

# Abandoned Object Detection System – A review

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**Abstract** - Detecting objects which are stationary or rather are kept at one particular location for a long duration without disturbing it are determined as abandoned objects. Detecting it by processing the video through various operations and obtaining a well-defined object with its accurate specifications and alerting about it to the user controller is the main objective of such systems. Various strategies used for detections and its peculiarities are been discussed in this paper. Also, the operations used in different stages are been discussed. Various filters are used to enhance the quality of detection and removing noise from the detected frames. Computer Vision Systems Toolbox of MATLAB having commands for performing the operations is also mentioned. Discriminating between humans and non-human in order to avoid false alarms can be done through learning algorithms. Reduction of false alarm rate is done by feeding the system with information to help avoid non-emergency cases and also by learning algorithms. Also reverse processing of identifying the owner of the object can be done by using the stored images in the memory. The final goal remains to observe unusual behaviour by human or non-human objects and report it for safety purposes.

**Key Words:** Abandoned object, Segmentation, Gaussians, Blob analysis, MATLAB, Morphological operations.

## 1. INTRODUCTION

Need for visual surveillance systems have been growing during recent years. Many organizations as well as governments have started to quip video cameras in their property for security reasons. Therefore there is myriad of data to be recorded and stored and to be analyzed. Here comes the need for automatic surveillance systems which will have limited storage requirement and processing to be done instead of keeping all the data recorded. The automatic systems are required to detect humans as well as non-human objects in the video. Also tracking of the moving objects is the goal for these systems. Then arrives the problem for building low cost and low power based systems with wireless networks of video camera sensors. The other design challenges include its efficiency of the algorithms and the memory constraints of the systems. Fully automatic surveillance is yet far from being implemented but its intermediate steps are in process.

Installing video camera surveillance systems in public places like airport, railway stations, malls, etc. is needed

to detect suspicious behavior of humans and objects and also for observing different objects that are carried around. There will be hundreds of cameras needed for large areas to be supervised; hence observing actions in all the footages and keeping track of objects is a quite tedious task. Abandoned objects are considered as potential security breach and thus measures are needed to detect them. Automatic systems will help decrease the task to a significantly lower time requirement and also help to keep record and identify the owner of the abandoned object.

The area which is to be observed must have a video camera installed. The video camera acquires image sequences and these sequences are digitized by an acquisition board, which processes the video and sends the results to a remote control center [30]. The general steps for processing a video for detecting abandoned objects are pre-processing, dual background generation, object detection and object tracking [9]. Pre-processing stage includes extracting the input video into frames and then processing the frames by resizing, converting it RGB to gray-scale and later applying the median filter to remove noise and sharpen the edges of the frames. Dual background generation is basically maintaining two backgrounds, the current background (CB) and the buffered background (BB). Buffered background is basically the first frame. The current background is initially the first frame and then the pixels of each background are compared with the buffered background. Adaptive median is used for background modeling to differentiate between objects that belong to background and foreground. In this way we can identify the static object which is becoming part of the foreground [10]. Object detection is carried out comparing the calculating the difference between the CB and BB every 10 seconds. Object tracking is done by creation of blobs i.e. rectangular regions of foreground consisting of various properties and then applying the tracking algorithm. GMM is used for background segmentation to detect abandoned object and plotting of bounding box around the object is done by using a blob analyzer [13]. Kalman filter is used to track object in video surveillance by using Background Subtraction to detect foreground object in an image taken from camera and then morphological operations are used to filter out noise and remove imperfections.

The process of abandoned object alert detection includes three parts: 1) Human detection, 2) System interface and 3) Occlusion handling [16]. In order to detect human or non-human objects, a learning framework is developed. After the object is classified as abandoned, some conditions are verified like the size, region of interest and abandoned time. These conditions are specified by the user using the system interface.

from various viewpoint classifiers by using simple arbitration heuristics. Generative models have an advantage over discriminative models when part of the images are occluded or missing [22]. Prior knowledge can be easily incorporated in generative models in the forms of structured latent variables, such as lighting and deformable parts.

## 2. Various Systems

There are many different systems proposed and tested by many researchers for detection of abandoned objects which are more or less similar to the general system explained before.

