Validation of an Algorithm for the Detection of the Image of a Person Using Multiple Cameras

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Abstract. Among the various contexts of technological evolution, there is the application of algorithms in cameras for the detection and identification of people and their utilization in various areas, for example surveillance in smart home environments and companies. This is considered as a complex recognition task. Therein, this research presents an algorithm that was designed and implemented in Matlab, the same that through a camera allows to detect the image of a person. The objective in this investigation is to corroborate the process in the detection of the image of a person in multiple cameras through the application of an algorithm. The validation of the data obtained was carried out through a mathematical model, which allowed us to substantiate the detection of the image of a person through five cameras, considering as parameters time and distance. As a result of the study and the application of the algorithm, its functionality was verified in the positive detection of the image of a person, a mathematical model was also obtained to confirm its effectiveness and validity through different tests.

Keywords: Algorithm detection · Image acquisition · Mathematical model · Definite integral · Cameras

1 Introduction

Among the contexts of technological evolution, there is the application of algorithms in cameras for object detection, which is of great importance in development and innovation. Thus, the recognition tasks are considered complex for a computer according to [1], because they have problems in the processes of object classification, edge detection, movement tracking, etc.

In [2], object recognition is defined as the process of identifying a specific object or the class of objects in an image or video. It is considered that from the study of the detection of objects the innovation in the detection of people can be started. As the

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author [3] states, the type of detection not only focuses on finding the kind of object to be detected, but also locating the extent of the object in the image.

According to [4], several researchers have developed methods and techniques to detect people in images, considering that the study of an effective method for recognition continues. There are several factors that motivate this research, one of them being the application for the safety of people, which are considered as the most important and according to [5], mention that facial recognition systems play a vital role in many applications, including surveillance, biometrics and safety, so the authors in [6] establish that the Viola-Jones algorithm is currently one of the most used to solve problems of searching a person's face.

Considering the security field is a topic widely taken into account in smart cities, offices and homes. According to the authors [7], they state that the safety of a home and family is very important for everyone, so that the systems of recognition of human silhouettes can be connected to the Internet of Things (IoT).

The objective of this investigation is to validate the process and information obtained by applying the algorithm in the detection of the image of a person in multiple cameras. The validation was carried out through a mathematical model, which allowed us to base the detection of the image of a person through these cameras, considering as parameters time and distance. The area as a function of time, considering a definite integral starting from a point zero.

As a result of the study in the application of the algorithm in the computer, for the detection of the image of a person using five cameras, the data were obtained in relation to the time and distance in which a person is detected with each camera. These data were used in the analysis through the application of a definite integral, considering the author in [8]. It concludes with the effective validity of the algorithm applied in the detection of the image of a person in a distance range of 3 m to 9 m, also the speed of image capture and its feasibility determine that the greater distance from the person in relation to the camera, the smaller the angle for detection.

This document is organized as follows, in Sect. 2 a review of the related works on the subject of our research, developed framework, applied algorithm, tools used and selection criteria is described. Section 3 describes the results obtained and the analysis of data in the application of mathematical models for the validation of the process in the detection of the image of a person with the five cameras. Finally, there are the conclusions of this investigation.

2 Related Works

We consider the authors [9], who state that there are several ways to detect and recognize a person, also [10] argue that there are studies with algorithm-based models to identify faces, people, traffic signs, tumors and aspects of visual data. Convolutional Neural Network (dCNN), is a model used to classify images, group them by similarity and recognize objects within scenes, as the authors [11] argue.

The authors [12–14] and [15] discuss Hidden Markov (HMM) as a model to describe the characteristics of a stochastic process based on computational methods for classifying the Human physical activity and for the recognition of different activities that the human performs, being appropriate for the application in pattern recognition.

According to [16] and [17], they state that Support Vector Machines (SVM) is an algorithm model associated with learning that analyzes the data used for classification and recoil analysis in relation to artificial intelligence. The models described are based on algorithms that can identify faces, people, traffic signals, tumors and many other aspects of visual data, as they considered by [11] and [18].

Based on the research work developed, Table 1 describes the algorithms found that allow the recognition of an image with their advantages and disadvantages. This information is considered of great importance since there are no similar research papers.

Table 1. Recognition algorithms

Algorithm	Description	Advantage	Disadvantages	Ref.
Markov chain Monte Carlo	Applied to the HMM model, it is used for the recognition of human activities	Latent movements that are selectively shared between multiple paths and activities efficiently	It has several limitations, for example the assumption of independence	[21]
Weakly Supervised Multi-Type Attribute Learning	It considers contextual signals and progressively increases accuracy using a limited number of data labeled by people	It divides human attributes into multiple types, contains incompatible attributes and only one of them can be positive	It does not need more training on target data sets. It is not so accurate	[11]
Viola-Jones	It is based on a series of weak classifiers called Haar-like-feactures	It stands out for its low computational cost and it allows its use in real time	Occlusion is a problem for this algorithm	[6, 22, 23]
EigenFaces	It is a method of facial recognition based on the component analysis approaches	It evaluates images of size 23 × 28 pixels in an order to compare interpolarization	It is not coupled with Support vector machine and Artificial Neural Network	[24, 25]
Adaboost	Adaboost is a boosting algorithm presented by Freund and Sachapire in the generation of online learning	Used to select features and train classifiers. Dramatically increase detector speed	It takes weak classifiers and multiple tries each time	[22, 26]

According to the authors [19], they state that the Viola-Jones algorithm is based on a series of classifiers called Haar-like-features, which were used in this investigation and that allowed the efficient application starting from an integral real time image considering that it presents a problem in occlusion when detecting an image.

