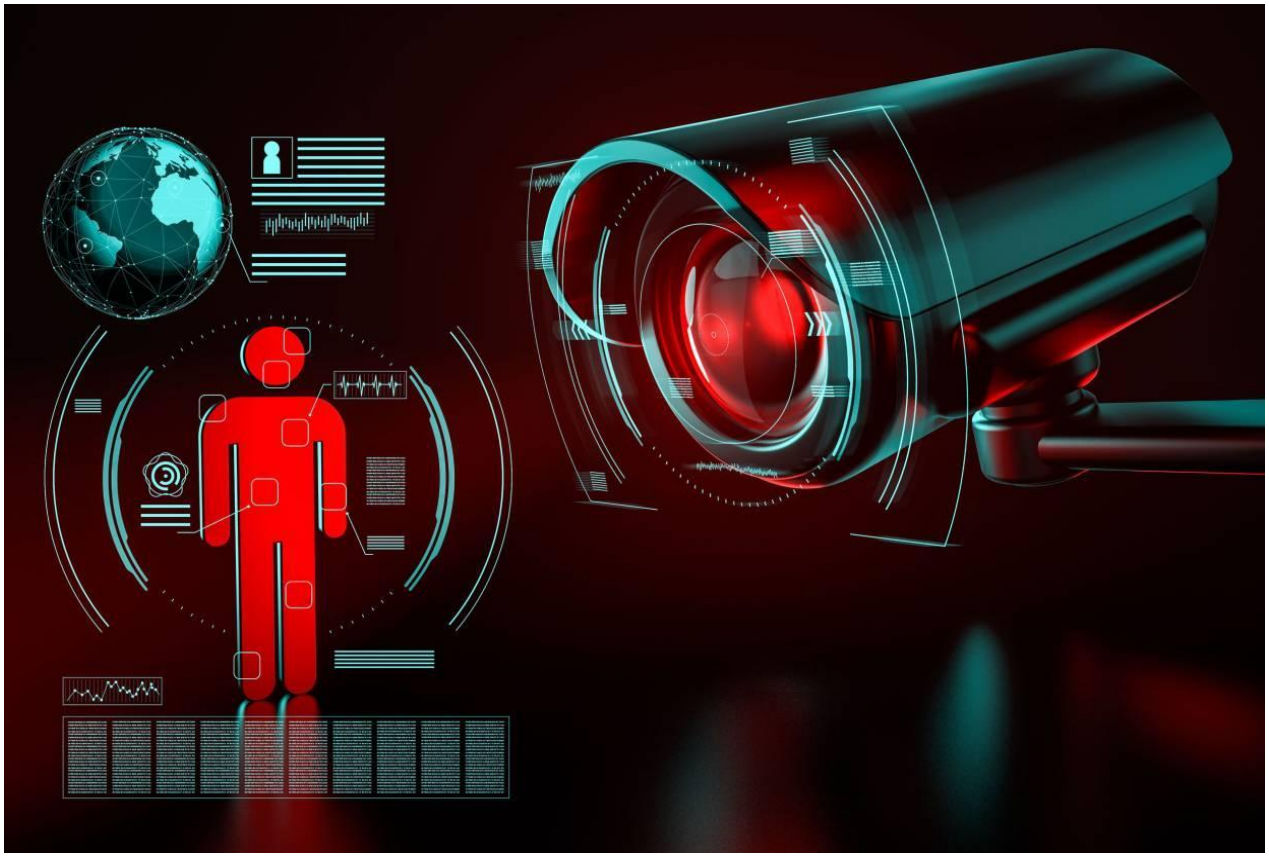
AI in Security and Surveillance



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20 AUGUST, 2022

FEYNN LABS PROJECT 3

"AI is one of the most profound things we're working on as humanity. It's more profound than fire or electricity"
Alphabet Inc. CEO Sundar Pichai

1. **PROBLEM STATEMENT**

Security And Surveillance are one of the fastest-growing industries and people are more than ever aware of its necessities. But across the country and the world, there is a problem of inefficiency due to overworked security personnel. Most often a single person is looking into feeds from multiple cameras which is a hectic task and is prone to errors. Moreover, security feeds in a majority of local retail shops are just to check recordings in case of a mishappening. They don't have any preventative measures. An AI revolution in the security industry is the need of the hour.