The system proposed in [2] uses the general system with detection of foreground and background as different steps and then later blob formation and its features calculation in two different steps, the rest of the system remains same as the general one. It classifies stationary object as object never seen before and removed object has been seen before. Also the system in [3] is similar to the one before and includes the selection of region of interest (ROI). In [4] there are different methods specified for background segmentation, namely running average method suitable for real time surveillance and approximate median model which is adaptive in nature. The approach detects abandoned objects even in different lighting conditions, crowded scenes and able to detect objects of different sizes. False detection has also been handled in this method. Also the system is simple and less intensive and it avoids using expensive filters.

If a formal event representation is matched by the provided sequence of observations along with meeting the prespecified temporal constraints [6] [38], the event is said to have occurred. There are four further types in which the event is divided into, One is when the owner enters with his bag, second is when the owner leaves without taking his bag, third, the bag is abandoned and last would be if the owner returns back for his bag. The algorithm designed over here computes of three computational modules that helps to determine the above stated activities: The detection that the bag is not attended by anyone, traveling along previous frames to discover who the owner actually is and the continuous observation of the scene [38].

A QVGA (quarter video graphics array) resolution that which is most commonly used by the CCTV cameras is being used in [1]. Fleeting double rate frontal area joining strategy for static-foreground estimation for single camera video pictures is being proposed in the paper which includes developing both short-and long haul foundation models gained from an info

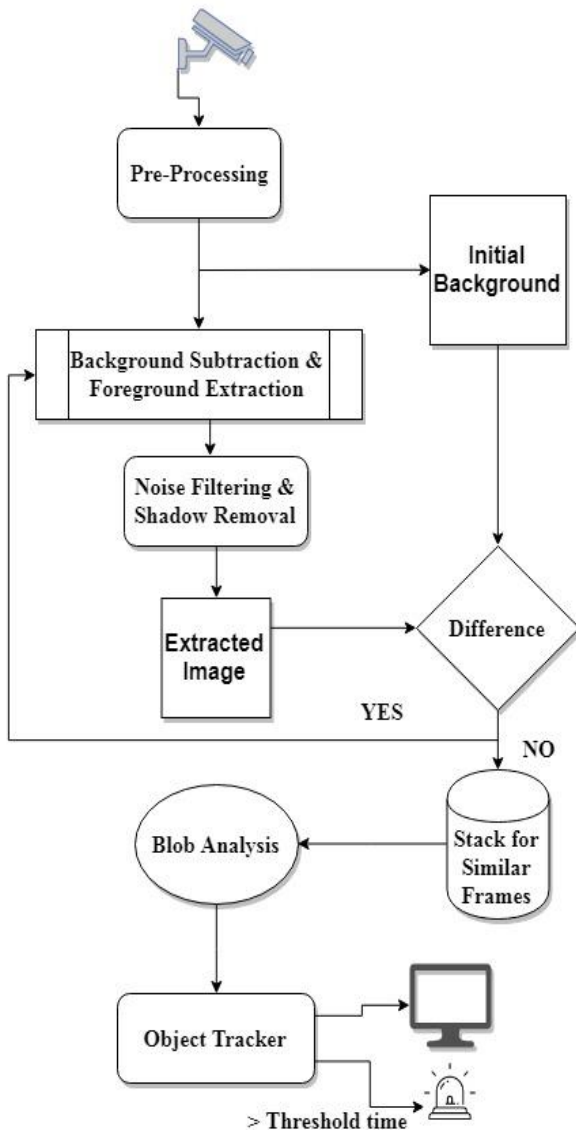


Figure 1. General Procedure for detection

Occlusion handling is needed to avoid false alarms. The detector is also needed to determine which features in the image correspond to which object structure, which is known a correspondence problem [20]. This helps to identify objects which are appearing again and is exactly same as the one seen before. A set of classifiers is used to determine a specific pose of the object [35]. The classifiers are trained to detect different poses and allow a small range of variation. To determine the final detection outcome the detector combines the results

reconnaissance video on-line. Thus, a basic pixel-based limited state machine (PFMS) which demonstrates the utilizations fleeting data to recognize the static frontal area in view of the succession example of each question pixel. Now, a clustering strategy is being proposed in [21] which guarantee that only those patches are joined which are visually same, and that the resulting clusters stay compact, an attribute that is important for further processing stages. In this strategy, image patches of size 25 x 25 pixels are extracted with Harris point detector, starting with each patch as a separate cluster only those two similar clusters C1 and C2 are merged as long as the average similarity between their constituent patches remains aloft a certain threshold  $t$ :

$$\text{similarity}(C_1, C_2) = \frac{\sum_{p \in C_1, q \in C_2} \text{NGC}(p, q)}{|C_1| \times |C_2|} > t,$$