2.1 Workframe

The purpose is to validate the algorithm that allows the detection of the image of a person, for which it is necessary to understand the process, the same that was based on the flowchart shown in Fig. 1, considering that the algorithm developed in Matlab will be employed and using the image acquisition tool applications, computer visio system toolbox to capture a pattern.

This work is largely motivated by efficient detection, considering that the objective is to enable the detection of a person's image in real time through a computer camera, on which the calculation of the integral image is based, as [6] manifest it.

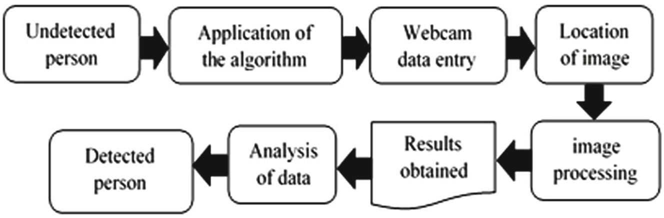


Fig. 1. Flow chart for image detection

2.2 Tools Used

The hardware used for the purpose of this research was a Toshiba Satellite C55-C5240 Laptop, Intel® Core ™ Intel Core i5-5200U 2.2 GHz processor, 8 GB RAM, 1 GB HDD, Toshiba HD Camera, 64-bit Windows 10, Intel HD Graphics 5500.

EasyCap device, used in the video signal. Toshiba Webcam HD camera, IR-Max 250 camera, IR-Hilook THC-T110-P camera, DS-2CE16D0T-IR Turbo HD camera, Genius Facecam 320X camera and Matlab 2017b was used as software.

2.3 Applied Algorithm

The algorithm used to detect a person's image in real time is based on Viola-Jones, which was improved and described below.

The data obtained in relation to the detection of the image of a person are imported to a local Excel file, in the directing route of data saving.

Algorithm: Image Detection

```
Data: video, peopleDetector, obj, frame, bboxes
peopleDetector = vision.PeopleDetector( )
obj=imaq.VideoDevice ( )
   set (obj);
   figure ( );
   while (true)
         frame=step(obj);
         bboxes=step (peopleDetector,frame);
         obj_p=insertObjectAnnotation (frame,bboxes);
         imshow(obj_p,)
         f=findobj( );
         pause (0.05)
   end
   release (obj)
    end
```

2.4 Selection Criteria

For the validation of the algorithm in the detection of the image of a person, five different types of cameras were selected in their size and class, for which their brand or specifications are not considered to limit this investigation.

Among the cameras selected and that were used for the development of the proposed objective, there are the computer webcam, Genius camera and cameras for infrared security type Domo and Bullet.

Table 2 describes the characteristics of the cameras considered in this study. The image resolution of the Toshiba and Genius camera was considered as 640 × 480 pixels considering that their configuration is not supported, while the resolution of the image on the Hilook, Max and Turbo cameras is assigned by default when used with the EasyCap device, which allows conversion in the resolution of the image.

Table 2. Camera features

Camera	Night vision	Image format	Image resolution
Toshiba	No	YUY2	640 × 480
Genius	No	YUY2	640 × 480
Hilook	Si	YUY2	720 × 576
Max	Si	YUY2	720 × 576
Turbo	Si	YUY2	720 × 576

With each of the five cameras described in Table 2, 30 images related to a person were detected in a distance range of 3 m to 9 m, with an interval of 1 m. Additionally, 210 images were obtained per camera and for this validation and 1050 data were considered as the total result of the five cameras used in this investigation.

2.5 Mathematical Model Implemented

With the information obtained, the respective mathematical calculations were developed, considering the authors [8] and [20].

The procedures described are based on the equation to obtain the area of a triangle (1), the velocity (2) and the definite integral (3). With the application of the equation, the respective calculations of the triangular waveform were made, which were feasible to validate the process in this investigation.

For this process, the graphs of Fig. 2 are considered, which have the shape of a right triangle between the projection axes and the stroke of the function.

$$A = \frac{1}{2} b * a \tag{1}$$

Where b is the base as a function of distance and a, the height of our data as a function of time being values (x, y) respectively. The speed (2) of the cameras used in this investigation was determined based on data related to time and distance.

$$v = \frac{d}{t} \tag{2}$$

Where “d” represents distance and “t” time, which are considered as (x, y) respectively. The definite integral (3) was considered, which was applied to evaluate the values obtained in relation to the time and distance parameters of each camera used for the detection of the image of a person. Where “d” will be the distance value and t is the time value obtained from each camera respectively

$$\int_{0}^{d} \frac{1}{2}(x/t).dx \tag{3}$$

3 Results and Analysis

3.1 Results of the Detection in Several Cameras

In Table 3, the person’s height, detection angle, camera height and distance are described, which are the parameters used and the data obtained in relation to the detection of a person’s image.

