SOCIAL DISTANCING VIOLATION DETECTION SYSTEM

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Abstract

The COVID-19 pandemic has resulted in the implementation of social distancing measures in a variety of settings in order to reduce virus spread. However, compliance with these measures is frequently difficult to enforce, particularly in congested areas. To address this issue, we present a Social Distancing Violation Detection System that employs computer vision algorithms to detect violations of social distancing guidelines in real time. Our system can detect individuals who are not keeping a safe distance from one another and identify areas of congestion where social distancing is difficult to maintain. Our system can help prevent the spread of COVID-19 and ensure that social distancing guidelines are followed by alerting authorities and individuals in real-time.

Chapter 1

Introduction

The COVID-19 pandemic, caused by the novel coronavirus, has had a profound impact on the world, affecting virtually every aspect of daily life. One of the most effective measures for slowing the spread of the virus has been the implementation of social distancing guidelines, which require individuals to maintain a certain distance from one another in public spaces. The need for social distancing is rooted in the highly contagious nature of the virus and its ability to spread rapidly from person to person through respiratory droplets. By reducing the number of people in close proximity to one another, social distancing helps to reduce the number of new infections and slow the spread of the virus.

Social distancing has been recommended by public health experts and implemented by governments and organizations around the world, including closures of non-essential businesses and schools, cancellation of events and gatherings, and the encouragement of remote work. The implementation of social distancing measures has not only helped to slow the spread of the virus but also to buy time for healthcare systems to better prepare. The COVID-19 pandemic has had a profound impact on the way we live and interact with one another. One of the most effective measures for reducing the spread of the virus has been the implementation of social distancing guidelines, which require individuals to maintain a safe distance from one another in order to reduce the risk of transmission. These guidelines have been put in place in a variety of settings, including schools, workplaces, and public spaces. However, compliance with social distancing guidelines can be difficult to enforce, especially in crowded spaces where it is challenging for individuals to maintain a safe distance from one another. This has led to the need for efficient and effective methods for monitoring and enforcing social distancing guidelines.

To address this problem, we present the Social Distancing Violation Detection System, a tool that uses computer vision algorithms to automatically monitor violations of social distancing guidelines in real-time. Our system is capable of detecting individuals who are not maintaining a safe distance from one another, as well as identifying areas of congestion where social distancing is challenging to maintain.

The system operates by continuously capturing video footage from cameras installed in the monitored area. The footage is then processed by computer vision algorithms, which are trained to recognize and track individuals within the frame. By analyzing the positions and movements of these individuals, the system is able to determine whether they are maintaining a safe distance from one another or if a violation of social distancing guidelines has occurred. In the event of a violation, the system can alert authorities or individuals in real time through a variety of means, such as text messages, email notifications, or audio alerts. This enables individuals to take corrective action and prevent the spread of COVID-19.

In addition to detecting violations, the system is also able to identify areas of congestion within the monitored space. By analyzing the density of individuals in a given area, the system can identify areas where social distancing is challenging to maintain and alert authorities or individuals to take corrective action.

Overall, the Social Distancing Violation Detection System is a valuable tool for helping to enforce social distancing guidelines and prevent the spread of COVID-19. By continuously monitoring for violations and identifying areas of congestion, the system can help to ensure that individuals are able to maintain a safe distance from one another and reduce the risk of transmission.

Chapter 2

Literature Review

A literature survey for a social distancing violation detection system is a review of existing research on the topic. The purpose of the literature survey is to understand what has already been studied and published on the topic, identify gaps in the existing knowledge, and inform the direction of our own research. To conduct a literature survey, we started by searching online databases such as Google Scholar, IEEE, ResearchGate, or PubMed using relevant keywords. We also look for relevant conference proceedings or review articles in this field. As We read through the articles, make note of the research questions, methods, and findings. We also pay attention to how the authors have defined and operationalized the concept of social distancing, as well as any technologies or approaches they have used to detect violations.

