

An Improved Frame Difference Background Subtraction Technique for Enhancing Road Safety at Night

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ABSTRACT

Night vision technology allows for vision in darkness as though just as in broad daylight. To this effect, this research is carried out to see the possibility of using thermal-based night vision to curb road accidents that have become rampant on the roads and consequently reduce damage and the loss of life. Thermal sensors have a higher range than the average vehicle head and taillights, which use the visible light spectrum. This study proposes a concept where signals are received from a FLIR camera, the grayscale images are processed by an enhanced technique; the WBODY_DET () algorithm in the MATLAB environment. This algorithm identifies and highlights all hot objects by drawing colored boundaries around them. The algorithm is configurable and can highlight categories of objects in a scene. For instance, engines can be highlighted with different colors from living bodies like humans, cattle, sheep, goats, cats, dogs, etc. for easy recognition by drivers/observers for further response. The crux of this algorithm is an object detection technique that uses simple thresholding. The accuracy of this algorithm is enhanced by using morphological operators and the property of connectedness within the resulting binary image to remove false positives. This heat-based vision system is best suited for night driving since all moving objects emit some form of heat energy due to the work involved in the movement. Findings show that the proposed model is highly efficient since it is fast, has over a 90% detection accuracy and it allows for easy identification of danger on the roads at night from longer distances and under bad visibility levels. It is recommended that all vehicles should be upgraded with this technology so the roads will be safer. It is also recommended that long-range cameras should be used as the longer the range of the camera the longer the reaction times the system will provide drivers and prevent a collision.

General Terms

Frame Difference, Night Vision, Computer Vision, Object Detection and Background Subtraction.

Keywords

Forward Looking Infrared (FLIR), Matrix Laboratory (MATLAB), WBODY_DET() (White body detection for images). Background Subtraction Technique, Enhanced Road Safety, Improved Frame Difference

1. INTRODUCTION

According to an official article released from the National Road Safety Authority in Ghana [5], Ghana records over 2,000 road accident deaths in 2020. One significant cause of road accidents in Ghana is over speeding. This factor is responsible for most car crashes in the country. On average 6 people perish on the roads daily. This daily figure translates to over 2,000 deaths on the roads and 12,380 accident injuries of

all kinds. Road accident causes and trends have remained virtually the same, indicating little change in terms of risk factors on Ghanaian roads. Detailed causes of road accidents are given,

- i. Poor driving skills
- ii. Mobile phone usage whiles driving.
- iii. Indiscipline
- iv. Broken down vehicles on road.
- v. Poor maintenance
- vi. Fatigue and drunk driving
- vii. Over speeding
- viii. Poor roads disregard for traffic regulations

Statistics obtained from the road safety commission website [5] for the years 2015 and 2016 respectively are shown in Figures 1(a) and (b) respectively.

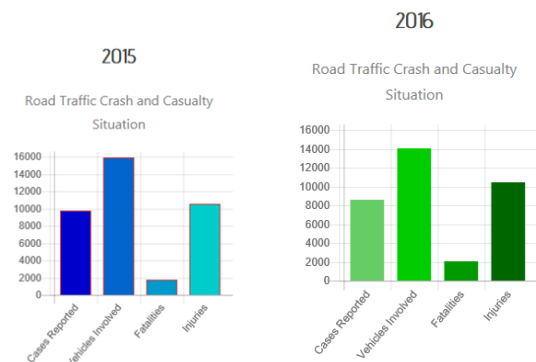


Figure 1: Number of road accidents (a) 2015 and (b) 2016 Statistics by vehicles and Gender

From the information obtained from government news outlets and statistics from the road safety commission, it is obvious that previous study of the causes of accidents on the roads indicate that drivers/owners of vehicles are the major contributors to road accidents and the national road safety commission has resorted to road safety campaigns and the use of road safety officers to ensure that the roads are a safer place to curb the problem.

At night, these signs and symbols become less effective even though they are reflective and readable. Even though they may warn of the possibility of an animal crossing the road, or possible pedestrian or vehicle crossings. A major flaw with these government provisions is their inability to prompt drivers about impending danger on the roads. Specifically, drivers need to be able to avoid collisions even if they cannot

see objects beyond their headlights at night. In situations where there is Also, with sharp bends, these information systems can only tell a driver of the presence of such a bend but cannot tell him or her if another vehicle approaching behind such a bend is coming at high speed or a pedestrian (such as a child) around the bend is in the middle of the street which is a position of danger, or if there is a broken-down vehicle around a bend in an inappropriately parked position on the road.

