Ensuring lock-down in COVID 2019 with help of still CCTV and UAVs

Avani Gupta

IIIT Hyderabad

Gachibowli

avani.gupta@research.iiit.ac.in

Abstract

During the Pandemic of COVID 19,ensuring social distancing to flatten the curve and prevent the disease from spreading is the only way to stop it. lock-downs help to ensure this very effectively. Police is working day and night to cater to those people and penalize the breakers. But police task forces being on ground does hamper the purpose of lock-down. This paper presents a Computer Vision and Robotics based solution which involves object tracking and face recognition to cater this situation. The solution presented here, makes use of live CCTV footage and autonomous Unmanned Aerial Vehicles UAV's for monitoring of lock-down breakers and a web-app which acts on police's end and helps penalise lock-down breakers. We also have a app at users end where he can report lock-down violation in his locality.

1. Introduction

Social distancing to flatten the curve [10] has been proved crucial to prevent the virus from spreading. [1] lock-downs have been quite effective to implement social distancing, many countries including India are announcing lock-downs. India experienced a lock-down of 21 days which later got extended to 42 days. There are many people who still can't understand the seriousness of the situation and break lock-downs. Police is working day and night to cater to this situation and penalize the lock-down breakers. Police officials risk their own lives to ensure the safety of entire nation. But police task forces being on ground does hamper the purpose of lock-down along with risk of spread among the policemen. Many policemen have even lost their lives due to becoming positive on duty hereby becoming "Corona Warriors".

With advancements in computer vision, aerial robotics, and reinforcement learning based control for autonomous drones it is possible to detect the law-breakers with cameras and hence ensure lock-down.

Another point being, police taskforce is limited and it is difficult to determine all cases of lock-down violation. The use of face detection algorithms and UAV's can increase efficiency of detection , and help police track the violation without themselves being on field.

This paper presents a methods for enhancing closed-circuit television (CCTV) systems by using face detection and object detection for real time detection and tracking of people breaking lock-down. We also use using autonomous unmanned aerial vehicle (UAV)also known as drones fitted with CCTV's for surveillance.

2. Literature Review

Police in India has been using remote controlled drones to monitor the lock-down. There are advancements in Re-inforcement Learning based autonomous drones used for surveillance of surroundings [7].

2.1. Face Detection

Also with advancements in Computer Vision it is possible to detect the person from the face detection techniques. Viola Jones algorithm [11] makes use of Haar Features which is based on similarity among human faces. Some of the Haar- features include:

- Property of Human faces like eye region is darker than the upper-cheeks and nose bridge region is brighter than the eyes

- Composition of properties forming match-able facial features like Location and size of eyes, mouth, bridge of nose and oriented gradients of pixel intensities.

FaceNet [8]is a popular method for face detection which uses a mapping from face images to a compact Euclidean space where distances directly correspond to a measure of face similarity.Now, FaceNet embeddings can be used as feature vectors for face identification. It uses a deep convolutional network which optimizes the embedding.

2.2. Drone surveillance

2.2.1 Usage in journalism

There are studies for using the drone surveillance in journalism for reporting [4]. They are used to gather videos and live report of in-accessible areas.

2.2.2 Real-time Traffic Monitoring

UAVs are also being used for real-time Traffic Monitoring [3]. They help by keeping track of trajectories, behaviors and vehicle types. As stated in [3], UAV's are equipped with image processing and collect various information like vehicle position, speed, and direction, the number of vehicles within an area, the number of vehicles passing through a given point etc.

2.2.3 Optimising number of UAV's required

Number of UAV's needed to cover a particular area can be optimised by making target clusters by taking in velocities of vehicles and distance to be covered and assigning a cluster to every UAV. UAV trajectories are guided by predefined Points Of Interest(points with high traffic). [2] and multiple cooperative UAV's. The multiple UAVs are capable of of identifying the targets in their FoV and estimating their positions and speeds, and exchange those information between each other and with a central point. UAVs trajectories are adaptive and POIs are mobile. They use kinematics eg: knowledge of Center of Gravity of their groups of targets to fly over the computed positions and adjust their velocities according to their targets.