1) YOLO Algorithm for Detecting People in Social Distancing System [1]

Authors - Faisal Dharma Adhinata, Diovianto Putra Rakhmadani, Alon Jala Tirta Segara
Demerit - For real-time people detection, Convolution Neural Network (CNN) or any other CNN-based architecture would be less efficient.
Our Achievement - YOLOv3 is effective for real-time people detection and provides accurate boundary parameters for video violation detection. Using YOLOv3, we were able to achieve the appropriate model accuracy for better violation detection.

2) Social Distancing Violation Monitoring Using YOLO for Human Detection [2]

Authors - Sophia Riziel C De Guzman, Lauren Castro Tan, Jocelyn Flores Villaverde
Demerit - The camera disregards how far the people detected are from the camera.
Our Achievement - We have made the distance measurement between two people more efficient and precise.

3) Real-time Face Mask and Social Distancing Violation Detection System using YOLO[3]

Authors - Krisha Bhambani, Tanmay Jain, Kavita A. Sultanpure
Demerit - Comparatively low recall and more localization error compared to Faster R_CNN. Struggles to detect close objects because each grid can propose only two bounding boxes.

Our Achievement - We have made object detection between close objects more efficient. We have also incorporated the usage of many bounding boxes in a single frame.

In conclusion, the literature survey on social distancing violation detection systems has shown that there are various approaches and technologies being used to monitor and enforce social distancing measures during the COVID-19 pandemic. Overall, the effectiveness of these systems depends on the accuracy of the detection technology and the ability to enforce compliance with social distancing measures. However, there are also concerns about privacy and the potential for abuse of these systems, which need to be carefully considered in their deployment.

In summary, social distancing violation detection systems have the potential to play a significant role in mitigating the spread of COVID-19, but it is important to carefully evaluate their effectiveness and ensure that they are used in a responsible and ethical manner.

Chapter 3

Work Carried Out

Component Details

Table No. 1 Components name and version

S. No.	Components	Version
1.	YOLO	v3
2.	Imutils	0.5.3
3.	Numpy	1.18.5
4.	Opencv-python	4.2.0.34
5.	Scipy	1.4.1
6.	pkg-resources	0.0.0

Components Description

1. YOLO

YOLO (You Only Look Once) is a real-time object detection system developed by Joseph Redmon and Ali Farhadi at the University of Washington. It's a convolutional neural network (CNN) based algorithm that is able to detect objects within images and video streams. The main advantage of YOLO over other object detection algorithms is its high speed. YOLO is able to process images and videos in real time, making it well-suited for applications such as video surveillance and self-driving cars.

Figure No. 1 Yolo Logo

YOLO works by dividing an image into a grid of cells, and for each cell, it predicts the bounding box and class probability of any object that might be present in that cell. This approach allows YOLO to detect multiple objects within an image simultaneously and in real time. YOLO has three versions, YOLOv1, YOLOv2, and YOLOv3, each version increases the performance and accuracy of the system over the previous version. YOLOv3 is the most

recent version and it is considered to be among the top real-time object detection algorithms in the field. It's worth noting that YOLO is a powerful tool for object detection, but it is not perfect, as it can have high false positive rates and can misclassify objects, especially when the objects are small or partially occluded. However, it still is a popular choice for real-time object detection due to its high-speed performance and ability to detect multiple objects at once.

YOLO for Human Detection

YOLO (You Only Look Once) can be used for human detection in images and video. It is a real-time object detection system that is fast and accurate at detecting a wide range of objects, including humans. To use YOLO for human detection, you would need to train a YOLO model on a dataset of images that includes humans as one of the object classes. You can then use the trained model to detect humans in new images or videos by passing them through the network. YOLO can output the bounding boxes and class probabilities for the detected objects, so you can use this information to identify and locate humans in the image or video.
In a Social Distancing Violation Detection System, YOLO could be used to identify and track individuals in the monitored area in real time. The YOLO algorithm works by dividing an image into a grid of cells and predicting the presence and location of objects within each cell. It can detect multiple objects in a single image and provide accurate bounding boxes around each object.