Most transport accidents that occur in the country happen by road and according to the Ghana road safety commission [9] via their website about more than half of these occur at night. The agency attributes the major causes to lack of attention and negligence by drivers and has therefore resolved to campaigns and awareness creation to tackle this problem. The cause of most of these night accidents may not even be the driver's fault since they are well trained and have been well informed about the so-called causes of these mishaps. Is it only careless driving at play or are there other hidden causative factors? Despite all the awareness creation campaigns [9] and driving signage mounted strategically on the roads accidents still occur. Keen observation suggests most of these accidents occur at night when visibility is poor. Man's vision is naturally limited at night since man is not a nocturnal creature.

Is there any possibility of augmenting vision for night drivers?

This study aims to show how image processing can help reduce night-time vehicular accidents.

The objectives of this study are as follows:

- i. to find out if image processing technology can help to constantly keep our roads safe.
- ii. to propose a technological approach to enhance road safety by alerting drivers, improving decision making, and prolong reaction time; thus, avoid danger.

How can technology alert drivers to possible dangers and improve driver decision-making and reaction times?

2. LITERATURE REVIEW

Night vision signifies the ability to see at night. This ability is typically possessed by nocturnal animals like owls and cats, but with the development of modern-day technology, devices have been developed which allow people to see in the dark and in harsh weather conditions such as rain, fog, dust, etc.

2.1 Night Vision

The muscles in the human eye can stretch or contract automatically, depending on the strength of light rays that are incident to the eye. When a person goes into the sunlight, the pupil gets constricted. When he or she enters a shaded place, at that time the muscles of the eye loosen up and make the opening of the eye lens sizable to allow enough amount of light to pass through, therefore most objects in shady areas appear blurred. Because of this phenomenon, the human eye is seen as having limitations. The muscles in the eye cannot enlarge the opening of the eye lens indefinitely. Consequently, in bad lighting, we are not able to see the objects because the image cannot be well-formed on the retina. The ability to pinpoint targets in the dark and under bad visibility conditions has been an important requirement in the military. The modern army's need to work at night and under extremely poor visibility conditions has been what has pushed the barriers in this area of study and created a widespread interest in this field. Since soldiers often must work at night, they are

faced with severe stress as far as the location of targets and possible threats are concerned. Also, various wildlife researchers and observers face problems of low lighting because many of the species under study are more active (nocturnal) at nighttime than in the day, therefore, to learn about their life cycles night vision is important. To allow people to see in the dark, night vision technology was developed. This chapter describes various techniques and different devices made to boost vision in the dark [8]. Night vision technologies can be broadly divided into three main categories:

- i. Image intensification
- ii. Active illumination
- iii. Thermal imaging

2.1.1. Background Subtraction

Background subtraction is the method of removing the foreground object or object of interest in a video scene or sequence of moving pictures from the background. In other words, foreground objects are obtained by subtracting the background. This process is used many by promising new video applications, such as video surveillance, navigation, traffic monitoring and control, gesture recognition for human-machine interfaces, etc. [10] Several methods exist for background subtraction with each having its pros and cons when it comes speed performance, accuracy, and computational resources needed. Most of these methods emerged somewhere in academic labs in the last 20 years [2].

A few have been scrutinized and handpicked from a lot of interesting ideas for the study. 3 algorithms were chosen that:

- i. are fast and are efficient enough for real-time implementation.
- ii. have a high degree of detection accuracy.

These three algorithms were chosen with the objectives in mind. An attempt will be made to improve or propose a novel procedure based on one of these techniques in chapter 3 so that a better procedure may be presented that can reliably increase driver response time and accurately help them make quality decisions in cases of danger.

- i. Frame difference algorithm (simple with the lowest complexity and most responsive to motion or position changes but can be noisy)
- ii. Approximate median algorithm (medium complexity but more accurate than frame difference method with less noise)
- iii. Mixture of Gaussians method. (most accurate amongst the three but complex and highly intensive on system resources with very little noise) [2].

2.2 Related Background Subtraction Works and Past Research

Two researchers [14] proposed an approach tackling the accuracy of background subtraction models by using a median filter to produce the subtraction model which they used afterward to isolate foreground objects in the next scene, repeating their process for successive scenes for object detection and tracking positions of objects in scenes. They made their method highly adaptive to variations in the scenery by doing successive inter-frame processing which is

constantly updating the subtraction model to be used to process every successive frame. Finally, they used open operations like the connectedness of binary pixels to enhance the accuracy of their method. The major drawback was that this approach is still quite computationally expensive.