Where the similarity between two patches is measured by Normalized Gray-scale Correlation

(NGC):

$$\text{NGC}(p, q) = \frac{\sum_i (p_i - \bar{p}_i)(q_i - \bar{q}_i)}{\sqrt{\sum_i (p_i - \bar{p}_i)^2 \sum_i (q_i - \bar{q}_i)^2}}$$

Rather than explicitly modeling the values of all the pixels as one particular type of distribution, a mixture of Gaussians is used to model the values of a particular pixel [34]. The Gaussians with respect to the background are determined based on persistence and the variance of individual Gaussians in the combination. Unless and until Gaussians doesn't include sufficient supporting evidence the values of the pixels do not fit the background distributions. Doing this will lead the system to adapt with fast changes of lighting, monotonous motions of scene elements, cluttered regions tracking, determining the objects which are slow and also it allows us to remove or add objects from the scene [39]. A mixture of Gaussians is used to analyze the foreground as stationary objects, moving objects or removed objects [12]. Different thresholds used to obtain masks for foreground and static regions. An integration of background modeling which is constructed with respect to mixture of Gaussians (also known as GMM) and Markov Random Field (MRF) is being used to detect and identify the status of abandoned object [23]. Also to intensify the shape of an abandoned object a cast-shadow approach is used and produce more accurate results for detection. A set of features which are reminiscent of Haar Basis functions can be used along at any scale or location in constant

time along with integral image representation of images [17].

Removal of shadow is done using temporal gain analysis approach [24]. The foreground areas are selected and comparison between the gradient images of present real and segmented frames is done. This is done to recognize any removed or abandoned objects. The approach used for proper shape extraction is shadow removing approach. It is performed in two different steps i.e. according to the consistency of photometric gain it segments the foreground region into various other individual regions, thus removing the regions completely as soon as any of the shadow points are detected [40]. The image  $F_t$  is used as masking the segment of moving objects into different tiny regions which is further characterized by the constant  $F_i$  and photometric gain  $A$ . The foreground regions which are considered are those which have the photometric gain greater than a unit while vice versa those which are less than that of a unit are shadow regions. The neighboring points are compared using correlation values which belongs to the same location on reference background image. There is a simple algorithm which determines a ratio between the neighboring points to determine the correlation measure  $D$  as [40]:

$$D((x, y), (x', y')) = \frac{I(x, y)}{I(x', y')} - \frac{B(x, y)}{B(x', y')}$$

The points  $(x, y)$  and  $(x', y')$  are those which belong to the region  $\{F_i\}$  which is selected randomly, but it is chosen to analyze in a repetitive way for all the region points. If  $D$  is less than that of experimental threshold (in our experiment 0.9), pixels  $(x, y)$  &  $(x', y')$  are correlated, and they are named as shadow points [40]. Another approach used to enhance segmentation and detection process is Sakbot (Statistical and Knowledge Based Object detector) [25]. By using the means such as various geometrical measures (Perimeter, Volume, Area ...), texture (the level of RGB content and gray level pattern), spatial positions (centroid and extent) and the status of the motion (i.e. whether it is in motion or it is stopped) Sakbot describes the objects. This approach completely utilizes both motion and color information to detect and classify foreground objects.

Making a model of an object is a merged recognition problem which implicates that the model images show both sources of variability, i.e., it should be taken from minimum of two distinct viewing positions and from three distinct illumination conditions [33]. Initially,

changes in view positions are compensated and then changes of illumination are compensated for, by using the alignment method which is photometric generates a model of the object. The concept of modeling a 3D object from a combination of 2D views of the object is being explained in detailed in [32]. Further creating such models and storing them can be used to detect a similar object in future, which is called learning. A codebook can be maintained to store the previously learned data. The key features of codebook background subtraction algorithm which is used to sample values over long times are: 1) an adaptive and compact background model that can capture structural background motion over a long period of time under limited memory, 2) the capability of coping with local and global changes, 3) unconstrained training that allows moving foreground objects in the scene during the initial training period and 4) layered modeling and detection allowing us to have multiple layers of background representing different background layers [18].