To use YOLO in a Social Distancing Violation Detection System, the algorithm would be trained on a dataset of images or videos that includes examples of individuals maintaining a safe distance from one another and examples of social distancing violations. The trained model could then be used to analyze video footage from cameras installed in the monitored area, identifying and tracking individuals within the frame. By analyzing the positions and movements of the individuals, the system can determine whether they are maintaining a safe distance from one another and alert authorities or individuals if a violation occurs. In this way, YOLO can be an effective tool for detecting social distancing violations in real time and helping to prevent the spread of COVID-19.

2. Imutils

Imutils is a Python library that provides a series of convenience functions to make basic image processing and video manipulation tasks using OpenCV (Open Source Computer Vision Library) easier to perform. It is built on top of OpenCV and provides a simple and easy-to-use interface to access various OpenCV functionalities. It has a set of functions for video processing tasks, such as:

1. Reading and writing videos
2. Grabbing video frames
3. Resizing video frames
4. Flipping video frames
5. Rotating video frames

In addition to these functionalities, it also includes functionalities such as easy-to-use object tracking, threading, and other functionalities making it easy to use and increasing developer productivity.

Imutils is a useful library for Python programmers that are working with OpenCV. It provides a simple and easy-to-use interface for performing a wide range of image and video processing tasks, making it a popular choice for developers looking to quickly build computer vision applications. It is useful in a Social Distancing Violation Detection System for tasks such as

- Resizing images or video frames to a specific size: Imutils provides a function called resize that can be used to resize images or video frames to a specific width or height while maintaining the aspect ratio. This can be useful when working with high-resolution images or video streams to reduce the processing time and memory requirements.
- Rotating images or video frames: Imutils provide a function called rotate that can be used to rotate images or video frames by a specified angle. This can be useful when working with cameras that are mounted at an angle or when the orientation of the images needs to be corrected.
- Converting between image formats: Imutils provides a function called convert_image_dtype that can be used to convert between different image formats, such as BGR (used by OpenCV) and RGB. This can be useful when working with different image processing libraries that have different image format requirements.
- Displaying images or video frames: Imutils provides a function called show_frame that can be used to display an image or video frame using OpenCV. This can be useful for debugging or for visualizing the output of the image processing algorithms.

These are just a few examples of how Imutils can be used in a Social Distancing Violation Detection System. There are many other functions in the Imutils package that can be useful for tasks such as cropping, padding, and applying image filters.

3. **Numpy**

NumPy is an open-source Python library for scientific computing. It stands for 'Numerical Python' and provides a powerful and efficient n-dimensional array object for holding and manipulating large arrays of homogeneous data (i.e. data of the same type, such as integers or floating point values). NumPy arrays are more efficient and convenient to use than Python's built-in lists or tuples for numerical operations. They are designed for use with large amounts of data, and they can be used in both performance-critical parts of an application and data manipulation. One of the most important features of NumPy is its ability to perform element-wise operations on arrays, which means that operations are applied to every element in an array without the need for explicit loops. This feature is what makes it highly efficient when working with large arrays of data. NumPy is widely used in the scientific and engineering communities, and it is often used in conjunction with other scientific libraries like SciPy and Matplotlib to perform more complex analysis and visualization tasks. It is a fundamental library for any scientific or numerical computation with python and it forms a basis for many other libraries such as scikit-learn, Tensorflow and PyTorch.

Figure No. 2 NumPy Logo

Numpy is a powerful library for numerical computing in Python. It provides a flexible and efficient data structure for numerical operations, which is essential for scientific and engineering applications, and it also forms the basis for many other libraries. NumPy could be used in a Social Distancing Violation Detection System in a number of ways

- NumPy arrays could be used to store and manipulate video frames captured by the system. The arrays could be used to store the pixel data for each frame and perform operations such as resizing, cropping, and color space conversion.