2. Market/Customer Need Assessment

Nearly every organization that deals with the public is in the need of security and surveillance. From a local retail store to a shopping complex everyone has a security camera installed.
But most often in small stores, no one is there to look into video feeds, and in big buildings like hospitals, and complexes there is an overworked staff.
According to Global Retail Theft Barometer (GRTB) Study, **India has the highest rate of retail shrinkage, a reduction or loss in inventory due to shoplifting and theft, in the world. "Retail shrinkage in India continues to rank the world's highest at 2.7 percent. The total cost of retail crime reached Rs 9,295.9 crore, shared at Rs 6,631 per family**," according to the GRTB 2010 Study. Things have not gotten better as the security industry faces an innovation crisis.

AI can help organizations in their security and surveillance needs in many ways, here I would like to focus on two use cases:-

1. Video surveillance technology can allow retailers to identify “red” and “green” shoppers. “Red” shoppers are those who demonstrate a pattern of shoplifting, while “green” shoppers are those with good intentions.
2. AI surveillance can also help detect dangerous objects like guns or knives at the entry or inside the building and alert the security personnel, and/or automatically lock the doors depending upon the situation.

3) TARGET SPECIFICATION

The proposed product can be used by the following organization:-

1. The detection of dangerous objects(weapons):-
    - Retail shops
    - Government buildings
    - Private buildings
    - Shopping complexes
    - Hospitals
    - Schools
2. Activity recognition to detect shoplifting:-
    - Retail store
    - Shopping complexes

4) External search (information sources):

1. https://www.researchgate.net/publication/349281117_Weapon_Detection_in_Real-Time_CCTV_Videos_using_Deep_Learning
2. How AI -Video Surveillance is Transforming In-Store Retail | Enterprise Mobility, Artificial Intelligence, Cloud, IoT, Blockchain Solutions & Services | Fusion Informatics Limited
3. https://towardsdatascience.com/yolo-you-only-look-once-real-time-object-detection-explained-492dc9230006
4. https://www.analyticsvidhya.com/blog/2021/03/introduction-to-long-short-term-memory-lstm/

5)BENCHMARKING

Without AI, surveillance generally comprises a single person scrolling through feeds of several cameras at a time. Sometimes the cameras are just to record, no preventative measure is there. A lot of human error which is bound to occur does happen and businesses have to endure huge losses.
AI can be used to assist the operator by signaling whenever it detects suspicious behavior for further investigation.
Using this system we will have a preventative approach rather than a reactive one and a lot of mishappenings would be avoided.
In a place where security personnel is already working, this system will assist him and increase efficiency many folds.

6) APPLICABLE PATENTS

1. US8345984B2: 3D convolutional neural networks for automatic human action recognition.
2. . US9858496B2: Object detection and classification in images.
3. US20160099010A1: Convolutional, long short-term memory, fully connected deep neural networks

7) APPLICABLE REGULATIONS

1. Customers should be made aware that they are under CCTV surveillance.
2. A letter should be given to the Police station and the Commissioner of Police of the respective Jurisdiction intimating them for installation of the camera.
3. If the shop is a part of a complex then intimate to the society and/or the maintenance committee for the same, however the same is also not mandatory.
4. All the guidelines regarding the installation of CCTV should be followed.

8) Applicable constraints (need for space, budget, expertise)

- Equipment Required:-
  CCTV cameras need to be installed along with the main server and display system.
- Expert Required:-

1. Required for a visiting basis.
   - A system engineer is required for the installation and maintenance of a system.
   - A data scientist is required to create, deploy and maintain the model for the detection of dangerous objects like guns or knives and for the detection of shoplifting.
2. Required daily
   - Security personnel can operate the system easily with minimal training of 1-2 days.

