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Theft-Detection using Motion Sensing Camera

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Abstract— Theft of valuable objects is some of the never-ending problems in the world. Several detecting devices are already available in the market today. Example of such is to provide an alarm which can be activated using a remote control. Unfortunately, these devices had no provision to automatically detect theft attempts by alarming the owner. To solve this problem, Camera footage based theft detection will be used in this project with the help of image processing to detect theft occurrence. The system will capture the image frames and by comparing the two frames, it will be able detect motion and immediately an alert message will be sent to the owner along with captured image and options such as neglect, call the police or fire brigade.

Keywords—Anti-Theft Device, Image processing, Raspberry Pi, RANSAC, Camera module, Motion Detection

I. INTRODUCTION

Theft is one of the most common and oldest criminal behaviors and it is increasing day by day. The rate of crime has increased not only in the single area in the world but also in worldwide. Due to increase rate of theft, the people have suffered in fear and loss. In order to stop this increasing theft across the world, there is a need for a theft deterrent system that is convenient in use, relatively free from false alarms and does not require frequent user action to arm and disarm the system.

An anti-theft system will be developed which will mainly focus specifically on the room security system. This device will be installed inside the room, mounted on the ceiling will detect motion and it would be efficient enough to differentiate between the false and real theft by detecting motion and differentiating between the small and large changes that are occurring in the frame. Software/Application is used to activate the output device by a click of a button or simply hit the key on the keyboard. Also, output device must be able to be turned off using a keyboard or click on the mobile phone. For this project, the system will be used to detect motion in the shop or any protected area using the camera.

II. EASE OF USE

The system consists of simple hardware structure and hence it would be easier for the user to arm and disarm the system according to his/her needs. The owner will just have to install the camera at the ceiling of the room or the shop and provide power supply to it. Once the system is started, it will detect motion and send an alert message to the owner. Since an application will also be built for the easy interaction of the user with the system such as START and STOP.

III. SYSTEM DESIGN

To resolve the problems of existing work we propose a new approach, which would be helpful to remove the unnecessary use of hardware and the cost of the project will be reduced. The proposed work will solve the problems of false alarm by removing outliers using various algorithms such as frame differencing, segmentation, etc.

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A. Block Diagram:

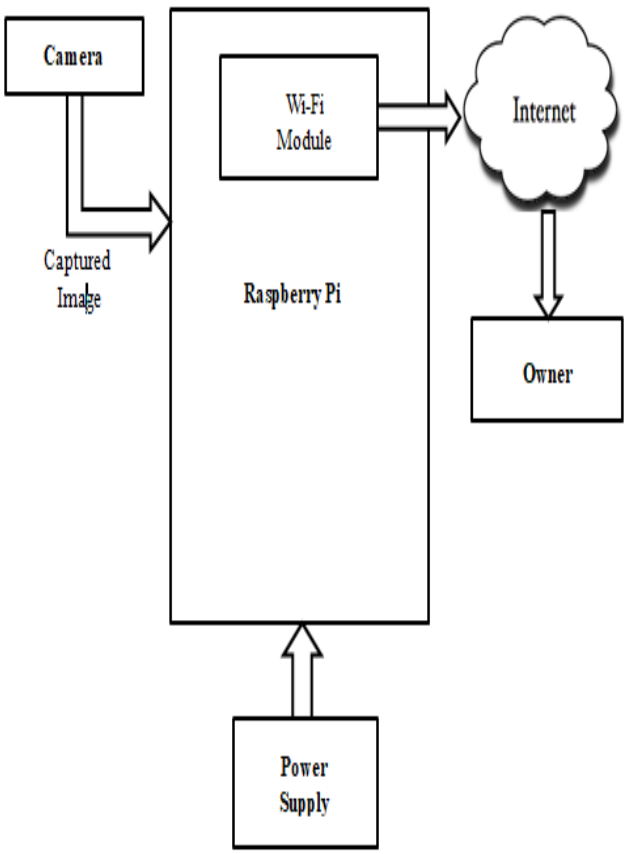

Figure 1: System Block Diagram

System Block Diagram i.e. figure 3.1 below served as the framework of the system. The Raspberry Pi 3 and Raspberry Pi Camera module is the main components of the system. It serves as a controller of the entire process. Wi-Fi module is built in the Raspberry Pi 3 b hardware, so there will be no need to add Wi-Fi module externally. The proposed system will be an intelligent system and it can eliminate the need for continuous surveillance by human resource. Thus, any human extra work is ruled out. In this project raspberry pi 3 B (model) will be used as heart system. The system will continuously check the status of place by sensors that, Is anyone entering the shop or not and sends the alert message to the owner with the captured images. In this security system motion will be detected by using image processing techniques.

A. Flowchart:

The below flowchart i.e. figure 4.2 gives the complete flow of working of the system from the capturing of an image to sending the alert message to the owner.

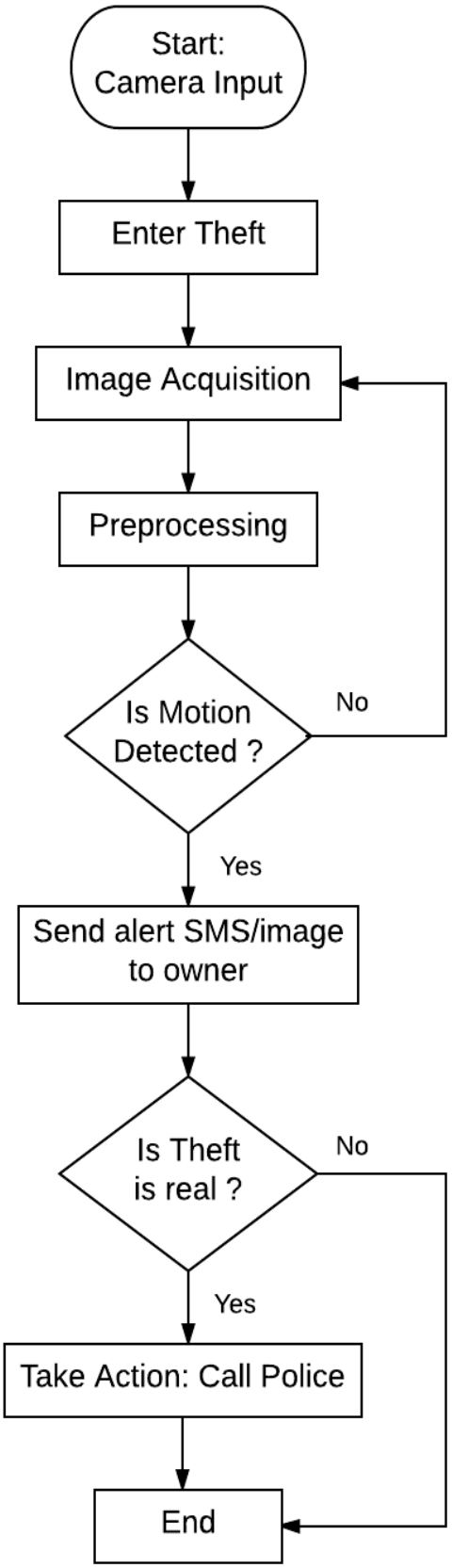

Figure 2: Flowchart

1. Start: Camera Input

After installing the Raspberry Pi Camera module inside the room or shop, the Anti-theft device will require a 5-12V power supply. The whole system will start working on providing the continuous power supply to the device.

2. Enter Theft

Once the system is installed and sufficient power supply is provided to it, it will start capturing the image. After closing the shop or room, if any motion happens in front of the camera it will detect it as Theft entry and start following the next steps of its algorithm.