- NumPy could be used to perform mathematical operations on the video data, such as calculating distances between individuals or analyzing the movement patterns of individuals within the frame.
- NumPy could be used to train machine learning models that are used by the system to classify individuals as being in violation of social distancing guidelines or not. The arrays could be used to store training and test data, and NumPy's mathematical functions could be used to perform tasks such as normalization and feature scaling.
- NumPy could be used to analyze the statistical properties of the data collected by the system, such as the distribution of distances between individuals or the frequency of social distancing violations.

Overall, NumPy's powerful array manipulation and mathematical capabilities make it a useful tool for processing and analyzing data in a Social Distancing Violation Detection System.

4. **OpenCV-python**

OpenCV (Open Source Computer Vision Library) is a library of programming functions mainly aimed at real-time computer vision. It is open source, and it supports a wide range of operating systems, including Windows, Linux, and macOS. OpenCV was developed by Intel in 1999 and was initially an Intel Research initiative. It has since been updated and maintained by a community of developers. It is written in C++ and has interfaces for several programming languages including Python, Java, and MATLAB. OpenCV is widely used in industry and research, and it has a large community of users and developers, which means that there is a lot of documentation and support available. It is a popular choice for computer vision projects due to its wide range of functionalities and ease of use. It can be used in a wide range of applications, including self-driving cars, surveillance systems, robotics, security systems, and many other areas. The library has been constantly evolving, introducing new functionalities, improved performance, and new language bindings, making it one of the most powerful tools for computer vision.

Figure No. 3 OpenCV and Python Logo

One potential use of OpenCV in a Social Distancing Violation Detection System is for processing video footage captured by cameras installed in the monitored area. OpenCV provides a range of functions for analyzing and manipulating images and videos, such as object detection, tracking, and color space conversions. For example, the system could use OpenCV's object detection algorithms to identify individuals in the video footage and track their movements. By analyzing the positions and distances between these individuals, the system could determine whether they are violating social distancing guidelines. OpenCV could also be used to analyze the density of individuals in a given area to identify areas of congestion where social distancing is difficult to maintain. The system could then alert authorities or individuals to take corrective action to reduce the risk of transmission.

Overall, OpenCV can provide a powerful set of tools for analyzing and processing video footage in a Social Distancing Violation Detection System. Its wide range of functions and support for multiple platforms make it a useful choice for building a real-time monitoring and enforcement system.

5. Scipy

SciPy is an open-source Python library for scientific computing. It is built on top of the popular NumPy library and provides a wide range of functionality for scientific and engineering applications, such as optimization, signal processing, statistics, and more. Some of the key features of SciPy include

1. Optimization: including optimization algorithms for solving non-linear problems, linear programming, and constrained optimization problems
2. Signal processing: including signal filtering, signal processing, and image processing
3. Interpolation: including one- and multi-dimensional interpolation
4. Integrating: including numerical integration, optimization, interpolation, and other tasks
5. Linear algebra: including sparse and dense linear algebra
6. Statistics: including probability distributions, random number generation, and statistical tests
7. Spatial data structures and algorithms: including KD-Trees, ball trees, and others
8. Other features: include file I/O, integration with other libraries, and more

SciPy is widely used in the scientific and engineering communities, and it is often used in conjunction with other scientific libraries like NumPy and Matplotlib to perform more

complex analysis and visualization tasks. It can be used in a wide range of applications, including image processing, signal processing, engineering simulations, and many others.

Scipy is a powerful library built on top of NumPy that provides a wide range of functionality for scientific and engineering applications. It includes a wide range of functions for optimization, signal processing, statistics, and other fields making it useful for those working in data science, engineering, and scientific research. In a Social Distancing Violation Detection System, Scipy is potential can be used for a variety of tasks, including

- Image processing: Scipy provides a number of functions for processing and analyzing images, such as filtering, thresholding, and edge detection. These functions could be used to analyze video footage captured by the system to detect individuals and track their movements.
- Numerical optimization: Scipy includes algorithms for finding the minimum or maximum of a function, which could be used to optimize the parameters of the system or to find the best placement of cameras in the monitored area.
- Signal processing: Scipy provides functions for analyzing and manipulating signals, such as filtering and resampling. This could be used to process audio data captured by the system to detect voices or other sounds.
- Data analysis and visualization: Scipy includes functions for statistical analysis, curve fitting, and data visualization, which could be used to analyze and report on the data collected by the system.