Most of the dynamic scenes in a video consist of persistent motion characteristics. So, optical flow is the approach to model their behavior. The motion target of the vector characteristics are used by optical flow method which changed with respect to time to detect moving area in video [28]. Better performance is provided under the camera in motion. Combining such flow information with standard intensity information, we present a method for background-foreground differentiation that is able to detect objects that differ from the background in either motion or intensity properties [42] [29]. Computation of these features, however, has some inherent ambiguities associated with them.

The aperture problem is caused when the motion which is in one dimensional pattern is viewed through circular patterns. Moreover, the motion cannot be estimated where the spatial gradient vanishes. This is sometimes called as the black wall problem. Further ambiguities can be caused by transforming the intensity in illumination invariant spaces. It is common for having an assumption that by the usage of these ambiguities in the process of estimation, the accuracy of such estimation would be highly enhanced. Using variable bandwidths for estimation of density is proposed using kernels. Not only such ambiguities are utilized but also arbitrary shapes modeling in a natural way for the underlying density is enabled using such technique. For modeling the density of background, an estimation of density in higher dimensional space of motion and density features is performed, and in thus performs foreground detection. But this algorithm is

uses complicated computation and is also very complex, so there is a need for special hardware support, and hence it is difficult for requirements of real-time video processing to be meet.

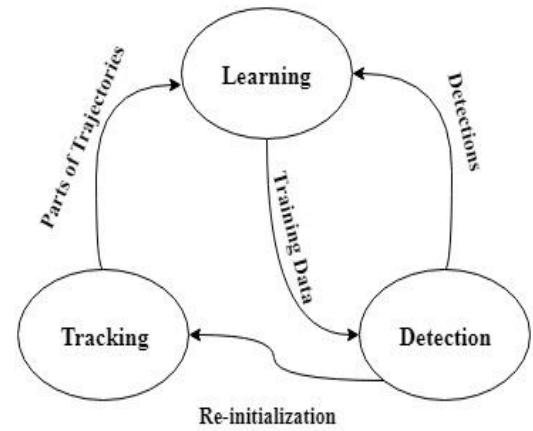


Figure 2. P-N learning flowchart

A learning algorithm to help recognize similar objects is P-N learning proposed in [26]. The detector evaluates every frame of the video. Two types of experts analyze its responses: first being P-expert – missed detection recognition, & the second being N-expert - false alarm recognition. The estimated errors by the system increase a training set for detector, and it in turn limits to avoid similar future errors. In similar way to any other process, the P-N experts are also making the errors themselves. However, if probability of error made by the expert’s is within limits (which are quantified analytically), the errors are compensated mutually leading to a stable learning. TLD is a framework designed for tracking an object which is unknown for a long-term in a video stream. Figure 2 shows its block diagram. The various components of the framework are characterized as follows: Tracker estimates the motion of an object between two consecutive frames with assuming that the motion of frame-to-frame is limited and the object is clearly visible. The tracker will probably fail and won’t ever recover if the object isn’t within the camera view. Detector performs full scanning of the images and localizes all appearances observed and learned in the past by treating every frame independently. Similar to any other detector, this detector also makes two types of errors: false negative and false positive. Learning helps to observe performances of both, detector and tracker, it estimates errors made by detector and creates training examples in order to avoid these errors in the future. The learning component assumes there is a chance of failure for the detector and the tracker. By the means of the learning, the detector generalizes with appearances of more objects and differentiates against background. Another approach to

which help discriminate between objects better and enhances the detection process is suggested in [27]. A high-level two-tiered system is used to detect still objects and to recognize which still objects are actually abandoned and which are not. This system uses a long-term and a short-term logic to make these decisions. To test the accuracy of an alarm, important data related to alarm and which is useful is required. Information like identification number, start time, trigger time, end time and image-plane location is recorded for every alarm. Using such an algorithm, a person sleeping or sitting in a frame will not be identified as abandoned but a true abandoned object as be easily identified.