2.2.4 Trajectory planning

Shortest Path Map-Based Movement model is used to guide the trajectory of the UAV so that it moves exactly above roads, and do observation regarding the targets in their FoV.

2.2.5 Real time Surveillance of People: Detection and Identification

Drones are used for real time tracking of people [9]. [9] used Haar-cascade classifier and max-margin object detection with convolutional neural network based features for face detection and color detection system for obstacle detection. They use image processing and machine learning to control the UAV automatically. They do tracking by calcuating Region of Interest using centroid which is calculated using pixel positions on axes and move drone by comparing the size of ROIs. If ROI is higher than threshold the drone is moved foward, else backward.

The distances from drones and their targets directly affect the size of the facial images in pixels. Since drones take picture from the air, altitudes of drones keep them distant from their targets on the ground. shows that augmenting 3D information captured by drone camera helps to boost face recognition performance in the case of large angles of depression. It uses Face++ and ReKognition which provides an open API for development of various kinds of applications.

2.2.6 Full coverage of Field by multiple UAV's by Reinforcement Learning

Multi-Agent Reinforcement Learning (MARL) algorithm [?]allows UAVs to learn cooperatively to provide a full coverage of an unknown field of interest while minimizing the overlapping sections among their field of views. [?]

3. System Architecture

We propose the architecture with real time detection and tracking of people. We use Haar-cascade classifier along with facenet embedding and max-margin object detection with convolutional neural network for face detection and object detection.
The system would act as a replacement for police surveillance, we use CCTV fitted on streets and UAV's for this. All areas under lock-down or special red-zones(hotspots) are tracked using drones and all other ares are tracked using CCTV's installed in streets. Now, when a person is seen on street, he is asked by the system fitted on streets for the reason of coming out (from home using Natural Language processing) if his reason is a valid reason(checked using Artificial Intelligence) he is allowed to proceed, if not, he is alerted to go back to home. Starting from his home he is tracked by cameras(with no deterrent to privacy) if he does'nt go home, the system sends a message of fine to his phone number.

3.1. Major Functionalities

3.1.1 Capture Footage

The video, audio of locations is recorded by CCTV's fitted on streets and drones.

3.1.2 Real time tracking path

The real time tracking of the path followed by people coming outside in lock-down is traced by drones street cameras and using object detection and path detection.
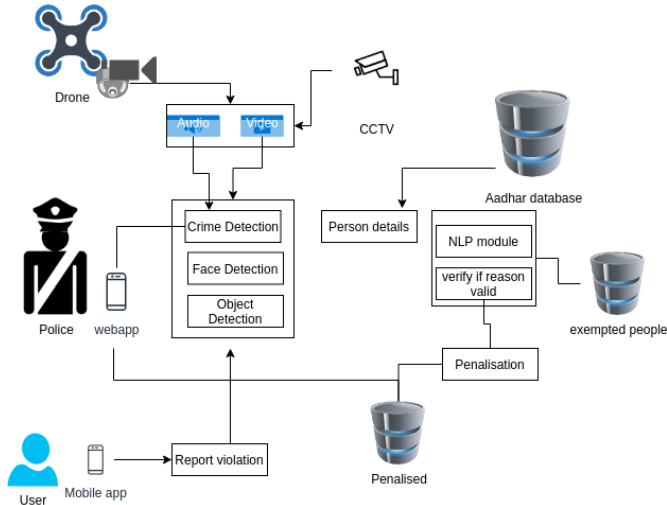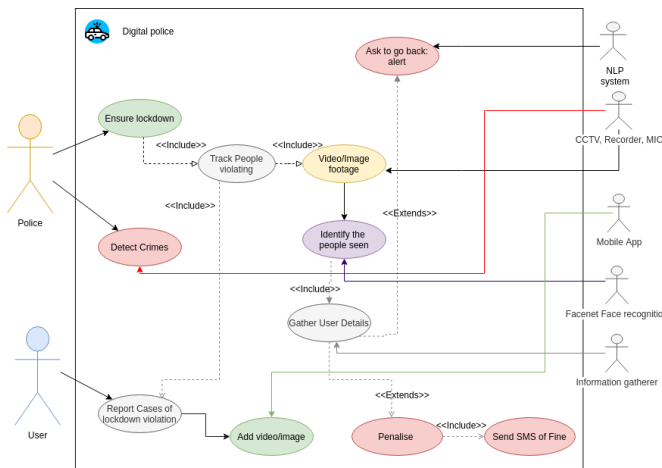
Figure 1: Components