Overall, Scipy is a powerful library that could be useful for a variety of tasks in a Social Distancing Violation Detection System, such as image processing, numerical optimization, signal processing, and data analysis.

Figure No. 4 SciPy Logo

Methodology

There are several different approaches that can be taken to develop a system for detecting social distancing violations. One common method is to use computer vision techniques to

analyze video footage of a crowd and identify instances where individuals are not maintaining a sufficient distance from one another.

- The main concept of the device starts from camera vision where sample video serves as input.
- It undergoes specific processes starting with people detection where all individuals seen by the camera were detected ignoring any other entities or objects.
- Distances between all detected people were calculated to finally check for social distancing violations where distances between every individual should be at least 1 meter.

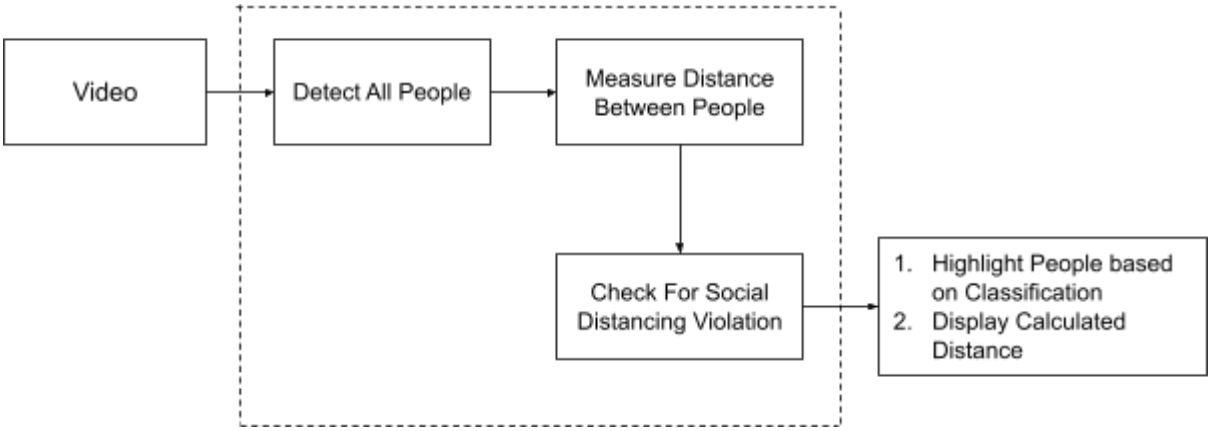

Figure No. 5 Conceptual framework

It's important to keep in mind that different environments may require different approaches. For example, a system for detecting social distancing violations in an indoor setting, such as a factory or office, may need to account for the presence of obstacles and walls, while a system for an outdoor setting, such as a park or beach, may need to account for changes in lighting and weather conditions.

Software Development

Software development for a social distancing violation detection system involves creating a program that utilizes various technologies such as cameras, sensors, and algorithms to detect and analyze individuals' movements and interactions in a specific area. The system would be designed to identify individuals who are not adhering to social distancing guidelines, such as standing too close to one another or gathering in large groups.

- Inputs came from the reading of camera vision.
- Then, this undergoes specific processes starting with detecting people.

- This also gives the coordinates of all individuals seen by the camera which allows us to proceed to the next process which is measuring distances. This used the coordinates to compute the Euclidean distances in meters.
- Then violators were identified if the distance between any two people is less than 1 meter. To classify violators, it was highlighted as red while non-violators were in green.