3. Image Acquisition

The proposed system acquires the input video by using Raspberry Pi camera module which will capture video at a resolution of 280 × 180 pixels. The camera will be fixed on the wall and capture video at a frame rate of 18 frames/sec. To detect moving objects becomes quite complicated in the presence of noise, reflections, shadows, illumination conditions. The proposed algorithm will be used to detect the difference between the frames [7].

4. Pre-processing

The pre-processing phase includes various interlinked activities such as background estimation, background subtraction, Outlier rejection, Frame Differencing and Segmentation.

a) Background Estimation

Background estimation deals with estimating background of an image. For the purpose of background estimation, a reasonable amount of captured frames will be processed in order to estimate the background. Background estimation approach deals with capturing the background only; this is the simplest case for background estimation, as there is no other object in the image and the whole frame is considered as the background. A single frame is sufficient for background estimation in such case [7].

b) Background Subtraction/Frame Differencing

Background estimation is followed by background subtraction in every image processing algorithm. Background subtraction is the most commonly used technique for object detection. It deals with subtracting background from the image in order to detect object components from the image. Background subtraction is done in pixels domain, where the process is applied pixel by pixel. In proposed system pixel by pixel, background subtraction is done with a tolerance 35 [2].

c) Outlier Rejection

The nearest neighbor search will be used as the matching method between the previous and current images. However, this method has drawbacks generating many outliers. These outliers could lead to large registration error. The RANSAC algorithm is used to remove outliers. The Below given algorithm shows the outlier rejection method with RANSAC.

Iteration := k
While iteration < k
  N randomly selected corresponding points
    Calculate $H_t'^{-1}$
    Consensus_set count: = 0
    For every corresponding point $\mathbf{p}_t'^{-1}$, $\mathbf{p}_t'$
      If $\left\| \begin{bmatrix} \mathbf{p}_t'^{-1} \\ 1 \end{bmatrix} - H_t'^{-1} \begin{bmatrix} \mathbf{p}_t' \\ 1 \end{bmatrix} \right\|^2 < \delta$ then
        Increase consensus_set count
  Increase iterations
Return best $H_t'^{-1}$

N corresponding matches are randomly selected and the rigid transformation H_t^{t-1} is calculated. The objective function used in the RANSAC algorithm determines whether matches can be inliers by measuring the Euclidean distance between the 3D points and the transformed 3D points. This means that a 3D point transformed by H_t^{t-1} should be located at the matched 3D point. The most voted candidate is selected as the transformation matrix in the RANSAC algorithm [2].

d) Segmentation

The frame subtraction result contains many undesired points such as ghost points and occlusion regions even though the registration is accurate. Therefore, these points will be removed using segmentation technique. The segmentation is started at the outliers of the RANSAC whose points are on the object after moving and its connected voxels are merged. If there is an occupied voxel in the 26-neighborhoods of the given voxel, the occupied voxel will be said, connected to the given voxel. All connected voxels are selected using the 26-neighborhoods until every neighbor of its neighbor has no connected voxels. The process starts at voxel v and connected voxels are found [2].

5. Decision Making-I

The proposed system has a very simple decision-making algorithm, based on feature matching. The first captured image will be stored in the database as the reference image. Object detected as a result of the new current image is matched with the database values using the technique of feature matching. If there is a match between the current image frame and the reference image frame stored in the dataset, the proposed system will send an alert message as well as the captured image as compared to the large original video to the user/owner. If there will be no match between the two frames, then it continues the process from the image acquisition steps [7].

6. Decision Making–II

The decision-making algorithm depends on the user/owner of the shop, after getting the alert and captured the image. The user will see the image and then decide whether the theft is real or not and whether the action has to be taken or not.

7. Take Action

After watching the image, if the user finds it real theft then he can call the police using the "Call Police" option provided in the application of the user or neglect it by clicking the "Neglect" option.

B. Use-Case Diagram

The below Use-case diagram i.e. figure 3.3 describes the overall role of the Anti-Theft device and the user.