Researchers [8] used an ahead validation and learning-based method to detect pedestrians using a far-infrared automotive night vision system. Their concept was to match gray levels in a scene to the sampled intensities and patterns exhibited by pedestrians. After correct matches were made, an adaptive local dual-threshold segmentation algorithm is used to extract the candidate regions. Then a weighted histogram of oriented gradients was used to describe pedestrians in the thermal spectrum. A three-arm classifier that combined EWOG and support vector machine (SVM) was used for the object recognition aspect. The resulting SVM was optimized to reduce the time overhead in decision making. The intensity differences between heads and their adjacent regions are further used to filter out any errors and enhance accuracy. The main advantage of their work was the good detection rate they obtained by using optimized support vectors to pinpoint objects of interest in a night scene. However, their approach was quite intensive computationally as compared to background subtraction methods.

Singla [11] presents a method of background subtraction based on frame difference subtraction. The first frame is stored as the background subtraction model and is therefore subtracted from the next frame under observation. This process is repeated in this manner till all frames are processed. The difference image which is a grayscale image is changed into a binary image by subjecting it to a pre-selected threshold value T . Any pixel which is greater than the value of T is selected as part of the binary image and given a new pixel of the value of 1 otherwise all other values that are suppressed by T are given the value of 0. Even though this method is very responsive to scene changes and stark variations between frames, it is not too accurate because it is too sensitive to movement and will also filter out all kinds of noisy movements like small objects moved by wind, birds flying in the background, waving tree branches, etc. [11] Singla used morphological operators to remove noise from the scene. Singla's approach was effective, and findings proved it worked however there still were some noisy elements in scenes that remained unaffected. Another advantage of Singla's method is that it is simple, fast, and computationally inexpensive.

Shahbaz et al [10] evaluated background subtraction algorithms and their impact on video surveillance. Several algorithms were considered for this study, the purpose being to give a general idea as to their strengths and weaknesses. Algorithms ranging from the most basic concepts that had a generalized output to sophisticated ones were analyzed for their speed, robustness, computational memory needs, etc. Their results showed generally the simpler methods had their advantage in speed and were about 5 times better than their complicated counterparts. The other aspect of their findings was that complex algorithms showed promise in the areas of accuracy and reliability. All in all, their published work produced an in-depth knowledge of comparative effectiveness of background subtraction methods as a plethora of options available as solutions for intelligent video surveillance. [12] Sobral et al used Online Stochastic Tensor Decomposition for background subtraction in Multispectral Video Sequences. The main concept of the approach was to handle the processing of large sizes of data more efficiently. The amount

of work required to process images grows linearly in proportion as the sizes and quantities of the image data also grow. It can therefore take a fast algorithm a long time to process data if the data size is very big as is the case with most real-life situations. Another problem that Sobrel et al tried to tackle is the processing of multi-spectral data which could be quite data intensive. Their approach provides a way to effectively process all these intensive data by breaking/decomposing them into spectrums and handling their processing concurrently using stochastic tensors. The main advantage of their approach was that it could handle up to seven bands at a time meaning the methodology was sensitive enough to handle backgrounds with a high amount of detail which automatically improves accuracy. However, in cases where it was applied to scenes that had fewer bands, it performed less efficiently.

Babae et al [1] employed the use of a deep convolutional neural network (C.N.N) for video sequence background subtraction. They transferred the overhead of processing to the C.N.N to perform their image segmentation. They wanted to improve the detection and tracking of moving objects in scenes. With this approach, there was no need to do feature engineering and parameter tuning because all data was got from the data set that was used for the training. They also proposed a new way of estimating the random background model by using a random 5% of video frames from a batch of test data. e.g., 2014 CDNET data source. By this, it can do background subtraction with a model obtained from training data. The main advantage of their algorithm was that there was no need to do feature tuning and engineering however like all neural network-based algorithms an intensive training was required on massive amounts of data to attain certain levels of accuracy. This can be quite a time-intensive computation.