Figure 2: Use case diagram

3.1.3 Detecting People

The person is identified using face detection algorithm which uses Haar-cascade features along with facenet embedding for face detection. It is connected to Aadhar card database by government. The database is searched for image of person and identification is done.

3.1.4 Asking reason of Travel

Now, the moment the person comes out from home, he is asked for the reason of travel by the AI (using Natural Language processing through a speaker)

3.1.5 Saving information of people who have a permanent need of travel

Identifying police and doctors automatically Ambulance, doctors, policemen are excepted automatically and are not asked for prompt by NLP module. They are identified using a trained classifier on videos and images of those. Saving information of other essential services people It is a smart system which saves the information of people who have valid reason of travel, Journalists, those connected with essential services like vegetables, groceries etc apart from doctors, nurses, policemen and doesn't ask those people any reason for travel.

3.1.6 Communication among all systems

If even after prompt the person does'nt go back(or tries to fool the system by turning back and taking different route, he can't. Here comes the most effective part of system. The systems communicate among themselves(all data shared among various UAV's and CCTV's). So the person is tracked until he goes home.

3.1.7 Message for Fine

- If a person does not follow the instruction alert, he is immediately sent a message for fine on his phone number.

- If a person follows but is found again without a valid reason he is sent a fine.

3.1.8 Maintaining Social Distancing

If a group of people found going together even with a reason they are alerted to follow social distancing norms.

3.1.9 Crime Detection

Crime is detected in the audio/ video and location is sent to the police.

3.1.10 Signal processing

The system detects crimes using signal processing of audio to identify fighting and image processing to detect an intruder.

3.1.11 Alert Police: Alert alarm on phone

The nearby police station is alerted about a crime through an alert alarm and message on a mobile app on policeman's phone.

3.2. Different Modules

3.2.1 Face Detection

We use Haar-cascade classifier along with facenet embedding for real time Face Detection.

3.2.2 Object Detection

Detecting various objects in Video/ image. We use max-margin object detection with convolutional neural network for object detection.

3.2.3 Natural Language Processing Module along with audio signal Processing

For asking the user the reason of travel and processing his answer, we use Natural Language Processing which is combined with audio signal processing to track what user says. Mic and recorder fitted in drone and near CCTV in streets used to interact with the person.

3.2.4 Drone Control

The Drone control is based on several parameters.

- *Reinforcement Learning based Control*
  We propose a Reinforcement learning based control which makes use of asynchronous methods of continuous control through DDPG, TRPO and PPO algorithms[6]

- *Optimising number of UAV's required* Number of UAV's needed to cover a particular area can be optimised by making target clusters as cited in [2].

- *Communication among systems* There is a communication among various drones as well as CCTV's fitted at different locations. They notify other systems with a range when lock-down is violated and convey the location and path of the person who violated lock-down.

3.3. Crime Detection

There is a sudden outburst of sound when a crime occurs. the energy of sound signal during fighting is higher than when in normal situation and the change pixel is increased when there is an intruder [5]. This property is used to detect crimes in a locality through audio and video.