9) BUSINESS OPPORTUNITY

With the economy and businesses growing, security needs are also expanding, which is further necessitated by the ever-increasing security risks and related threat perceptions. Deployment of specialized personnel and systems to prevent and manage security risks and threats including accidents and incidents are vital for peaceful operations at a place. Therefore, the need for implementing security measures and systems at public places such as airports, railways & metro stations, shopping malls & markets, hotels, and public utilities as well as industrial complexes, commercial spaces, offices, and residential blocks have risen multifold. **Indian Private Security Industry (PSI) has also expanded at a Compounded Annual Growth Rate (CAGR) of around 20% over the last decade** by adding new players in the field as well as scaling their operational capabilities. In fact, Private Security in India is the 2nd largest sector, after agriculture, in terms of employment, with close to 09 million employees. Traditionally, it has been an unorganized sector with around 40% of the market share being with the organized

players. However, the industry is progressing towards being organized as the consumer demand for security is gradually evolving.

10) CONCEPT GENERATION

Security is one of the fastest-growing industries in India with a CAGR of 20%. But security in the country is in immediate need of rescue. In the majority of places in India where CCTVs are installed, either no one is looking at the video feed constantly or the feeds are too much for the deployed staff to observe properly.

To assist the people working in the respective industry, I want to create a deep learning model which can work in sync with a human operator(owner/security personnel) to increase the efficiency of the security system.

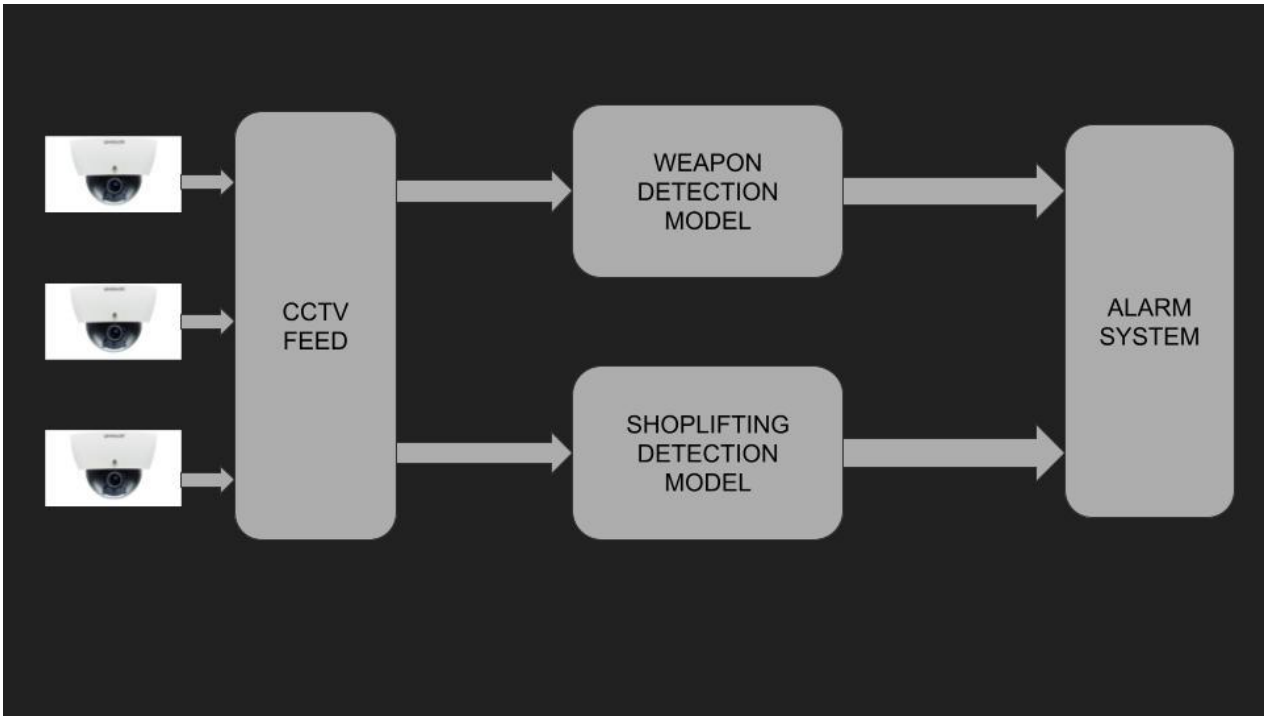
11) CONCEPT DEVELOPMENT

The product will mainly consist of two features:-

A weapon detection system: The product will use deep learning to recognize dangerous objects. It will work on the footage obtained by the CCTV cameras installed. A YOLO model will be used for this task. It will be trained using a dataset of images of people holding weapons and some common objects.
If it senses a dangerous object it will send an SOS message or lock the door depending upon the situation.