In some scenarios, the Abandoned Object can be carried away leading to false alarm [7]. To solve such situations, another GMM model using primitive backgrounds, called PBGM is used. At first, PBGM is unstable, but the process of updating is the similar to that of the original GMM. However, when it becomes stable, if PBGM is not matched with the new incoming pixel, its least significant distribution would not be replaced; neither will the required procedure for updating. This is different from the previous GMM model. Thus, when primitive background is stable, long-term monitoring encourages only slight light changes, and the new incoming objects will not be incorporated. When this system detects any suspicious Abandoned Object, the region in the primitive background is compared with the color histogram of the object extracted by the system. The condition of the object will be regarded as "REMOVED" if the two histograms are matching; or else, it is considered that an Abandoned Object shows up. Having added PBGM to the monitor, the latest condition of the observed object (has been removed or remains abandoned), such an approach can handle various complicated environments properly. Nevertheless, in many public area cases, the likeliness that an Abandoned Object might be interrupted by shadow is high. This leads to less- accurate detection of an Abandoned Object. Hence, in order to make shadow interference less severe and obtain more precise segmentation in AO, this model is amended by making using of a shadow removal scheme and Markov Random Field (MRF)[43].

### 3. METHODOLOGIES

#### A. Data Extraction and Conversion

The video captured is needed to be converted into frames for further processing [5]. For getting the 10 frames per second (fps) from the video JMyron java library is used. Update method is called once per frame in order to run the vision processing and camera

updating. Here a Gaussian blur filter is used to remove noise and produce a very pure smoothing effect without side effects. It produces a very detailed image and well defined image. Gaussian function has a consistent frequency response and also certain other characteristics which mean large blurs can be applied much faster than other filters.

#### B. Binarization processing

Binarization is a process where a standard threshold value is desired and a colored image is converted into 0's for black and 1's for white [11]. Analyzing an image that has encountered binarization processing is a method called "blob analysis" [47]. Dual operations like dilation and erosion are performed over structuring elements. These operations have opposite effects. Erosion is the fitting of structuring elements to connected regions set to 1 with the background to 0, and dilation is the fitting for structuring elements into background [46].

#### C. Region of interest

Region of interest is a subset of data within the identified data for particular purpose. It varies from different regions to regions and for various purposes. It is a subset basically consisting of the data when the object is detected for the first time in a system. This subset is then further used to compare with the data received later in the system and find similarity to identify abandoned objects.

#### D. Store Background

Here the first frame of the video is stored as background image and it used later for subtraction operation by using its intensity and color information. The RGB frames here are converted into YCbCr color space. It is converted into binary form for blob analysis and the gaps are filled using morphological closing operated for neighboring elements.

#### E. Video Segmentation

Video segmentation basically means modulating the video for ease of processing. It can be done at various levels as per requirement. Also various information can be extracted which is available in the different frames of the video by segmentation.

F. Background Subtraction and Foreground Extraction

Background subtraction is carried out by comparing the initial stored copy of background with the current frame. The common background is extracted and then the edges of the object are detected using edge detection schemes which are based on object configurations like size, color and sharpness. Following these the foreground is extracted and then separated. The foreground is stored in a separate stack based on LIFO model. These steps are followed for all the frames.

G. Kalman filtering

A Kalman filter is used to gauge the state distributed by a Gaussian of a linear system [15]. It is based on the use of recursive algorithms and also state space techniques and hence is a recursive predictive filter. It estimates the state of a dynamic system. This dynamic system can be disturbed by mostly white noise or some noise. To enhance the estimated state the filter uses measurements related to the state but a little disturbed. Thus Kalman filtering is composed of two steps: 1) Prediction 2) Correction [48].

H. Blob analysis

Blob analysis is a fundamental technique used for consistent images in machine vision. It basically creates a rectangular region of a subset of data of the image where it is consistent. This blob is created over region obtained by considering parameters like area, number of tracks, centroid, etc. It helps to create tailored solutions for vast region of the video surveillance. It has three important steps, namely extraction, refinement and analysis.

I. Object tracker

The object tracker uses the statistics of data about the object obtained from blob analysis to determine if the object is stationary or not. It receives data like count, area, color, etc. It compares these data and checks whether if it has changed less than a ratio to determine it as stationary or not.