Cui and Créput [4] present combination frame differencing, a more reliable form of a frame difference algorithm that implements background subtraction with the canny edge and morphological filters. Their main subtraction technique is the 3-frame difference, which is a method of moving object segmentation where the k th frame is subtracted from the $k-1$ st frame to get a difference image, then the $k+1$ th frame is subtracted from the k th frame for a second difference image. The two different images are then combined using the logical AND operation. $(k - 1) - k = D1$, $k - (k + 1) = D2$; $D = D1 \cap D2$.

3. FRAME DIFFERENCE TECHNIQUE

[11] According to Singla, the frame difference algorithm is a background subtraction algorithm that allows for the detection of moving objects in static background scenes by finding the differences in object positions between subsequent frames.

3.1 Concept

Firstly, the first frame is captured through a camera and afterwards, sequences of frames are captured at determined intervals. Next, the absolute difference is calculated between any consecutive frames and the difference images are kept in storage. Then, the difference images are converted first to grayscale and then to binary image. This is achieved by masking the converted grayscales with a threshold value. Finally, morphological filtering is used to remove any noise artefacts. [11] Singla also states that the highlighted values within the binary images depict the regions in the frames where motion has occurred between any two slides.

3.2 Coloring Over Grayscale

Colored parts of an image jump to life or grab the attention of the observers. It is easy for viewers of images to pick out any painted or highlighted object of interest in the scene [3]. This effect is observed during the activity of solving crossword puzzles. A word which is not highlighted in a puzzle blends seamlessly into the puzzle but the moment you circle it that word comes to life or jumps out of the mixture or jumble of words.



(a) Unsolved crossword puzzle

Highlighted word: Hairstyle pops up from the myriad of letters in the puzzle because it was highlighted.



(b) Circled crossword puzzle

Figure 2(a) Unsolved crossword puzzle and (b) Circled crossword puzzle. Solving crossword puzzle activity can be broken down into the procedure below

Basically, this involves.

- i. Creating a layered mask over the grayscale image
- ii. Segmenting or choosing parts of the image to be colored.
- iii. painting, highlighting, or filling the chosen areas with color.

Much the same way that highlighting word in crossword puzzles emphasizes a selected portion of a puzzle, portions of an image can be selected using a threshold value. In image processing, an area of interested can be localized and highlighted for further processing and is called Logical Indexing.

3.3 Graphical Depiction of Logical Indexing



i. $X =$

(a) Grayscale image



ii. $X > T =$

where $T = 150$

(b) Binary mask obtained after threshold is applied

Figure 3(a) Grayscale image (b) Binary mask obtained after threshold is applied.

The aim of this method or algorithm is to detect warm bodies in a thermal image or frame. An enhanced version of common foreground detection techniques is enhanced. Using a threshold value to do a pre-selection of relevant pixels by simple logical indexing. Then the property of connectedness or continuousness of like pixels and morphological operators are used to remove objects that are big enough to be considered connected but small enough to be outside the size range of mammals at a certain distance from the camera to further fine tune the selection. The procedure is ended by drawing rectangular boundaries around the chosen objects.

3.4. Math Notation for Logical Indexing Based Feature Selection.

3.4.1. Feature Selection

$$\sum r_i c_j > B, X=1$$

$$A(X) = \begin{cases} \sum r_i c_j > B, X=1 \\ \sum r_i c_j < B, X=0 \end{cases}$$

$$\{i, j\} = \{1,2,3,4,5,6,\dots\}, \{n \in \mathbb{N}: F > B\} = \{0,1\}$$

Equation 1. math notation of logical index.

3.4.2. Matrix Operation

$$\mathbf{A} = \begin{bmatrix} A_{11} & \dots & A_{1n} \\ \vdots & \ddots & \vdots \\ A_{n1} & \dots & A_{nn} \end{bmatrix} > \mathbf{B} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 1 \end{bmatrix}$$

Equation 2. Matrix A masked by scalar value B resulting in a binary image.

3.4.3. Pseudocode

Algorithm/Steps:

- i. Adjust contrast of grayscale input to enhance clarity[pre-processing]

$F = \text{grayscale.png}$.

- ii. Single out and identify all white objects that meet a criterion in image by logical indexing $B = 180$.

$$N = F > B$$

Equation 2. Matrix A masked by scalar value B, the threshold value.

- iii. Count and label the white connected regions in the resulting binary image.

$\text{num} = \text{label}(N)$.

- iv. Define and use round morphological shapes to remove noise from selection.

$\text{sedisk} = \text{strel}(\text{'disk'}, 4)$.

$N = \text{imopen}(N1, \text{sedisk})$.

