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AI-POWERED REAL-TIME SOCIAL DISTANCE MONITORING SYSTEM WITH IMMUTABLE DATA STORAGE

A PROJECT REPORT

Submitted by

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ABSTRACT

As per the latest reports from several credible institutions such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), the COVID-19 pandemic has had a severe impact on the world. With so many deaths coming to the fore, the best way to safeguard oneself from COVID-19 is to make sure not to contract it in the first place. For that, people need to follow social distancing. In this project, I am proposing a computer vision-based approach focused on the real-time automated monitoring of people to track social distancing violations through cameras installed in public places. In the proposed model, advanced deep learning techniques have been used in combination with geometric techniques to build an effective and robust model. Further, to ensure the reliability of the data collected, the entire data in regards to the social distancing violations is stored in an immutable ledger - blockchain. This automated system is self sustaining and can reduce the deployment of manpower in public places to check for such violations.

PREFACE

The COVID-19 pandemic has brought about a major paradigm shift in the way we conduct ourselves. It has forced us to follow certain norms, which, as social beings, we find hard to follow. However, for our own safety and the safety of our loved ones, it is imperative that we follow those norms. These norms include, wearing masks, washing hands frequently, limit going outside and most importantly, following social distancing. However, it has been noticed that many people worldwide do not follow the social distancing guidelines diligently. Towards this end, in this project, I aim to use two of the most dynamic and emerging technologies, namely Artificial Intelligence (AI) and Blockchain to monitor social distancing violations in real time and store them in an immutable form.

ACKNOWLEDGEMENTS

I would like to express my most sincere appreciation to my supervisor, Mr. Vikas Hassija, for his invaluable guidance, consistent support, timely help, and providing me with an excellent atmosphere for doing my project. During the entire duration of my dissertation work, despite his busy schedule, he has extended cheerful and cordial support to me for completing this project work. I also want to communicate my profound regards to all the other faculty members of the department of CSE & IT, JIIT, who have given their great effort and guidance at appropriate times. My gratitude also goes to people who have voluntarily helped in developing this project.

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ABBREVIATIONS

AI	Artificial Intelligence
CV	Computer Vision
YOLO	You Only Look Once
DNN	Deep Neural Networks
WHO	World Health Organization
CNN	Convolutional Neural Network

Chapter 1

INTRODUCTION

1.1 Problem Statement

Without any doubt, the COVID-19 pandemic has brought the world to a standstill. The world we lived in a year ago was remarkably different from how it is currently. The pandemic has proved to be a grim danger to the human race. Seeing the necessity of the hour one must always take certain precautions of which one being social distancing [1]. Maintaining social distance is a recommended solution by the World Health Organization (WHO) to minimize the spread of COVID-19 in public places and consequently to slowdown the growth rate of new cases. A majority of the governments and national health authorities around the world have made it mandatory for the public to follow social distancing guidelines, i.e. to have at least 2 meter distance from the nearest person. This has come to the fore as a mandatory safety measure in all public places, including schools, colleges, shopping malls, gardens, monuments, cinema halls, among others [2].

However, to ensure that people follow social distancing guidelines, it is imperative to monitor public places, identify the delinquents and punish them commensurately. However, the task of monitoring, especially in high population countries like India, cannot be efficiently carried out by officials. Moreover, in the times of the COVID-19 pandemic, front-line workers already find themselves overwhelmed with the huge workload.

1.2 Proposed Solution

To solve this conundrum, through this project, I propound the idea of Artificial Intelligence (AI) powered Real-Time Social Distance Monitoring System with Immutable Data Storage. In simpler terms, in this project, I propose a data integrity validation tool to enable the use of AI for physical distancing detection by mitigating concerns related to privacy and tampering through a hybrid on and off-chain system. Since, there are a lot of keywords to understand in this project, let me break it down to facilitate better understanding:

1.2.1 AI (Computer Vision - YOLO)

Under the umbrella of AI, I develop a hybrid Computer Vision and YOLO (You Only Look Once) v3-based Deep Neural Network (DNN) model for automated people detection in the crowd in indoor and outdoor environments using common CCTV security cameras.