A system to detect shoplifting in shops: The product will use an activity recognition system with the help of LSTM(long short-term memory) to detect if a person is shoplifting. It will be trained using the footage from the UCF crime database. If it senses someone has stolen something it will alert the authorized person along with the video feed of that instance for further investigation.

12) FINAL PRODUCT SERVICE PROTOTYPE :



The final product will be a mobile app where the user(owner/security personnel) will get alerts. After the alert is sent, the system will save the video of the particular instance where the weapon or act of shoplifting was detected for further investigation. Also, it will automatically contact legal authorities with some delay. The delay is added so that the user may cancel the SOS message in case of a false alarm.

In the backend, the system will consist of CCTV cameras whose feeds are continuously passed into the main server. The main server will have the deployed model for the detection of weapons or shoplifting. If an anomaly is detected it will send the alert to the mobile app and an SOS message to the authority.

13) PRODUCT DETAILS

A. The Weapon Detection System

- Algorithm Used:-

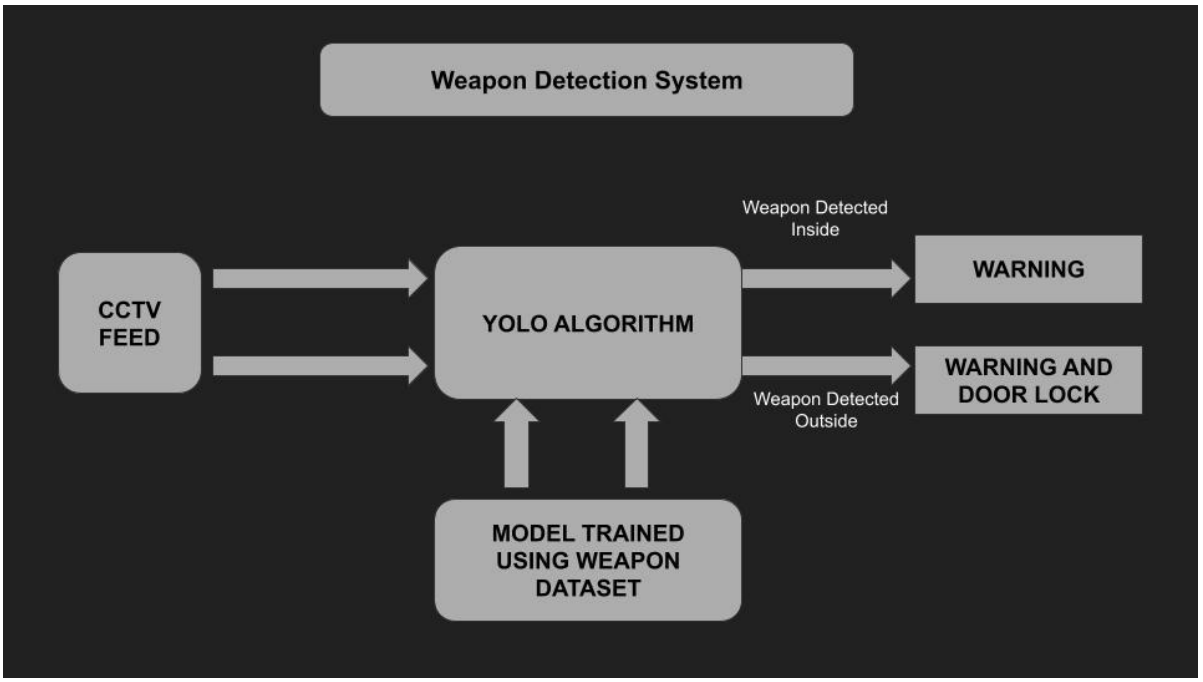
  The system will use the YOLO algorithm for object detection. The YOLO framework (You Only Look Once) deals with object detection in a different way than the traditional R-CNN family of techniques. It takes the entire image in a single instance and predicts the bounding box coordinates and class probabilities for these boxes. The biggest advantage of using YOLO is its superb speed – it's incredibly fast and can process 45 frames per second.