- v. Parse the labelled binary image to region props function to get the bounding box property.

$\text{BoundingBox} = \text{Region_props}(\text{num})$.

- vi. Parse the properties to the rectangle function in a loop, draw a rectangular box over each body.

For (1:num)

$\text{rect}(\text{property: BoundingBox, boundarycolor: yellow, linewidth: 2})$

end.

3.5 Logical Index Enhanced Frame

Difference Technique

WBODY_DET Function

The proposed method to tackle the object detection problem is outlined here.

Algorithm/Steps:

- i. Read image into a variable.
- ii. Single out and identify all white objects that meet a criterion in image by logical indexing.
- iii. Count and label the white connected regions in the resulting binary image.
- iv. Define and use round morphological shapes to remove noise from selection.
- v. Parse the labelled binary image to region props function to get the bounding box property.
- vi. Parse the properties to the rectangle function in a loop
- vii. Draw a colored rectangle around identified objects using coordinates of target objects from step five (5).

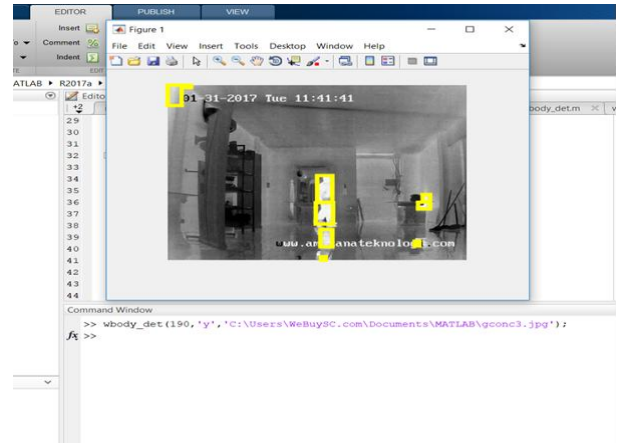



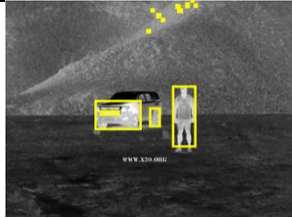
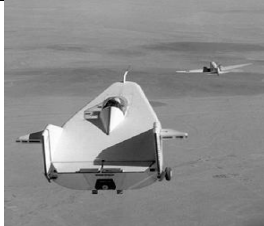
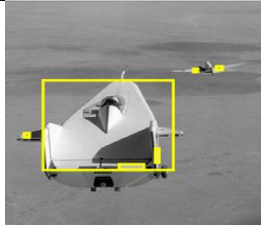


Figure 4. WBODY_DET Algorithm implemented in MATLAB

Table 1 Table displaying image results after wbody_det () processing.

	WBODY_DET () processed image
	
(a)Original image of unprocessed surveillance feed	(b)wbody_det processed version of (a)
	
(c)original image of man and car in the dark	(d)wbody_det processed version of (c)
	
(e) original image of lifting body MATLAB	(f)wbody_det processed version of (e)