The proposed You Only Look Once (YOLO) Model leads to a robust people detection and social distancing monitoring. The model has been trained against one of the most comprehensive datasets by the time of the research - the Microsoft Common Objects in Context (MS COCO) dataset.

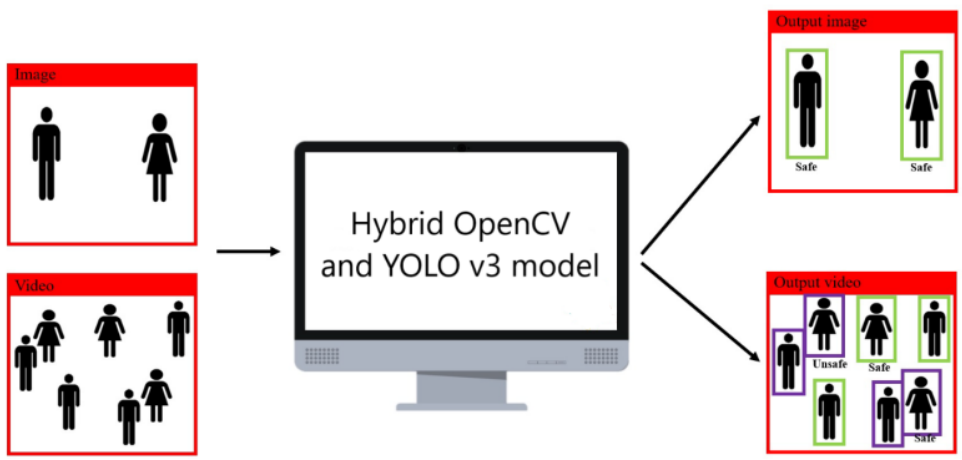

Figure 1.1: AI Model Function

1.2.2 Immutable Data Storage (Ethereum Blockchain)

Secure, immutable and decentralized database in the form of ethereum blockchain:

- Preserves data integrity
- Removes risk of data tampering or corruption
- Provides transparency

- Ensures increased transparency

These benefits are essential to consistently enforcing social-distancing guidelines and slowing the spread of COVID-19.

Chapter 2

LITERATURE REVIEW

By using modern AI concepts like Computer Vision (CV) and Deep Neural Networks (DNN), we can unearth the relationship that exists between certain features. For instance, the use of such techniques may facilitate better understanding of medical imaging, sports activities, behaviour demonstrated by pedestrians in the public spaces, sports activities, and much more by analyzing spatio-temporal data and performing a concrete statistical analysis on that information [3, 4].

Among AI related works in the healthcare domain, many researchers have attempted to (a) predict the illness trends in specific locations [5], (b) establish techniques to count the number of persons in a crowd, or the density of people in public places [6], and (c) approximate the distance of individuals from the popular swarms [7] using a amalgamation of geo-location cellular and visual data. However, these approaches require expensive infrastructure to be designed and built.

The recent advances in Deep Learning, CV, and pattern recognition, have enabled the computers to comprehend and interpret the visual schematics from a digital stream of data, such as images or videos. At the same time, it has enabled us to recognize and classify different kinds of objects [8, 9, 10]. Object detection techniques play a very crucial role in building models that can monitor social distancing violations. For example, CV could make CCTV cameras, as we know it, more "intelligent". Besides monitoring people, these intelligent cameras will be able to natively determine whether or not people are following social distancing regulations.

As discussed above, one of the most vital application of object detection is human detection. A lot of work has already been done in the direction of human detection [11] as well as human action recognition [12]. However, most of these techniques are constrained in the sense that they only give good results in indoor settings. These techniques have been found to have very low accuracy when used under problematic lighting conditions which are prevalent outdoor.

Feature extraction and complex object classification models, especially those involving human detection generally use Convolutional Neural Networks (CNNs). Now that much more efficient CPUs and GPUs are available, Convolutional Neural Network (CNN) have made it possible for the researchers to develop faster and more accurate models than ever before. The authors of [2] used a Deepsort algorithm [13] in conjunction with a Deep Neural Network based human detector, to assess the distance violation index. i.e. the the ratio of the number of people violating a specific preset distance measure to the total number of the people in the video feed.