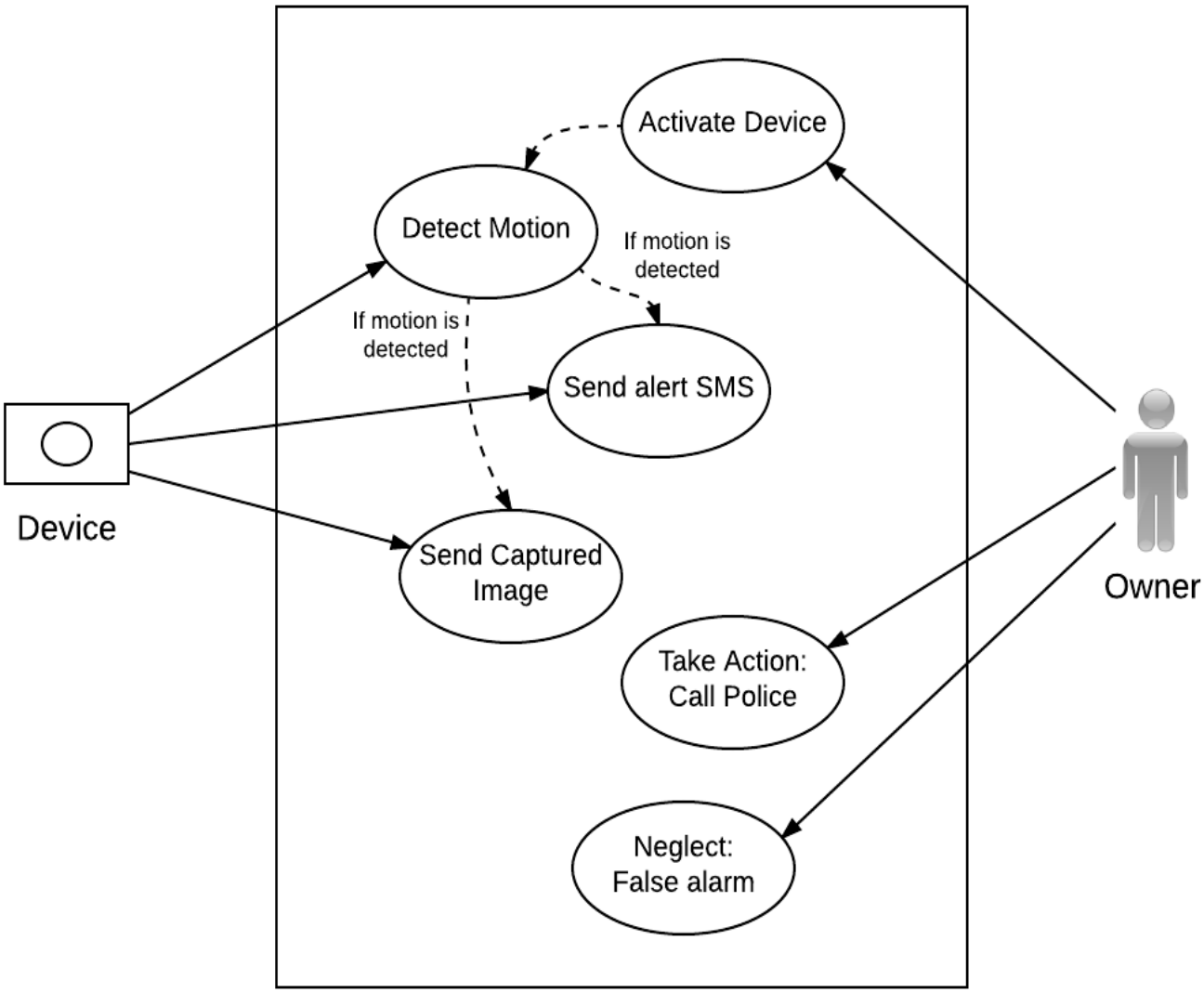

Figure 3: Use Case Diagram

1. Device/System

The Anti-Theft device, once installed will be activated by the owner and then the motion detection work will be started by the camera with the help of written code for image processing techniques. If motion will be detected, then it will send the alert message to the owner along with the captured image. The application on the owner side provides an option to the user for handling the received alert message.