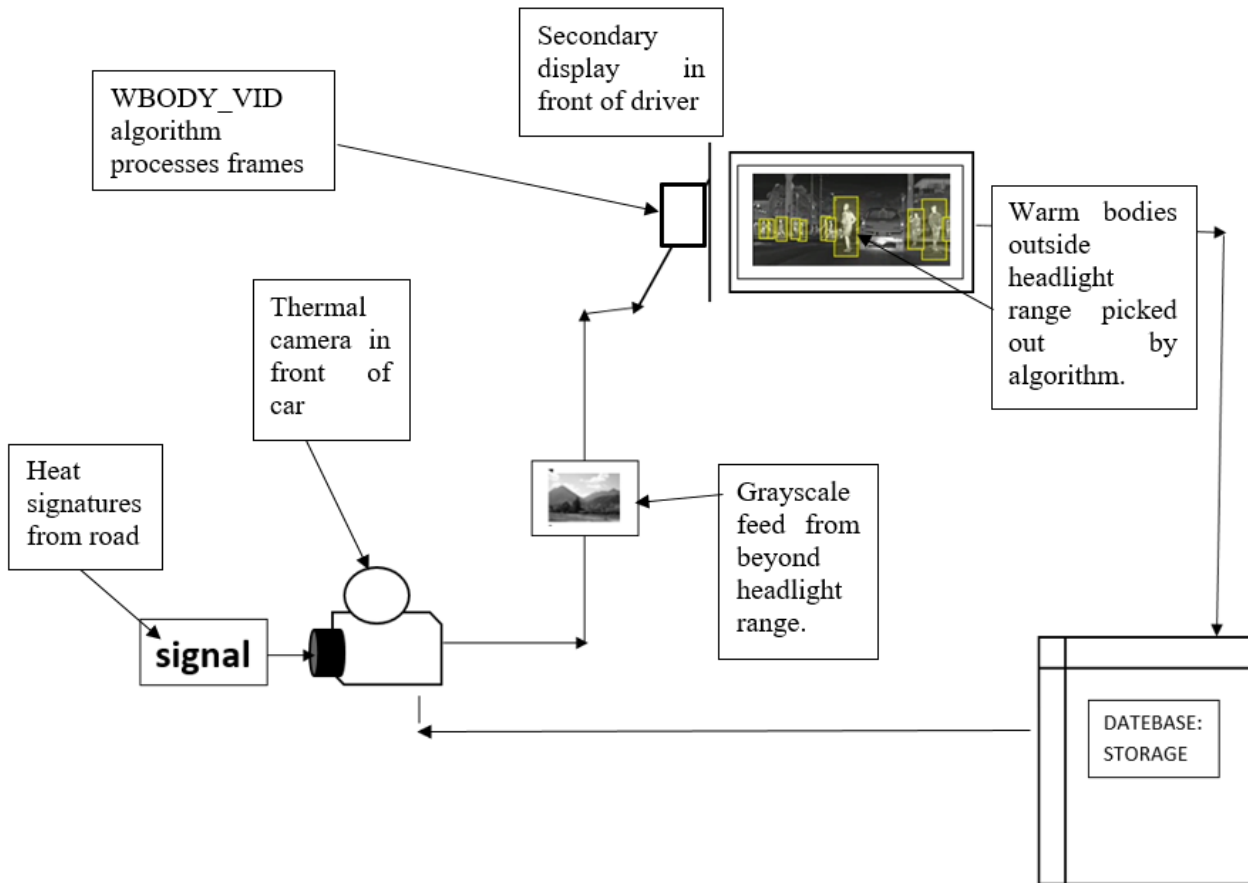


Figure 5 depicts the proposed model of the night vision system. Signals from the road are captured by a sensitive camera

3.6 Proposed Model - Continuity Enhancement Night Vision Architecture (CENVA)

Following the success of the implemented Logical indexing enhanced frame difference algorithm, the study proposes a model for a night vision system that would be powered by the wbody_det () algorithm. A detailed description of how the model functions is outlined in the paragraph below.

In this model, heat signatures (grayscale imagery) are picked up beyond vehicular headlights from warm bodies and are detected by the thermal camera that is positioned in front of the vehicle. This camera then sends the thermal grayscale image to the processor behind the display which then runs the algorithm. The algorithm takes the grayscale video data and splits them into individual frames. The frames are then each analyzed in the fashion outlined in section 3.4.3 of this chapter (. i.e., a frame is masked by a pre-selected threshold value to single out all white or warm bodies in the image). White bodies with no form of continuity (connectedness) in the resulting binary image are also dropped. The result is further enhanced by picking out all round shaped bodies with a radius of less than 4px in the image. This final difference image is now used to segment objects of interest in the original frame. The algorithm is configured to count the chosen white bodies and highlight them by drawing a solid boundary around them. The processed image is then sent to the dashboard display for viewing. This

process runs very fast and is repeated for each frame of the video feed.

4. RESULTS AND FINDINGS

Since there is a lot of obscurity at night, image processing algorithms like the one above can uncover hidden threats to human life and vehicular damage.

4.1 Testing Environment

The implementation of this system can be done in secondary displays on dashboards and sun visors. The frames of the video signal can be grabbed at regular intervals say every 5ms of time. The proposed method is implemented in a MATLAB 2017a environment with the MATLAB language, on an Intel(R) Core (TM) i7-3720QM CPU @ 2.60GHz 2.60GHz personal computer with an 8.00 GB. Installed Ram. The said machine was running the 64-bit windows operating system, X64-based processor.

4.2 Software Tools

[13] MATLAB 9.2 is a powerful scientific tool used for various works including the modelling of network and surveillance systems. It was used to simulate the model. It was also used to process the input to produce output. Also measure the efficiency of the algorithm used for the processing in terms of time. Function (grayscale thermal images) were captured, processed, converted, and enhanced for viewing.