In another study carried out in [14], the authors have tried to reduce the computational costs associated with object detection models by using a MobileNet V2 network [15]. However, the trade-off of using this lightweight model was that it resulted in lower accuracy than the more computationally intensive models. Another drawback of this model is that it only works well in indoor settings, and does not have any statistical model to assess the spread of the COVID-19.

Chapter 3

DATASET DETAILS

The YOLO neural network used in this project has been trained on Microsoft Common Objects in Context (COCO) dataset [16]. MS COCO is a large-scale object detection, segmentation, and captioning dataset. COCO has several features:

- Object segmentation
- 330K images (>200K labeled)
- Super pixel stuff segmentation
- 5 captions per image
- 1.5 million object instances
- Recognition in context
- 250,000 people with key points
- 80 object categories
- 91 stuff categories

Chapter 4

RESEARCH METHODOLOGY & DESIGN

4.1 Workflow

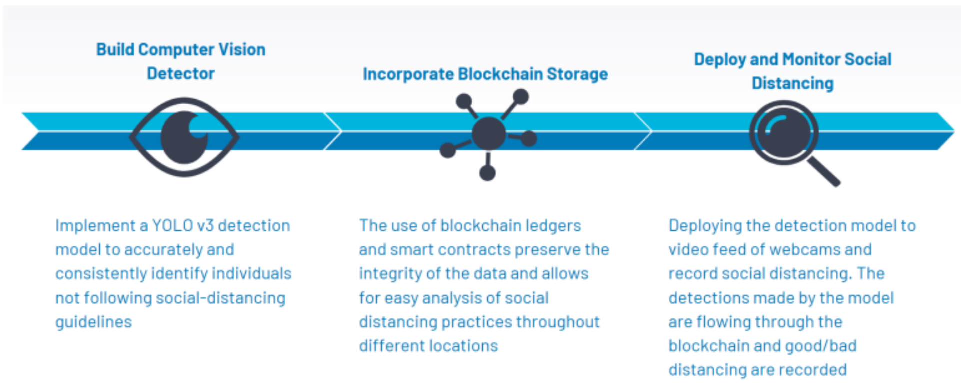

Figure 4.1: Workflow of the Project

The workflow would be as follows:

1. Any live feed monitored via CCTV cameras will be fed into the system.
2. The YOLO v3 social distancing tracker would identify the number of violations in real time.
3. Following that, Event ID, location, timestamp, and number of violations are combined and hashed with SHA256 and stored On-Chain through a smart contract.
4. Hashes are easily computable given event data, but hashes are not easily reversible. This mitigates privacy concerns about distancing data and ensures integrity.
5. Data can be easily verifiable by computing and verifying hash with event logistics and ID in Off-Chain database.
6. The use of blockchain ledgers and smart contracts preserve the integrity of the data and allows for easy analysis of social distancing practices throughout different locations.

4.2 Step-by-Step Process of Detecting Social Distancing Violations using the YOLO v3 network

Step 1: Use opencv for detecting all persons in a video stream

Step 2: Compute the distances between all the persons who were detected in the previous step. Make sure to calculate pairwise distances.

Step 3: Check if the calculated distance is less then 2m.