3.4. Webapp at police's end

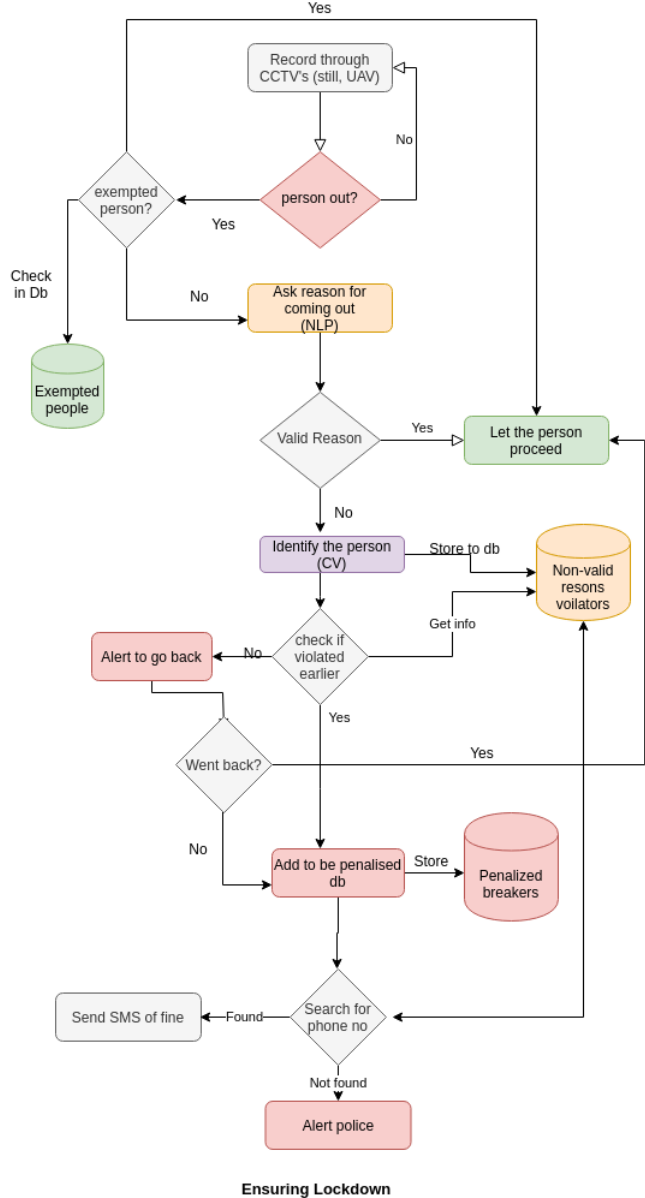The web-app at Police's end is used to alert the police in case of crime Detection

Figure 3: General flow

3.5. Information Gatherer

The information gather is connected to Aadhar Database and gathers all information about the lock-down breaker and criminal. Also it store the voilation history and penalized data of people which is displayed to police to web-app if required.

3.6. Mobile App for Users

A common person can report the lock-down voilation through the mobile app by uploading the image and video.
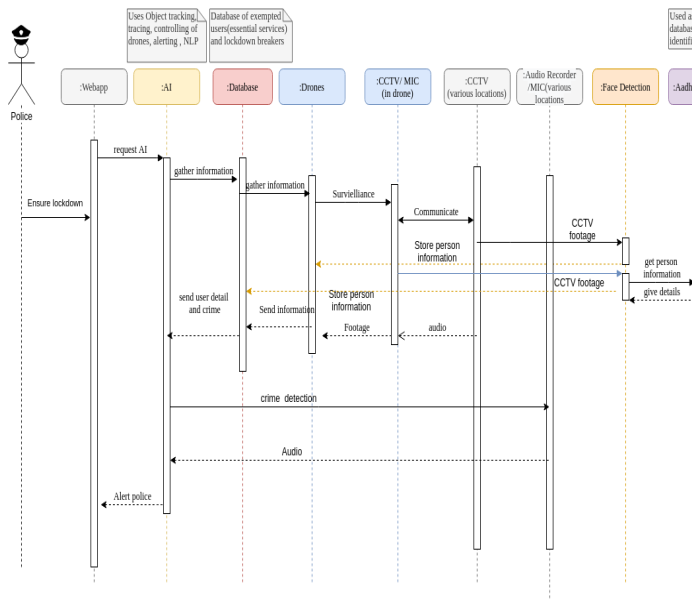
Figure 4: Sequence Diagram

