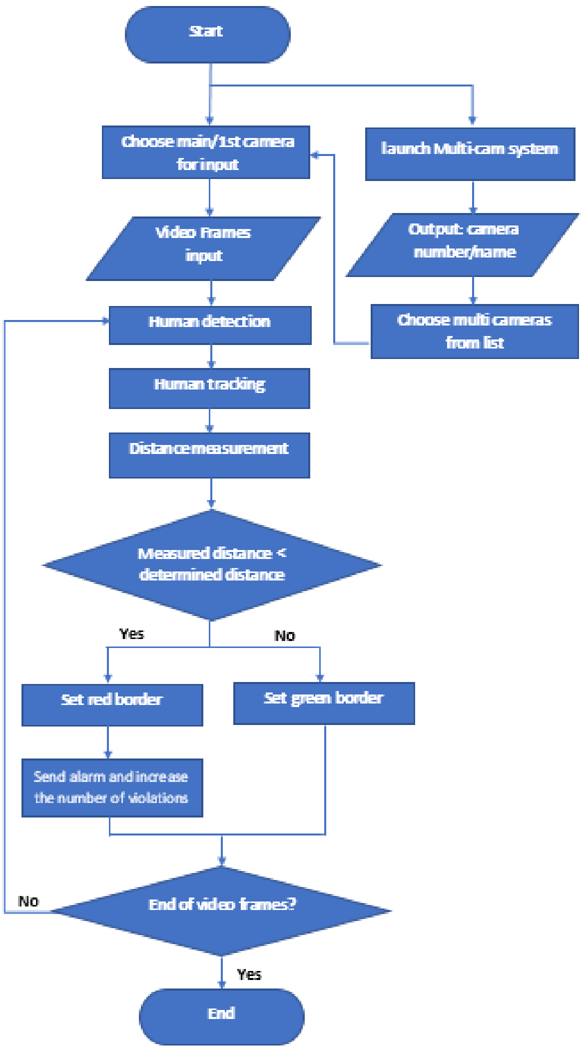

Fig. 1: The flowchart of the proposed social distancing system

The system input is a sequence of video streams taken by the installed surveillance cameras. The range of view for each camera covers different regions. Human detection is the first technique used in the proposed system to monitor the physical distance between individuals. Many challenges had to be overcome, such as faint videos, diverse articulated poses, and background complexities to boost surveillance cameras' detection performance. YOLO algorithm with a deep-sort technique for separating people from the background in the frame with the help of bounding boxes has been used. For the human tracking stage, a unique ID is assigned for every detected person. The bounding box's centre is considered the initial point to measure the distance between all detected people in the scene. To track the movement of people, each detected person will keep their first assigned ID regardless of their position in the live feed. The distance between people is scaled and measured by calculating the Euclidean distance between the centroids. A threshold value for the distance is set; according to WHO guidance, the distance range to prevent transmission from one person to another is 1 to 2 meters. Therefore, any distance lower than the threshold value is considered a violation; a warning using red-coloured bounding boxes will be shown over those who violate safety measures. The remaining people in the scene will be marked using a green box.

As mentioned earlier, the system runs on a shared memory programming model. The workers simultaneously perform a different task on each core. However, the system has two phases: the pre-processing phase and the parallel camera phase. In the pre-processing phase, the system will be created and the number of cameras will be calculated. The master core will distribute each camera to the available cores. Several threads will be created based on the number of available cores, note that the optimal number of threads on each core is one. The first implemented phase uses OpenMP technology: dynamically, OpenMP partitions the iterations of the loop based on the available number of workers (threads), which is made available by the parallel pool. As well as synchronizing tasks is no guarantee anymore. If the number of workers equals the number of loop iterations, one worker will perform one loop iteration. If their iterations are more than workers, some workers will perform multi-loop iterations to reduce communication time. However, the second phase will be that each core will continue to implement the YOLO algorithm, combining three techniques: object detection, object tracking, and distance measurement on a real-time basis for one camera. Fig. 2: *Operation* illustrates the flowchart of the system operation procedure after impleminting the parallel technique.