- Dataset Used:-

  The *Sohas weapon* dataset includes weapons and small objects that are handled in a similar way. It contains six different classes such as pistol, knife, bill, purse, smartphone, and card.
  Further web scraping can be done to increase the size of the dataset.

- Working:-

  A YOLO model will be trained using a dataset of weapons and people holding weapons and some common objects. The feed from the CCTV will be passed into the model frame by frame which will detect the presence of any weapon. If the weapon is detected at the gate, it will immediately shut down the door and alert the authorized person for further investigation. If it detects a harmful object inside the shop it will send an SOS message to the police station with a delay of some seconds and to the authorized person. In case of a false alarm, the authorized person can cancel the SOS message to the police.



B. Shoplifting Detection

- Algorithm Used:-

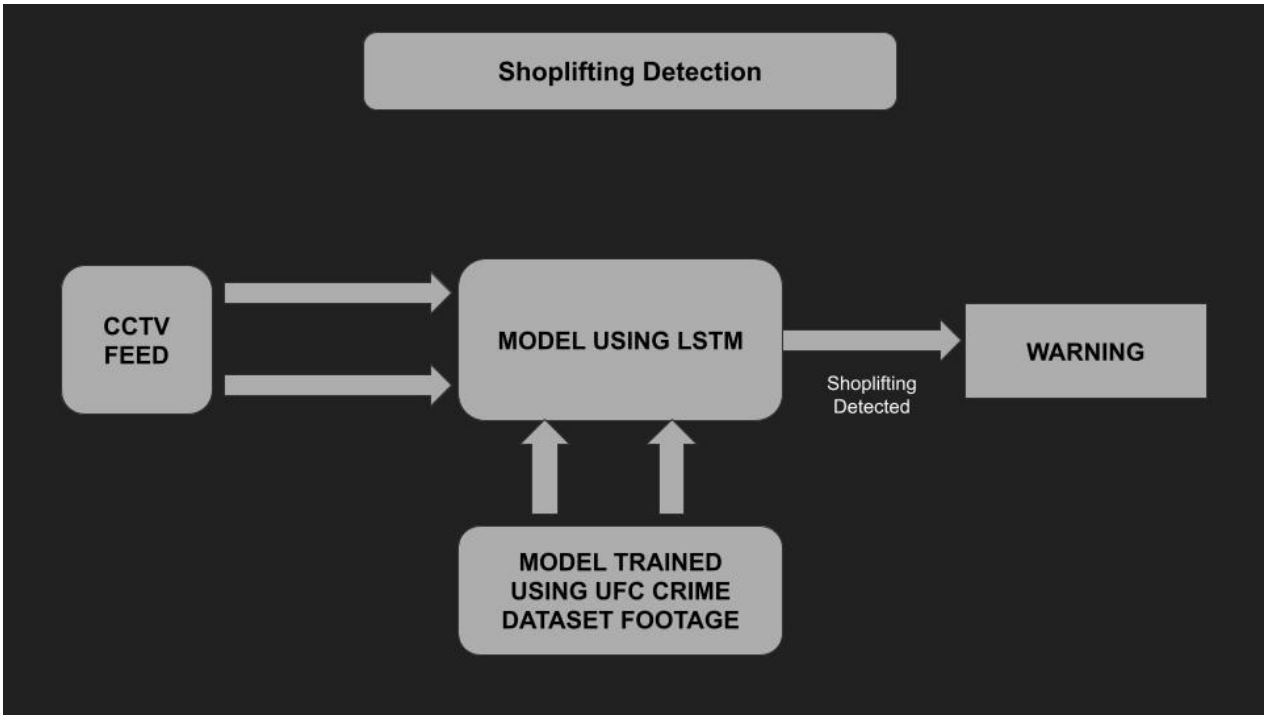
  Here along with a CNN, we will use LSTM(Long Short Term Memory Network) an advanced RNN, a sequential network, that allows information to persist. LSTM units include a 'memory cell' that can maintain information in memory for long periods of time. This memory cell lets them learn longer-term dependencies. They are used for activity recognition.