4. Conclusion

We thus designed a robust system "Digital police" with the help of face detection, drone surveillance, Natural language processing, signal processing for helping police ensure lock-down as well as law without actually going out in fields. The system uses drone and CCTV's deployed at various street locations to recognise the people who are seen out in lock-down and penalizes them by sending message of fine on mobile phone. The system not only helps ensure lock-down is not broken but also ensure safety by citing crimes as and when they are detected and alerting police.

References

[1] P. Block, M. Hoffman, I. J. Raabe, J. B. Dowd, C. Rahal, R. Kashyap, and M. C. Mills. Social network-based distancing strategies to flatten the covid 19 curve in a post-lockdown world, 2020. 1

[2] B. Coifman, M. McCord, R. G. Mishalani, M. Iswalt, and Y. Ji. Roadway traffic monitoring from an unmanned aerial vehicle. *IEE Proceedings - Intelligent Transport Systems*, 153(1):11–20, 2006. 2, 4

[3] M. Elloumi, R. Dhaou, B. Escrig, H. Idoudi, and L. A. Saidane. Monitoring road traffic with a uav-based system. In *2018 IEEE Wireless Communications and Networking Conference (WCNC)*, pages 1–6, 2018. 2

[4] A. Gynnild. The robot eye witness: Extending visual journalism through drone surveillance. *Digital journalism*, 2(3):334–343, 2014. 2

[5] P. Intani and T. Orachon. Crime warning system using image and sound processing. In *2013 13th International Conference on Control, Automation and Systems (ICCAS 2013)*, pages 1751–1753, 2013. 4
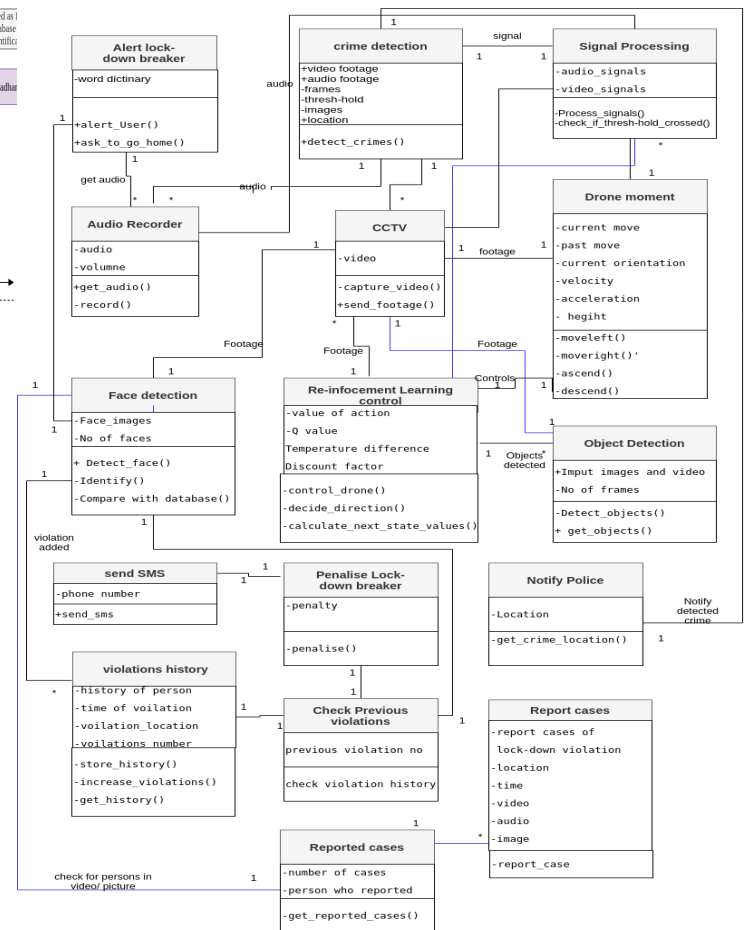
Figure 5: Class Diagram