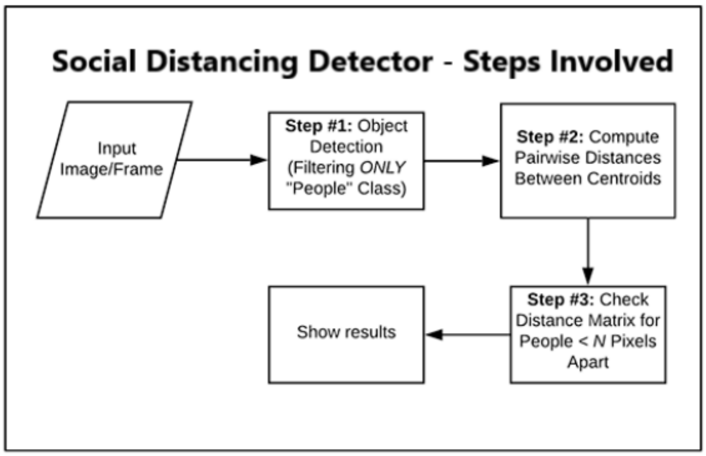

Figure 4.2: Social Distancing Detector - Steps Involved

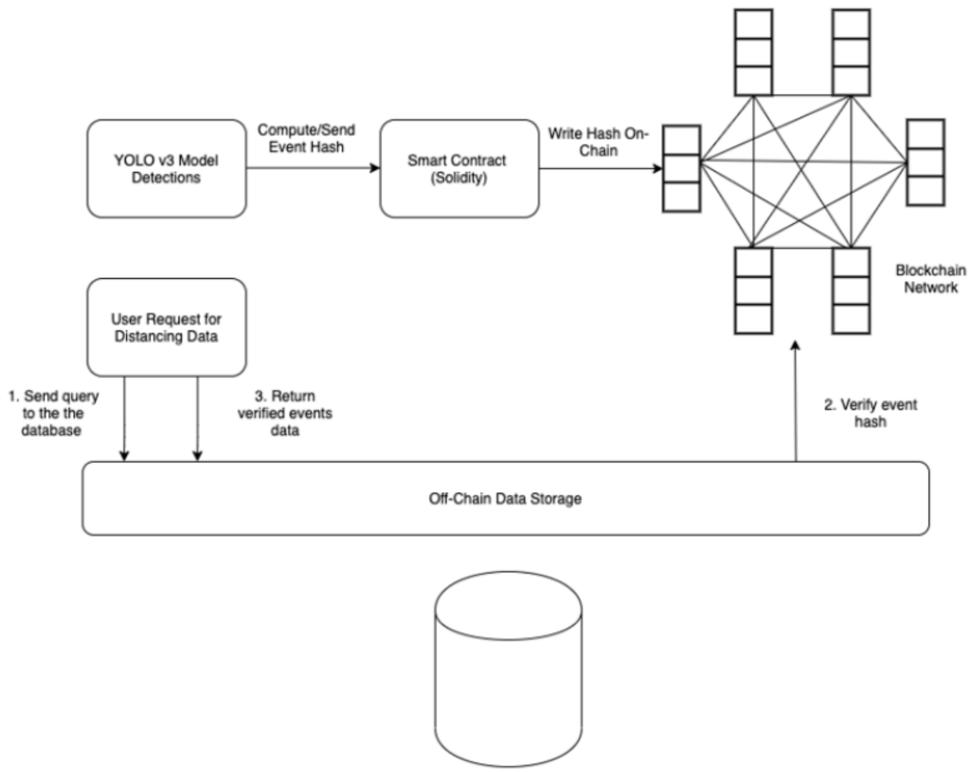

Figure 4.3: Application Diagram

Chapter 5

IMPLEMENTATION DETAILS

5.1 Tech Stack Used

- Python 3.9 for constructing and running neural networks (YOLO) and theCV model
- Flask for APIs
- HTML and JavaScript for frontend
- Solidity for Smart Contracts (Logic)
- IPFS for on chain storage
- Ganache (Ethereum test nodes) for simulation
- Infura API and Web3 for provider
- MySQL for off chain storage