- Dataset Used:-

  UCF-Crime Dataset consists of long untrimmed surveillance videos which cover 13 real-world anomalies, including Abuse, Arrest, Arson, Assault, Road Accident, Burglary, Explosion, Fighting, Robbery, Shooting, Stealing, Shoplifting, and Vandalism. We will use the shoplifting footage to train our model.

- Working:-

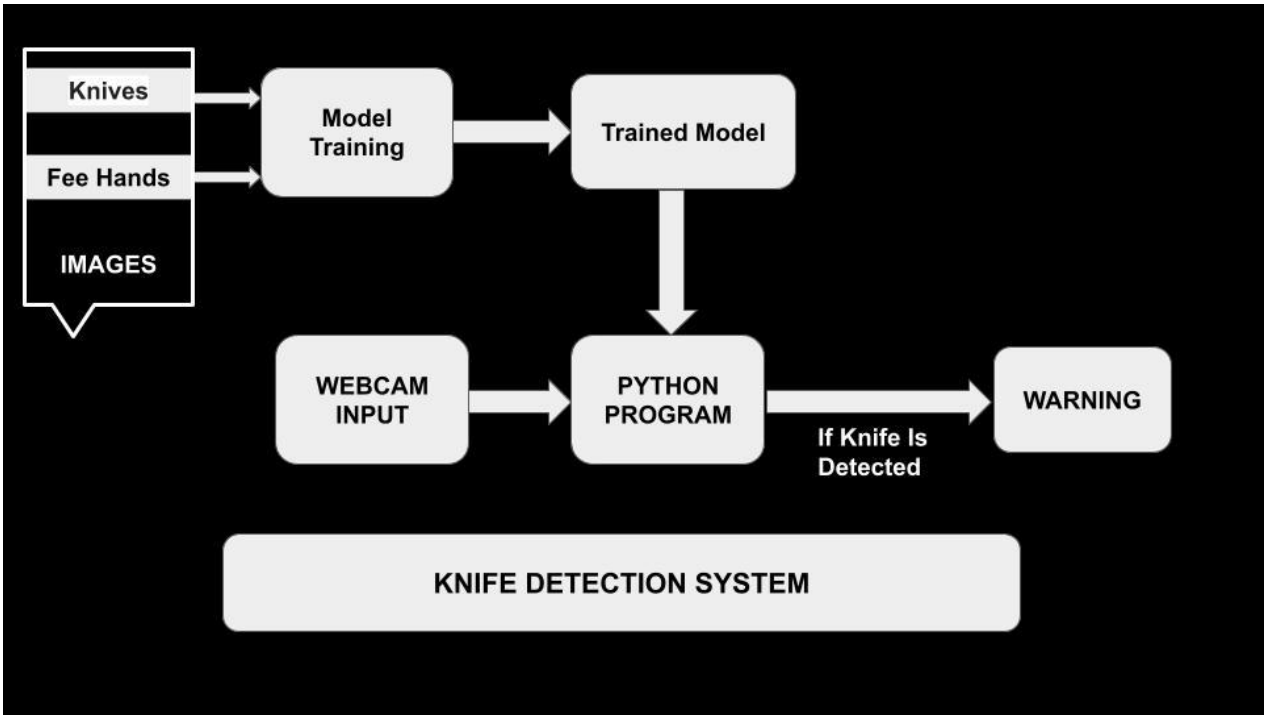
  A model using the LSTM network will be trained using to recognize the action of shoplifting using the UCF crime data footage. The model will take input from the CCTV camera feed, as soon as it detects an anomaly it will alert the concerned person and save the video of that instance. The video can be then accessed by the authorized person using the mobile app for further investigation.



14) Implementation on a small scale:-

For the small-scale implementation, I have created a model which can detect if a person is holding a knife in a live video feed. The model used is MobileNetV2 trained on a dataset of images of people holding a knife and images of free hands.
First, we have trained a convolutional neural network and after that, we saved the trained model for further use. Then using a python program we input video from the webcam and

slice that video frame by frame. Each frame of that image is passed into the knife detection model created earlier. If the program predicts that a person is holding a knife we send the warning message.