[6] V. Mnih, A. Badia, M. Mirza, A. Graves, T. Lillicrap, T. Harley, D. Silver, and K. Kavukcuoglu. Asynchronous methods for deep reinforcement learning, 02 2016. 4

[7] H. X. Pham, H. M. La, D. Feil-Seifer, and A. Nefian. Cooperative and distributed reinforcement learning of drones for field coverage, 2018. 1

[8] F. Schroff, D. Kalenichenko, and J. Philbin. Facenet: A unified embedding for face recognition and clustering. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pages 815–823, 2015. 1

[9] O. Surinta and S. Khruahong. Tracking people and objects with an autonomous unmanned aerial vehicle using face and color detection. In *2019 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT-NCON)*, pages 206–210, 2019. 2

[10] L. Thunstrom, S. Newbold, D. Finnoff, M. Ashworth, and J. F. Shogren. The benefits and costs of flattening the curve for covid-19. *Available at SSRN 3561934*, 2020. 1

[11] P. Viola and M. Jones. Robust real-time face detection. In *null*, page 747. IEEE, 2001. 1
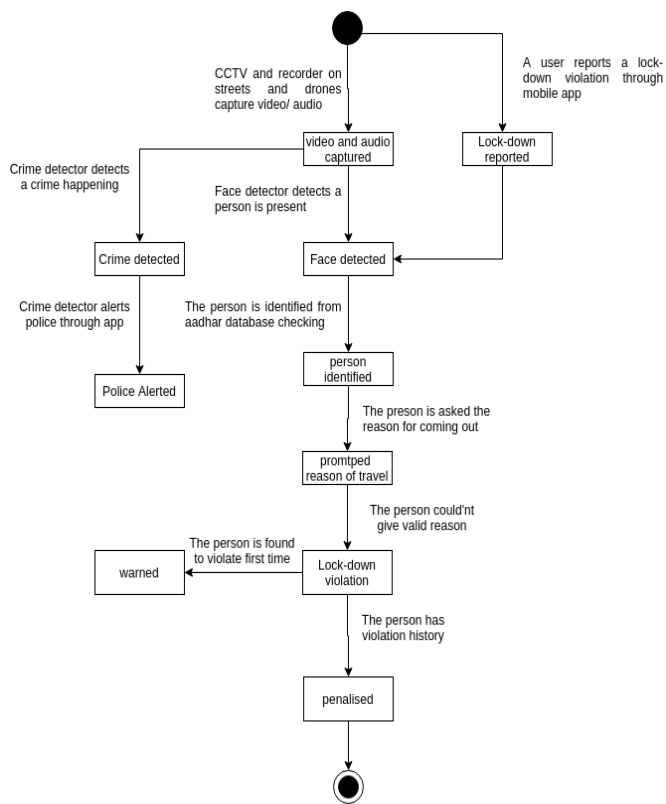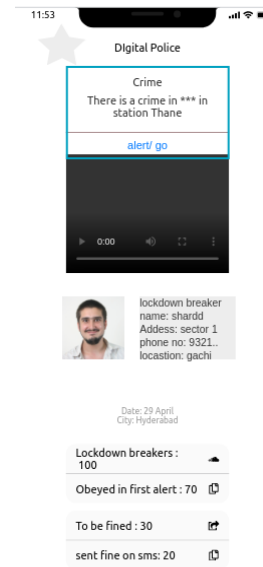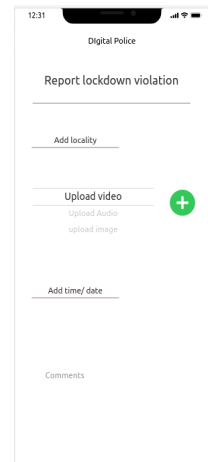
Figure 6: State Diagram

(a) Police's end

(b) Common person's end

Figure 7: Webapp Interfaces