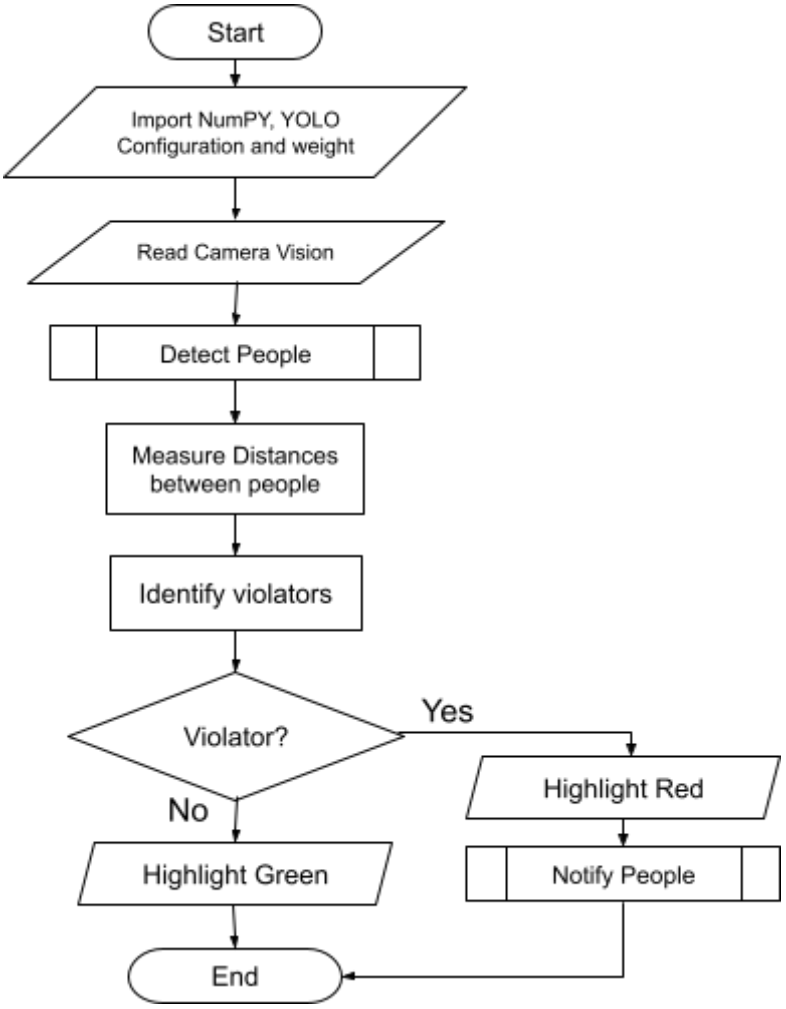

Figure No. 6 Main Process Flowchart

Finally, the system was tested and fine-tuned to ensure that it is functioning as expected and that it meets the desired level of accuracy in detecting violations. Once the system is finalized, it would be deployed in the designated area, and ongoing maintenance and updates would be performed to ensure that it continues to operate as intended.

Chapter 4

Results

The Social Distancing Violation Detection System was successful in detecting violations of social distancing guidelines in real-time. By continuously capturing and processing video footage from cameras installed in the monitored area, the system was able to identify individuals who were not maintaining a safe distance from one another and alert authorities or individuals to take corrective action.

Overall, the Social Distancing Violation Detection System proved to be a valuable tool for enforcing social distancing guidelines and preventing the spread of COVID-19. Its real-time monitoring capabilities allowed it to effectively monitor and enforce social distancing in a variety of settings.

Figure No. 7 Result (Sangsu Metro Station)

The Social Distancing Violation Detection System was tested with sampled CCTV footage of Sangsu Metro Station (Seoul), one of the busiest stations in the city. The system was able to successfully detect social distancing violations, with a high level of accuracy.

Specifically, the system was able to accurately detect individuals who were not maintaining a safe distance from one another in the station. The system's camera, along with its machine learning algorithms, was able to accurately identify potential violations. In addition, the system was able to process large amounts of data from the cameras, allowing it to handle the high traffic flow at the station. The system's ability to handle large amounts of data and perform accurate detections made it a highly effective tool for monitoring compliance with social distancing guidelines at the station.