Github Link:- https://github.com/Anni0223/Knife-Detection-System

15) CONCLUSION:- The problems persisting in the security industry can be easily solved with the power of artificial intelligence. It will assist security personnel in performing their job faster and better. Small businesses will be able to avoid the huge losses they endure due to shoplifting. A safe ecosystem for the smooth functioning of businesses can be created with the requirement of a minimal one-time investment with the help of AI.

BUSINESS MODELLING

A) Feasibility: The product can be easily developed within 5-6 months.

B) Viability: The security industry is the need of the hour and its demand will continue to rise for the next decades.

C) Monetization: The product can be easily monetized.

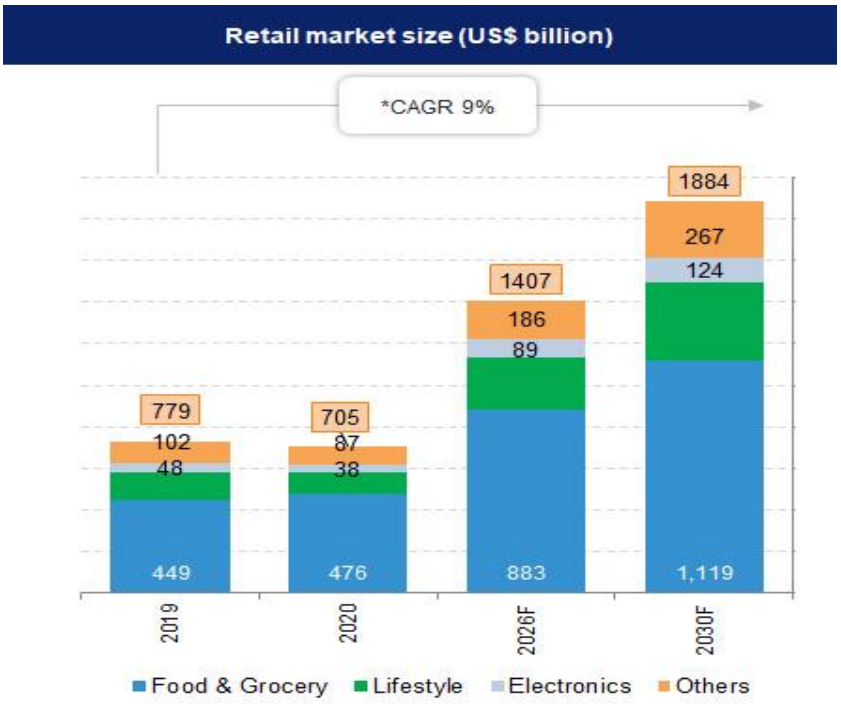
Business Modelling

Our product will consist of two components and will be sold differently based on customer requirements.
The weapon detection system will be required by an organisation that has a possibility of armed threat/intruders or in an area where armed robberies are frequent, the system will be installed near the entrance.
The shoplifting detection system will be the main product we would focus on. Both these products will follow an **IaaS or Infrastructure as a Service business model**, it will have an initial cost of installation and then an annual subscription that would compete with the traditional cost of maintaining a security infrastructure(manpower and maintenance).

Financial modeling

Our product will mainly target the retail market in India(retail stores, departmental stores, and shopping complexes).
Along with this, we can focus to sell weapon detection systems to organizations like banks that have intrusion threats.