Table 2. Description of video data used for the testing of the algorithm in chapter 4.4.

Video #	Duration (seconds)	Description
1	7	Double lane urban road drive with other vehicles from another lane
2	8	Single lane urban road drive with two vehicles approaching
3	10	Double lane urban road drive with other vehicles from another lane
4	25	Neighborhood drive with lady walking her dog
5	59	Passengers disembarking from aircraft on tarmac by a tarmac shuttle
6	69	Roadside coverage of busy road
7	78	City drive to the office
8	88	Drive on 6 lane highway with other vehicles in traffic
9	165	Drive from parking lot to main busy road
10	206	Drive around town with other vehicles

4.3 Comparative Analysis of Proposed Algorithm and Frame Difference Algorithm

Table 3. Comparative analysis (speed and accuracy) of proposed algorithm against frame difference algorithms.

Video Duration (seconds)	Time of Execution (seconds)		Accuracy score(10marks)	
	Frame Difference algorithm	Proposed algorithm	Frame Difference algorithm	Proposed algorithm
7	15.79182	15.86296	8	10
8	15.7913	16.3806	10	10
10	21.80975	21.49918	7.5	8
25	97.49759	83.73731	10	8
59	124.2716	144.128	9	10
69	71.36536	68.23479	6.53	8.85
78	148.6214	153.3875	10	10
88	91.74885	86.07706	10	8.5
165	192.4624	170.6702	10	10
206	408.7478	408.3224	10	10
TOTAL	1188.107793s	1168.300027s	91.03	93.35
AVG	118.8107793s	116.8300027s		

Time Analysis

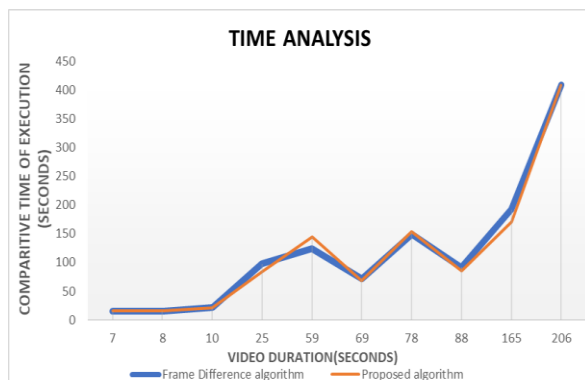


Figure 6. Time analysis (speed) of proposed algorithm against frame difference algorithms

Based on the trends and metrics above, it is evident that the proposed algorithm displays a slight edge in the observed

running time for majority of the videos that were tested and shows comparable speeds to the frame difference algorithm in processing the other remaining videos. An arithmetic average of the running times of the two algorithms under reveals that the proposed algorithm uses approximately 2 seconds less time in its overall computation of the selected videos. This makes it superior in terms of average running time to the frame difference algorithm.

Accuracy Scores

Table 4. Comparative analysis (speed and accuracy) of proposed algorithm against frame difference algorithms

Algorithm	Accuracy score (%)
Frame difference subtraction	91.03%
Wbody_det ()	93.35%

The findings indicate gains in average speed (about 1.9807766 seconds) and accuracy (about 2.32%) over general background subtraction methods since the frame difference algorithm is the fastest background subtraction method. In terms of accuracy, it was still better than the frame difference algorithm. proposed 93.35, frame difference 91.03%). This implies that a night vision system based on this algorithm will give the driver almost 2seconds more reaction time in most collision cases as compared to background subtraction methods as well as giving reliable alerts as accurate as the best algorithms utilized in the automobile industry.

4.4 Merits and Demerits of WBODY_DET

The main advantages of the WBODY_DET algorithm are as follows.

- i. It uses simple thresh holding which makes it simple and efficient.
- ii. It is still very accurate because it uses connectedness in the binary image morphological operators to eliminate noise.
- iii. Able to detect immobile white bodies such as a parked/broken vehicle.
- iv. Binarizing the image after thresh holding makes further processing very fast.
- v. Program statements are executed fast, hence the algorithm has a good execution time.

It has the following disadvantages.

- i. Time of execution increases proportionally with increase in size of video data.
- ii. Not too sensitive to white bodies with small sizes as it also uses connectedness in selecting objects of interest.
- iii. Can detect a lot of false positives in scenes with too much whitish ambience.