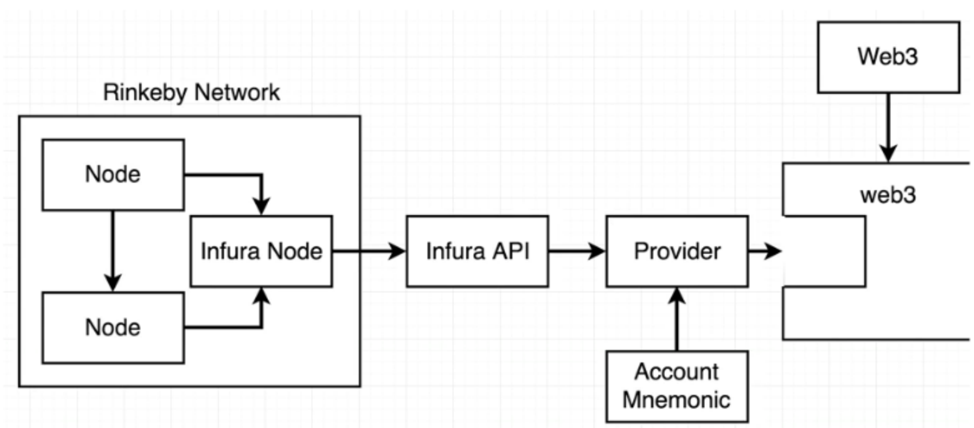

Figure 5.1: Contract Deployment Flow

5.2 Dependencies (Modules/Packages)

- pandas==1.0.1
- scipy =1.4.1
- numpy =1.18.1
- matplotlib==3.1.0
- scikit-learn==0.21.2
- seaborn==0.9.0
- keras==2.2.4
- tensorflow-gpu==1.14.0
- opencv-python==4.2.0.34
- scikit-image==0.15.0
- imutils==0.5.3
- web3 =5.12.1
- Flask =1.1.1
- mysql-connector-python =8.0.21

5.3 Software Details

- Python version: 3.9
- MySQL version: 8.0
- Ganache version: 2.5.4
- IPFS Desktop 0.13.2

5.4 Hardware Details

- Operating System: Microsoft Windows 10 Home (x64)
- Processor: Intel Core i5-8250U (8th gen
- GPU: Inbuilt Intel UHD Graphics 620 (No dedicated GPU)
- RAM: 8GB

Chapter 6

TESTING

6.1 Neural Networks

Since the model weights for YOLO that were used in this project are pre-trained, there was no use of testing the neural networks. The reason behing using a pre-trained model is because training YOLO on the MS COCO dataset that consists of over 3.30K images would consume a lot of resources. It requires a very high computational machine, which I currently do not have access to.

6.2 Smart Contracts

In blockchain development, there are generally, two kinds of software tests:

- **Unit tests** which pivot around each individual function separately.
- **Integration tests** which are written to ensure that all parts of the code work well in tandem.

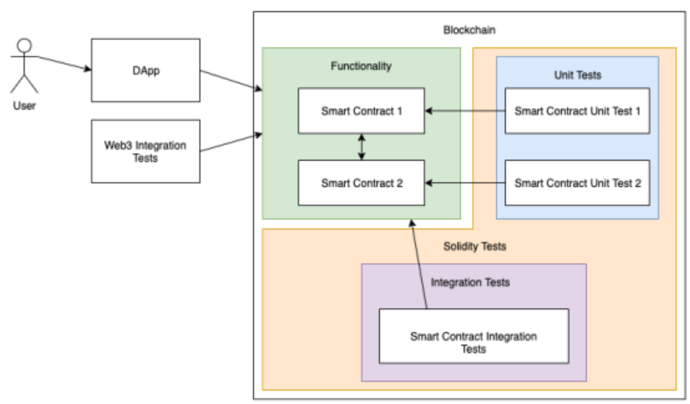

Figure 6.1: Testing Framework for Solidity Smart Contracts

Truffle suite has pretty good support for writing both types of Solidity tests. Solidity programming language gives us the freedom to run layer tests around the Blockchain. Such tests are able to call functions within the contract in a fashion similar to the blockchain itself. To make sure that the behaviour of smart contracts is as expected, we can:

- Write unit tests using the Mocha library in Javascript. Basically, we can use the combination of "it" and "describe" constructs to check whether the function returns value as expected.
- Write integration tests that check whether the contracts are able to interact with each other properly. Such test also ensure the smooth functioning of mechanisms like inheritance.

Chapter 7

CONCLUSION AND FUTURE DIRECTION

In this project, I utilized YOLO neural network and Blockchain technology to make a social distancing tracking system. By using blockchain to store transaction hashes, proposed framework ensures a collation of an immutable storage based on blockchain along with a set of optimally constructed access rules that control who can access those records.

For the future, I plan to implement a mask detection system in the existing framework. For this, I need to review existing systems which have implemented mask detection as part of their working.

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