4. MATLAB TOOLBOX

All the steps needed to carried out for video surveillance and detection of abandoned objects can be carried out in a processor like Raspberry Pi which is the most powerful processor. Raspberry Pi B or Raspberry Pi 3 model can be used along with coding in Python language [14]. Various operations like

background segmentation, morphological operations, kalman filtering, dilation, erosion, binarization, etc. can be carried out on Raspberry Pi using python coding. The input here is given in '.avi' format and it is easy to process.

MATLAB has a Computer Vision Systems Toolbox for video & image processing. It allows working with binary images and carrying out various functions simultaneously in frequency domain [36]. It works in a similar fashion as the other types of processor but is faster and easy to use. It takes the first image as the reference image with its pixel values and compares it with the second image which is the input image [37]. They are compared by taking their difference.

Various MATLAB commands used from toolbox for video processing are:

Command	Description
int32	Y=int32(X) converts the values in X to type int32. Values outside the range [-2 <sup>31</sup> ,2 <sup>31</sup> -1] map to the nearest endpoint
repmat	B = repmat (A, n) returns an array containing n copies of A in the row and column dimensions. The size of B is size (A)*n when A is a matrix.
step	The step method calculates and returns statistics of the binary image given as input that as per the specified property values. AREA = step (H, BW) calculates the AREA of input binary image (BW) blobs when the AreaOutputPort is set to true. H specifies the System object on which to run this step method.
Complex	z = complex(a,b) creates a complex output, z, from two real inputs, such that z = a + bi. a and b are not double or single. b is all zeros.
Release	release (obj) releases system resources such as memory, file handles, or hardware connections, and allows you to change properties and input characteristics.

isDone	End-of-file status (logical) Status = isDone(videoFReader) returns a logical value indicating that the VideoFileReader System object™ videoFReader, has reached the end of the multimedia file after playing it PlayCount number of times.
vision.VideoFileReader	The VideoFileReader reads data like audio, images and frames from a video. It can also read files of the form of images. videoFReader = vision.VideoFileReader(FileName) returns a video file reader System object™, videoFReader, that sequentially reads video frames or audio samples from an input file, FileName.
Vision.BlobAnalysis	The BlobAnalysis object computes statistics for connected regions in a binary image. H = vision.BlobAnalysis returns an object from the System (H) which is used to evaluate statistical data for regions connected with each other in a binary image.
vision.Autothreshold	The Autothreshold block uses a threshold value calculated by Otsu's method to get an intensity image from a binary image. The threshold value is calculated by histogram splitting of input image such that there is minimum variance of each pixel group.
Vision.MorphologicalClose	J = imclose(I,SE) implements morphological closing on a binary or the gray-scale image (I), by returning the closed image (J). Single structuring element (SE) is an object returned by the strel or offsetstrel functions. The morphological close operation uses same SE for dilation and erosion. It is basically dilation and erosion in the same order.
Vision.ShapeInserter	ShapeInserter is used to draw different shapes of specified dimensions and colour. The shapes

	can be customized and placed as per requirement.
Vision.textInserter	TextInserter is used to display a required text on the image. The text can be customized in size, colour and placed on the image as per requirement.
Vision.ColorSpaceConverter	ColorSpaceConverter is used to convert images from type to another. The images can be converted from RGB to intensity or YCbCr and vice versa.
Vision.VideoPlayer	The VideoPlayer object can play a video or display image sequences videoPlayer = vision.VideoPlayer returns a video player object, videoPlayer, for displaying video frames.

### 5. CONCLUSIONS



Figure 3(a). Original Image



Figure 3(b). Output image – abandoned object detected



Figure 3(c). Output gray-scale image

The figure 3 shows the general output achieved by incorporating a video surveillance system. Figure 3(a) shows the original image and figure 3(b) shows the detected object with green frame around it and the figure 3(c) shows the grey-scale version of the final frame of detected object. Various methods suggested and operations performed are more or less of similar fashion to carry of the basic steps required for video surveillance. The proposed methods differ in speed, outdoor conditions, functions used, memory required, etc. Some functions have a particular advantage over the other while having some disadvantage too for particular cases. Few methods work well only in good lighting conditions while few work in less crowded one's. Also different platforms can be used like Raspberry Pi or MATLAB software to carry out the operations. There is no one standard approach, function or platform to be used to detection of abandoned object. Instead, based on the conditions where video surveillance is to be done the functions and operations must be decided and select whichever suits the best and meet the requirements for achieving the end goals.

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