2. Owner/User

The device will require 5-12V of continuous power supply, which should be provided by the owner before starting it. If the device detects motion and sends an alert message to the owner, the owner will check the image that will be sent along with the message and decides whether it is a real theft or not. If the theft is real, the owner will take action against that and click on the "Call Police" option on the application and ask for help with police and if the message is a false alarm, then the owner will neglect it by clicking on the "Neglect" option.

C. Data Flow Diagram

The DFD level 1 i.e. figures 3.4, shows the complete flow of the data and system from the camera that is capturing the image to the owner/user who will take action against the alert message. First of all, after starting the device, it will start

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capturing the image frame using Raspberry Pi Camera Module and then the noise errors/outliers will be removed using RANSAC algorithm. The cleaned image frame as a reference image and the next image frames as the current image will be stored in the Image Database.

After storing the image frames, it will compare both the reference and current frames and if it will find any difference then it will conclude that motion is detected and if the difference will not present then it will end that process and start new comparisons of newly captured frames. The device will send an alert message and captured image frame at the time of motion if any motion is detected. The owner will see the message and image and decide what action to be taken against it. If the user finds it as a real theft, then he/she can call the police or neglect it, using the options provided in the mobile application to control the device.

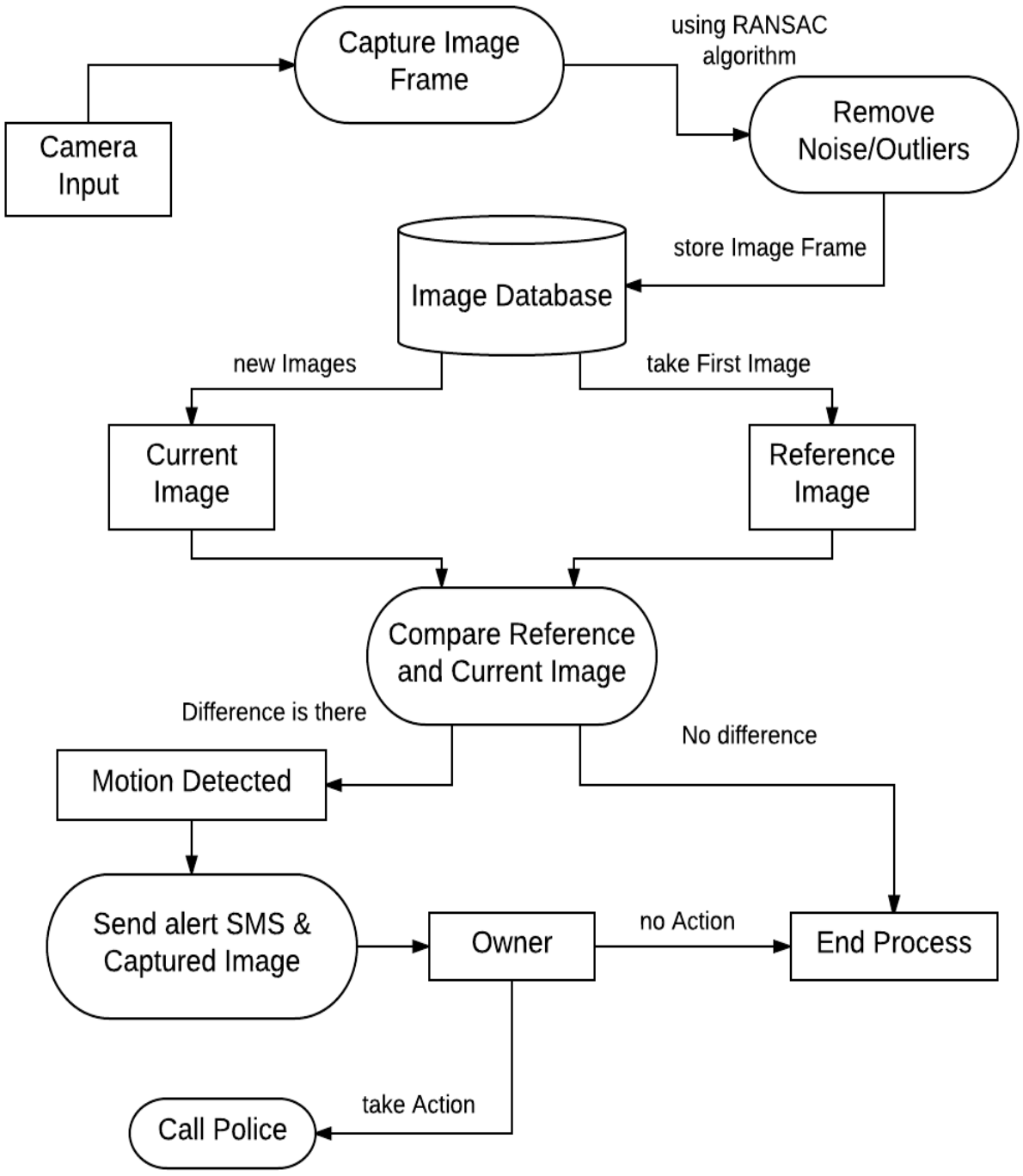

Figure 4: DFD Level-1

D. Sequence Diagram

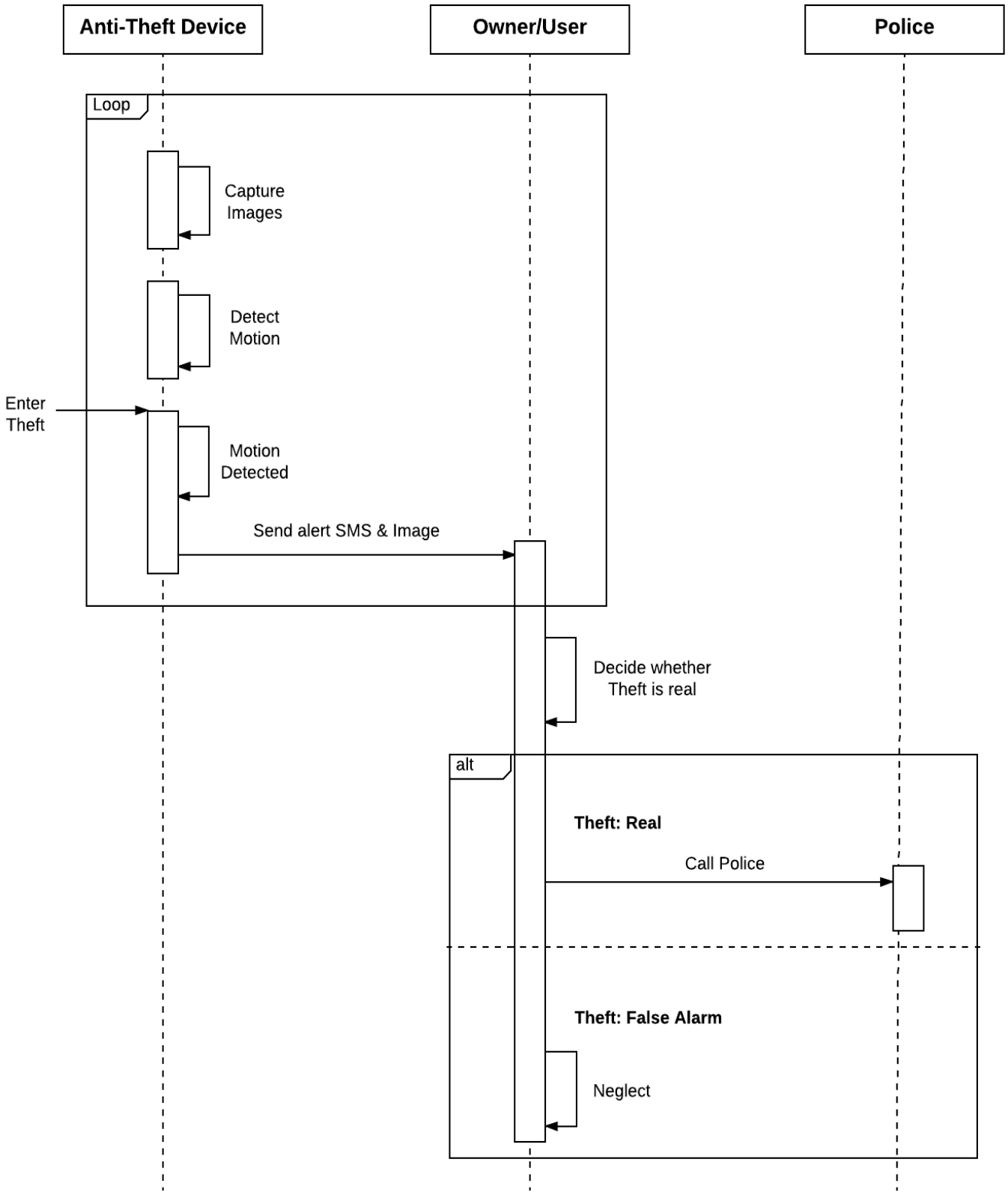

Figure 5: Sequence Diagram

The Sequence diagram of Anti-Theft device i.e. figures 4.5 gives the clear idea of how the objects such as device, owner, and police will work together in sequence. When the device will start, it will capture images and detect motion by comparing the frames and if any theft will enter into the shop/room, it will detect that action as motion and send an alert message to the owner along with the captured frame. This whole process from the device end is combined into a single loop box because the above-mentioned process will run again and again in a loop.

Once the alert message will be received by the owner on the application, the owner will have to decide whether the theft is real or it's just a simple movement and false alarm by seeing the images sent by the device. Since, there are two possible situations that theft could be real or false alarm, hence "alt" box is used to represent both the alternatives. In the first alternative, if condition (Theft: Real) is true then the owner will call the police and ask for help and in the second alternative, the condition (Theft: False alarm) will be checked and if it is true then the owner will neglect the alert message.

The sequence of all the roles of objects is shown in the sequence diagram of an anti-theft device and the loop containing the process i.e. capture images, detect motion and send an alert message to the owner will run in the loop for the continuous surveillance by the device and hence the human effort to focus continuously will be reduced.

IV. EXPECTED RESULTS

