IAS Final Exam

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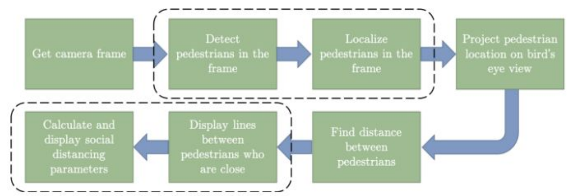
Question 3.

Efficient Social Distancing using IOT and AI.

Abstract: The requirements of a pandemic necessitate a broad range of activities involving surveillance, detection, mitigation, prevention, and recovery, all of which benefit from rapid turnaround times. Hence to effectively control any time critical situation, the use of AI with IOT, if implemented correctly, can prove invaluable. Statistical models such as the SIR model which categorizes people into susceptible, infected and recovered have been more successful in predicting the flow of an epidemic than AI based models. The most promising solution based on the SIR model is one based on the concept of Social Distancing where a population is instructed to avoid contact with each other to stop the spread of the pandemic. Social distancing can be difficult to implement in society. Monitoring a large population can be difficult and can cause security concerns. We assume that given that a basic set of needs are met, the general population will adhere to social distancing, as it is in their best interest to stay safe. Our aim, through the IOT platform, is to provide mechanisms, so that all the basic set of needs for a population can be easily met in a safe and secure manner.

Related Work: Most of the preexisting works related to social distancing deal with monitoring and alert based systems. The Newcastle University Urban Observatory was established to better understand the dynamics of movement in a city. It makes use of thousands of sensors and data sharing agreements to monitor movement around the city, from traffic and pedestrian flow to congestion, car park occupancy and bus GPS trackers. More recently using computer vision, pipelines for monitoring and alert systems based on proximity, have been designed to enforce social distancing amongst the population.



Most existing solutions deal with enforcing social distancing without considering the needs and demands of society, even the very basic ones. Hence we focus mostly on using IOT and AI to extend existing methods and help maintain social distancing efficiently.

Objectives: The primary objective is twofold. a) Avoid proximity to people whenever possible. b) Satisfy all the material demands of people, with focus on essential items. The two objectives are required to be fulfilled in a given area of the population, such as a neighbourhood or a colony. They also need to be reasonably scalable to larger sections, such as towns, cities etc.

Solution Outline: Given the problem, the primary task is that of distributing items in an area without explicit contact amongst the population. In the proposed solution goods are placed in a safe public location, unattended, with a 24x7 surveillance system to monitor any activity on it. On arrival, the distributor of the location is tracked and instructed to deposit the goods in the desired locations. The people in the community are registered to the system and each is assigned unique timings between which they can take the items from the common location. There will be electronic weight measuring systems installed at every distribution station with secure wireless links to our platform servers that record how much purchases are being made, and accordingly all payments will be made online.

Design: We now define the various components of the system and how we can use IOT and AI to build and augment them.

Platform: The platform will be running on distributed cloud servers in the closest zone. Each sensor will be connected to a local gateway which will communicate to the kafka endpoints hosted in the cloud. Data streams can be directly ingested into kafka from the gateway. Sensors which require higher bandwidth will expose a TCP endpoint and will share data directly to the servers via SSL encryption. In addition there will be an associated mobile application for users in the colony. This application will be used to register to the platform on the server. It will also be used as a location sensor using the GPS systems of the mobile. These will also serve as a means of broadcasting information to the people. For transaction management the application will use any of the readily available UPI gateways like paytm, GPay etc.

Tracking and Surveillance: The distributors entering a colony will be asked to register at entry point on the platform with valid identity proof on the mobile application. This information is now registered on the platform and is now accessible to all the residents of the colony, for follow up queries, complaints etc. It will also be used to track the distributor during its visit to the colony. Distribution centers will be scattered across the colony, each equipped with a) An overhead 360 camera b) A wireless weight measuring sensor, c) A display kiosk with which the distributor will register, show information on his products, and have QR codes for payments. All these will be connected wirelessly to a nearby gateway kept in a safe location. Every activity in the distribution centres, from the arrival of a new purchaser to his payment will be logged in the platform. Face detection algorithms will be running in the platform to detect the registered users. Any missed payment will be detected and the information will be relayed back to the distributor with the information of the violator only, who can then follow up with them more directly.

Social Distancing and AI. Social distancing is maintained by giving each member a unique time during which they can go and purchase supplies from the distribution centre. The user gives a list of preferences based on time slots in a day. They are restricted to choose time slots with certain intervals between them, for example one from the morning, one from evening and so on. Internally our platform will run an optimization algorithm to determine the most fair outcome of allocation. The system will maintain the given configuration amongst members until one of them changes their preferences and the new preference is non-conflicting. AI will be used to predict supply and demand based on previous purchasing data, and will automatically create logs for restocking supplies once it sees supply dropping. It is crucial that the AI be tuned properly and knows the trends of the calendar, such as festivities where certain items are more seasonal, as well as the buying habits of each individual. The AI can initially be pre trained with user data when no restrictions are in-place as lack of adequate supply all the time is less of an issue then.

Implementations: Now with the goals and design clearly defined we explore how we can implement the above using our existing IOT platform, and what additional requirements need to be fulfilled.

Currently our platform supports sensors that can connect to a gateway and export data via kafka to the platform. They can also be registered to the platform and be queried and filtered based on several factors like name, location, type etc. Sensor data are also kept in databases which can be again queried based on time and count, and aggregated if the data is numerical. All these combine to provide a powerful API accessible to anyone who writes the tracking and surveillance algorithms. One missing feature is a direct TCP connection to high bandwidth requirements like video sensors. This feature is almost its own standalone component and hence its implementation can be fairly straightforward. We have already shown our platform capability of logging and tracking through the infection tracking use-case.

We can treat the mobile application as a combination of a GPS sensor, information displayer, and user endpoint sensor. This will make it so that we can seamlessly integrate the application with the IOT platform. The app may be developed independently as long as it interfaces with the platform to provide the above three basic functionalities. In this case the app acts as a sensor combination and a gateway directly ingesting data into the platform kafka.

The platform will contain a set of algorithms. For example, when a new distributor wants to update the information it display on the distribution center kiosk, it will use the corresponding algorithm to update kiosk info with his information given during registration. There will also be similar algorithms for any payment operations done on the platform. They will be initiated at the mobile endpoint whenever someone wants to do a transaction and will use the payment gateway of choice.. A large number of such small instantaneous needs to take place smoothly everyday. Our platform has a load balancer and several runtime environments using docker, in execution or in standby to execute all such algorithms. Other algorithms need to be periodically executed or when changes occur, like, updating the preferences of users and resolving conflicts. The can be scheduled weeks or days in advance so that people have time to make adjustments and stick to the timings provided. The scheduler has all the capabilities to handle these situations.

Our platform does not provide any readymade AI models that can be deployed instantly. That does not mean it cannot run AI models inside its runtime environment. All our algorithms will be in python and hence have support for its extensive machine learning libraries. This also makes the platform very flexible when it comes to designing AI algorithms. As long as the runtime is on a capable system any AI algorithm can be executed.

Conclusions: We have provided a solution to integrate an IOT platform and AI algorithms hosted on it to enforce social distancing amongst a population without compromising on the needs of the residents. Many of the components of the system are preexisting such as mobile phones, thereby keeping costs low. Our platform is scalable and fault tolerant through the use of technologies like Kafka and Docker. Also a rich and simple sensor API, and the use of python, with its extensive libraries, make almost all use cases achievable.