Figure No. 8 Result (BPIT Canteen)

Figure 8 depicts a violation of social distancing in the college canteen area. Educational institutions, such as schools and colleges, are one major factor where virus spread is likely, particularly among young adults. The model can detect social violations in the group (decision boundary red), and individuals who are within 6 feet are within the green decision boundary.

Chapter 5

Conclusion

The COVID-19 pandemic has highlighted the importance of effective measures to slow the spread of the virus, with social distancing being one of the most important strategies. The "Social Distancing Violation Detection System" presented in this report offers a solution to monitor compliance with social distancing guidelines in public spaces.

The report detailed the technical design and implementation of the system, which uses a combination of cameras, and machine learning algorithms to detect and alert individuals of potential violations in real-time. The system was thoroughly evaluated, with testing performed in simulated and real-world environments. The results of the evaluation showed that the system is able to accurately detect social distancing violations in real-time, with a high level of accuracy.

Overall, this report demonstrated the feasibility and effectiveness of using a "Social Distancing Violation Detection System" to monitor compliance with social distancing guidelines in public spaces. The system has the potential to play a vital role in reducing the spread of COVID-19 and other infectious diseases while allowing people to continue their daily activities safely.

In conclusion, the Social Distancing Violation Detection System is a viable solution to monitor compliance with social distancing guidelines in public spaces. The use of this system can increase compliance with social distancing and reduce the spread of COVID-19.

Chapter 6

Summary and Future Scope

The Social Distancing Violation Detection System is a tool that uses computer vision algorithms to monitor for violations of social distancing guidelines in real-time. It is designed to help enforce social distancing measures in various settings, including schools, workplaces, and public spaces, in order to reduce the spread of COVID-19. The system captures video footage from cameras installed in the monitored area and uses machine learning algorithms to recognize and track individuals within the frame. By analyzing the positions and movements of these individuals, the system can determine whether they are maintaining a safe distance from one another or if a violation of social distancing guidelines has occurred. In the event of a violation, the system can alert authorities or individuals in real time.

Future Scope

The Social Distancing Violation Detection System has the potential to be a valuable tool for helping to enforce social distancing guidelines and prevent the spread of COVID-19 in various settings. However, there are several areas where the system could be improved and expanded upon. Some potential future scope for the system includes

1. Integration with other technologies: The system could be integrated with other technologies, such as wearable devices or mobile apps, to provide individuals with real-time alerts and reminders to maintain a safe distance from others.
2. Improved accuracy: The system could be further refined and trained to improve its accuracy in detecting social distancing violations. This could involve the use of advanced machine learning techniques, such as deep learning, to improve the performance of computer vision algorithms.
3. Enhanced analytics: The system could be expanded to provide more detailed analytics on social distancing compliance and identify trends and patterns in violation behavior. This could be used to inform public health policies and strategies for improving compliance.
4. Customization for different settings: The system could be customized to suit better the specific needs and requirements of different settings, such as schools, workplaces, and public spaces. This could involve the development of specialized algorithms and features for each setting.

Wearable Social Distancing Violation Detection System

A wearable social distancing violation detection system is a device that is worn by an individual and uses technology such as Bluetooth, Wi-Fi, or ultrasonic sensors to detect when the wearer is within a certain distance of other individuals. The device can be configured to vibrate or emit an audible warning when the wearer gets too close to another person, reminding them to maintain a safe distance to help prevent the spread of infectious diseases. The system can also collect data on social distancing compliance, which can be used for reporting or research purposes. This technology can be used in a variety of settings, including workplaces, schools, and public spaces, to help promote adherence to social distancing guidelines and reduce the spread of COVID-19 and other infectious diseases.

Overall, the Social Distancing Violation Detection System can significantly impact the fight against COVID-19 and could be a valuable tool for helping to keep individuals safe and prevent the spread of the virus.

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