With the approach to smart surveillance, the user will be allowed to depict a time for monitoring intruders. During the survey time, the systems will continuously poll data from the pi camera. In case of an intrusion, the motion will be detected by the Pi camera and sent it to raspberry pi for further analysis. If the image processing flags a possible intruder, the user is notified through the alert message along with the captured image. The user can also view and download the footage of the intruder to be used as evidence.

Along with all these features, the overall results which are expected from the system are as follows:

- An anti-theft device which can give a real-time alert message to the owner.
- A user-friendly application for the owner to control the device i.e. when to start or stop.
- An efficient device that has the ability to distinguish between the real theft and false alarm.
- A device that can give authority to the user or owner to take actions against the alert message through options.

V. CONCLUSIONS

The system will capture images only when the motions exceed a certain threshold that is pre-set in the system. It thus reduces the volume of data that needs to be reviewed. Also, it will help to save data space by not capturing static images which usually do not contain the object of interest. It will be applicable to both office and home uses. After successfully implementing the project, it can be applied to the motion detection for a smart home security system which would be very much helpful in auto theft detection for security purpose. It can also be useful in bank, museum, and street at midnight. As a future work, we can introduce Artificial-Intelligence into the system to distinguish between real theft and just a simple movement of the object.

VI. ACKNOWLEDGMENT

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