4.5 Worst Case Running Time

For the worst-case scenario of running times, the Big-o notation is as follows:

Big O notation for wbody_det () is $O(n) = 2n + 17$.

5. CONCLUSIONS

Results from the study above supports the idea of the effectiveness of singling out white bodies in a grayscale image which translates to highlighting warm bodies in a thermal image. This serves us a guide or warning prompt to night drivers who cannot see beyond their headlights. The methodology explored has the capacity to be tweaked to recognize different temperatures thereby differentiating between car engines, pedestrians, cattle, and other livestock resulting in an avoidance of collision and injury. The objective was to come up with a system that could alert and give drivers enough reaction time. Such a system should be powered by night vision technology.

5.1 Major Findings

The proposed methodology proved to be quite effective since the algorithm:

- i. Gained 2 seconds of reaction time in comparison to one of the fastest algorithms reviewed; the frame difference algorithm.
- ii. Obtained a very close match in terms of accuracy identifying objects and alerting of drivers.

6. RECOMMENDATION

- i. Long range cameras should be used as the longer the range of the camera the longer the reaction times the system will provide drivers.
- ii. The proposed algorithm can be vectorized in future works to further improve its accuracy and speed.

7. REFERENCES

- [1] Babae, M., Dinh D, T., and Rigoll, G. A deep convolutional neural network for video sequence background subtraction. *Pattern Recognition* Volume 76, April 2018, 635-649. <https://doi.org/10.1016/j.patcog.2017.09.040>.
- [2] Benton, S. Background subtraction, part 1. *MATLAB models: EDN Network.*, 2010.
- [3] Cleverpedia. What is Grayscale Coloring? 2020. <http://www.cleverpedia.com/grayscale-coloring-tutorial/>
- [4] Cui, B., and Créput, J-C. Moving Object Detection and Tracking Based on Three-Frame Difference and Background Subtraction with Laplace Filter. *International Conference on Artificial Intelligence and Soft Computing ICAISC - P. 2007 Modeling and Simulation Design*, 2018, pp 3-13.
- [5] GHANAWEB. Ghana records more than 2000 road accident deaths. 2020. <https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Ghana-records-more-than-2000-road-accident-deaths-1120157>
- [6] Gonzalez, R.C., Woods, R.E. (2002). *Digital Image Processing*. Prentice Hall, 2002. <https://doi.org/10.1016/j.compeleceng.2013.03.020>.
- [7] Lee, E. Yuxunion-night vision thermal imaging (laser infrared camera)-English Version, (May,2018). <https://youtu.be/GtPYLSw168s>.
- [8] Liu, Q., Zhuang. and Kong, S. Detection of pedestrians for far-infrared automotive night vision systems using learning-based method and head validation. *IOP Publishing Ltd. Journal of Sensors* Volume 2016, ArticleID3403451, pp 8, 2013. <http://dx.doi.org/10.1155/2016/3403451>
- [9] NRSC. WELCOME TO HOMEPAGE OF NRSC, (2018). <http://nrsc.gov.gh/index.php/statistics>.
- [10] Shahbaz, A., Hariyono, J. and Jo, K.H. Evaluation of background subtraction algorithms for video surveillance. *Frontiers of Computer Vision (FCV)*, 21st Korea-Japan Joint Workshop, 10.1109, 2015, FCV.7103699.
- [11] Singla, N. Motion Detection Based on Frame Difference Method. *International Journal of Information & Computation Technology*. ISSN 0974-2239 Volume, 2014, 4(15) pp. 1559-1565
- [12] Sobral, A., Javed, S., Jung, S.K, Bouwmans, T. and Zahzah, E. Online Stochastic Tensor Decomposition for Background Subtraction in Multispectral Video Sequences. *ICV Workshop, Computer vision Foundation*, 2015. http://openaccess.thecvf.com/content_iccv_2015_workshops/w24/papers/Sobral_Online_Stochastic_Tensor_ICCV_2015_paper.pdf
- [13] Tekalp, A.M. *Digital Video Processing*. 2nd edition, Prentice Hall Press, 2015b, Upper Saddle River, NJ, USA. ISBN:0133991008 9780133991000.
- [14] Zhang, R., and Ding, J. Object Tracking and Detecting Based on Adaptive Background Subtraction. *Procedia Engineering*, 29, 2012, 1351-1355, <https://doi.org/10.1016/j.proeng.2012.01.139>.