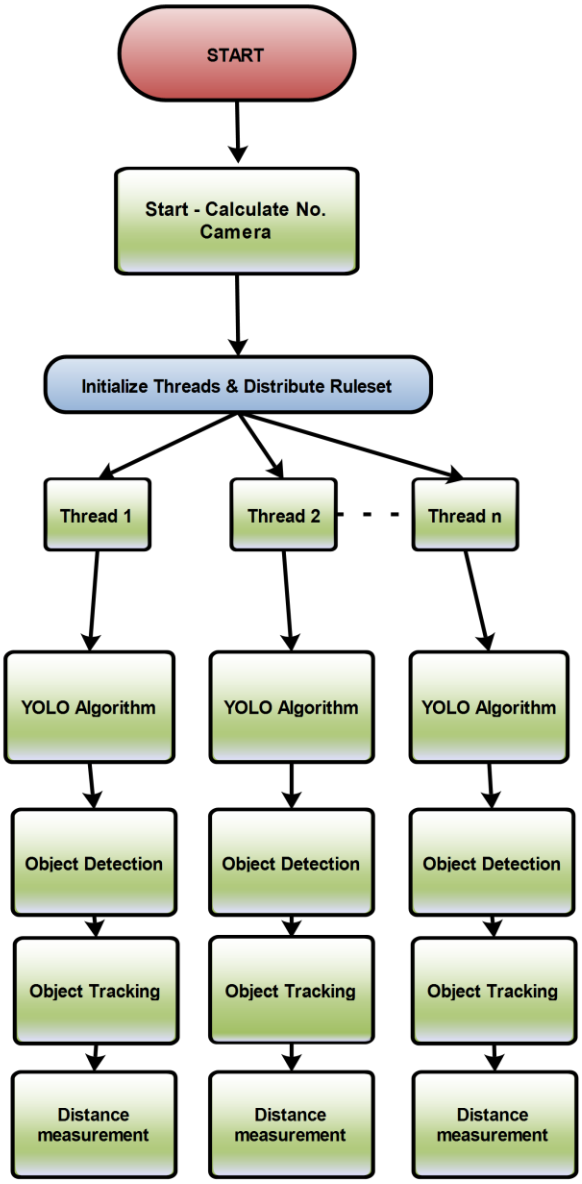

Fig. 2: Operation procedure using the parallel system

4 Experiments and Results

This work aims to help Al-Zaytoonah University of Jordan implement the precautionary measures that prevent the spread of Covid-19 among students and staff to return to work from the campus. This will make it among the pioneer institutions that use an automated "social distancing" system as a part of its risk management plan. Al-Zaytoonah University has a network of indoor and outdoor surveillance cameras installed in different areas onn campus. To test the performance and accuracy of the proposed system, real-time data collected from various units were used.

The live stream video of people is taken as the input, and it will be read frame by frame for the precise calculation of the distances between all detected people in a frame. To ensure there is no violation of the assumed physical distances, every person detected in the frame is represented using points and circles. The individual whose distance is lower than the acceptable minimum threshold value, set to 1.5 meters in this experiment, is represented by a red box. In contrast, the individuals who keep a safe distance from others are characterised by a green box. Fig. 3 demonstrates some examples of the input/output of the social distancing monitoring system in a real-time base.

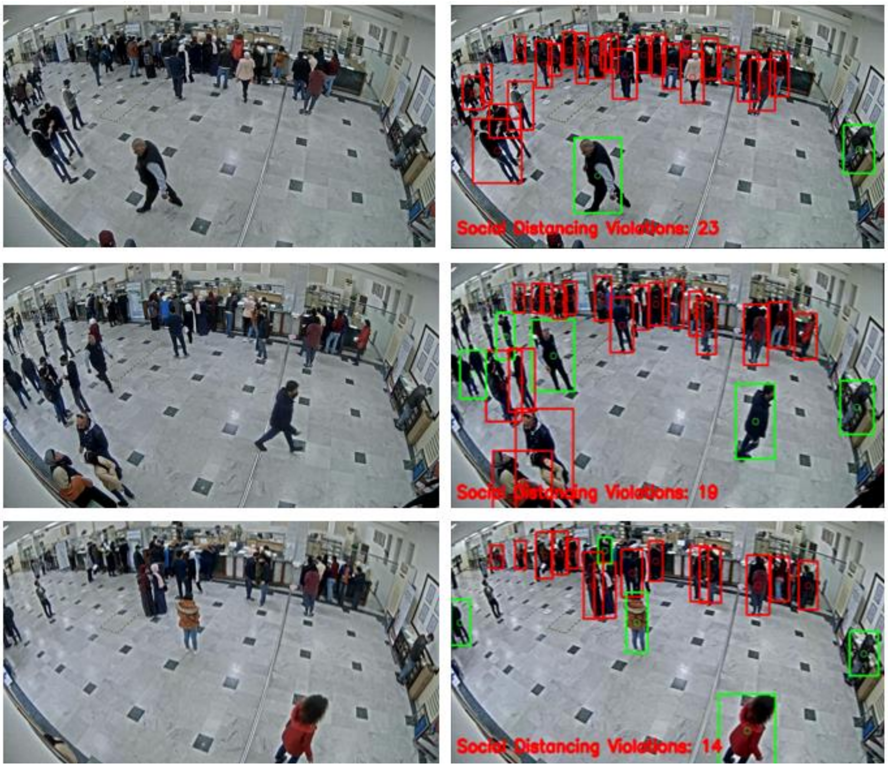

Fig. 3: Examples of the input/output of social distancing monitoring system in real-time base, where (a) shows the video frame before running the system while (b) the output after running the system.

The performance of the proposed system is evaluated through many experiments that have been performed using different types of fixed cameras, where the fields of view vary according to the camera type and position. The input videos were taken from Fisheye cameras and average CCTV cameras already installed inside and outside the university buildings. The maximum range of coverage for indoor scenes is 22 meters and 58 meters for outdoor cameras. The minimum lens distances are 1 meter to the field of view.

Although this system exhibited overall good results when reading from more than one camera in different places with different numbers of people in each scene, more experiments need to be conducted in crowded areas so as to ensure the effectiveness of the proposed social distance monitoring after students and staff return to work from the campus. In addition, the accuracy and reliability of this system are highly affected by a range of factors related to the cameras being used, mainly focal length, resolution, location and quality.

5 Conclusion

In this paper, a new multicore programming model developed and tested at Al-Zaytoonah University of Jordan is proposed. The multicore programming model implements data of real-time moving objects to provide an effective social distance monitoring solution. When the new system is installed, Al-Zaytoonah University of Jordan implemented precautionary measures guidance, which aids in preventing Covid-19 spread amongst students and staff when returning to the campus. This, in turn, makes the university among the pioneer institutions that use an automated "social distancing" system as a part of its risk management plan. The proposed parallel social distancing system combined three techniques: object detection, object tracking and distance measurement in the real-time base for multiple cameras. The results showed high efficiency of this system in tracking people and determining the distances between them in accordance with public safety instructions.

Future work to improve the outcome of the current project should include using a multicore programming based on general-purpose computation on graphics processing units (GPGPU). More experiments need to be conducted in crowded places to ensure the effectiveness of the proposed social distance monitor after students and staff return to work from the campus.

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