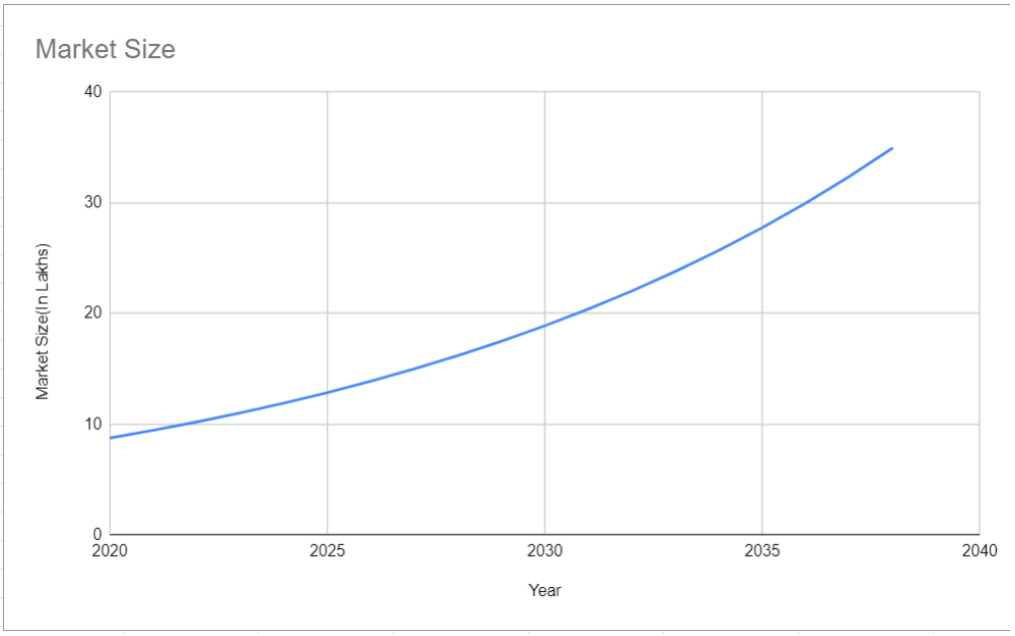
The Indian retail market is estimated to be US$ 600 billion and one of the top five retail markets in the world by economic value. India's retailing industry was essentially owner-manned small shops. Larger format convenience stores and supermarkets accounted for a little percent of this industry but their share is continuously rising.



As per Kearney Research, India's retail industry is projected to grow by 9% over 2019-2030, from US$ 779 billion in 2019 to US$ 1,407 billion by 2026 and more than US$ 1.8 trillion by 2030.

Over 19 million(as of 2020) outlets operate in the country and only 4% of them are larger than 500 sq ft (46 m^2) in size. These 7-8 lakhs stores are our most suitable segment as they have a need for good security. As the industry is expected to grow at a CAGR of 9 percent, assuming a CAGR of 8.5 for these stores.

By 2025 there would be around 11-12 lakhs of these large stores and around 16-18 lakh by 2030.



Large Retail Shops Market

Let x(t) represent the Large retail shops market in India, x is a function of t, and is an exponentially increasing function, using the following table we will calculate the equation for the market trend.

Year	Market Size
2020	7.5
2021	8.1
2022	8.748
2023	9.44784
2024	10.2036672
2025	11.01996058
2026	11.90155742
2027	12.85368202
2028	13.88197658
2029	14.9925347
2030	16.19193748

Using the given table the equation for the market x(t) is:

$x(t) = 9447840(1.08)^x$

Where x is the number of years, 2023 is the year 0(starting Year).

Financial Equation(Year-Basis):

For the financial equation let us consider the following variable:

y = total profit

m_1 = product installation price:- 40k

m_2= product annual fees:- 10k,

c_1(business setup cost(recurring)**)**

- System engineers(2) and ML Engineer :- 12+8 = 20 lakhs.
- Office cost and bills(Rent,Internet,Electricity) :- 4 lakhs
- Maintenance :- 1 lakh

c_2(business setup cost(one time)**)**

- Systems, servers, and internet installation cost: - 4 lakh

c_3(Installation cost per client)

- System and CCTVs cost:- 40k

X(t): Sales as a function of time.

T: Time in years.

Financial equation(year-basis) :

$$\mathbf{Y = m_1.x(t) + \sum_0^T m_2.x(n).(T+1-n) - c_1T-c_2-c_3.x(t)}$$

$$\mathbf{Y= 40000*\ x(t)\ +\sum_0^T 10000.x(t).T - 2400000*T-400000-40000.x(t).}$$

Where x(n) is the sale in the nth year and T is the year being analyzed after the company is established, the year of establishment is the year 0.