Table 3. Parameters and measurement data

Person stature (m)	Detection angle	Camera height (m)	Distance (m)
1.67	28°	0.88	3.00
1.67	24°	0.88	4.00
1.67	20°	0.88	5.00
1.67	16°	0.88	6.00
1.67	12°	0.88	7.00
1.67	8°	0.88	8.00
1.67	4°	0.88	9.00

Table 4 shows the average of the 1050 data obtained by the five cameras, considering the time in seconds detected by the image of a person in relation to the distance from 3 m to 9 m, with an interval of 1 m.

Table 4. Detection time per camera in seconds

Distance (m)	Types of cameras				
	Hilook (s)	Max (s)	Turbo (s)	Genius (s)	Toshiba (s)
3.00	0.4035898	0.3966187	0.3969076	0.3740454	0.3778240
4.00	0.3996954	0.4138642	0.4262454	0.3771838	0.3748886
5.00	0.4319552	0.4117347	0.4056770	0.3741177	0.3747536
6.00	0.4126833	0.4128826	0.4129655	0.3722851	0.3741777
7.00	0.4101977	0.4164330	0.4111486	0.3792567	0.3813519
8.00	0.4089741	0.4166274	0.4148233	0.3783192	0.3798207
9.00	0.4103726	0.4115626	0.4095482	0.3796371	0.3774584

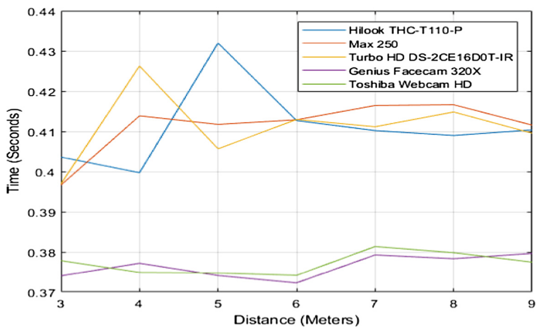


Fig. 2. Time-distance strokes

The values in Table 4 are shown graphically in Fig. 2, which are the result of the application of the algorithm in the detection using the five different cameras in a distance range from 3 m to 9 m. In addition, the strokes related to the average time and distance at which a person's image was detected are displayed.

The stroke values of the Hilook THC-T110-P camera are shown, which shows variations and this demonstrates that this camera is less efficient as it is displayed in the range of 3 m to 9 m, showing the largest peak of all the strokes in 5 m as well as a low speed at 4 m and low continuity from 6 m to 9 m progressively climbing presenting a high peak at 5 m. The Max 250 camera stroke shows a low starting peak at 3 m and displays more continuous speeds of all data in a distance range from 4 m to 9 m. The stroke of the Turbo HD DS-2CE16D0T-IR camera shows a high peak at 4 m with a drop peak at 5 m and a continuity in its speed in the range of 6 m to 9 m.

The strokes of the Genius FaceCam 320x camera represent a slight peak at 4 m with a slight scalloped fall from 4 m to 6 m and a moderate climb to 7 m maintaining continuity in the range of 7 m to 9 m. and finally, the strokes of the Toshiba Webcam HD camera range from a drop peak to 4 m, maintaining its continuity in the range of 4 m to 6 m, to climb a peak at 7 m and a slight stepped drop in the range of 7 m to 9 m.

The results obtained and shown in Fig. 2 display how strokes of the five cameras allowed to demonstrate the effectiveness of the algorithm in the detection of the image, considering the speed performance of the different cameras used in this investigation.

It must be considered that the proposal is not to evaluate the cameras, but the efficiency of the algorithm and that these results allow to demonstrate that the algorithm works, independent of the type and brand of the cameras, of course the values vary according to their specifications.

The application of the algorithm in the detection of the image of a person was feasible to validate its effectiveness in the five cameras. Table 5 shows the results of the detection at different focal angles and their respective accuracy classified as positive, false positive and false negative.

Table 5. Focal angle and image detection

Camera	Focal angle		Detection
	Inclination	Rotation	
Hilook	0° a 180°	0° a 360°	Positive/False-Positive/False-Negative
Max	0° a 180°	0° a 360°	False-Positive/Positive
Turbo	0° a 90°	0° a 360°	Positive/False-Positive/False-Negative
Genius	0° a 180°	0° a 360°	Positive/False-Positive
Toshiba	0° a 180°	0°	Positive

To determine the effectiveness of the algorithm in the detection of the image of a person, the shorter detection time of each camera was considered as an indicator, which was represented with a 100% effectiveness, taking into account that at a lower time the effectiveness in detection will be greater.

Tables 6 and 7, describes the effectiveness rate in percentages based on the time and distance range of 3 m to 9 m, in relation to the detection of an image through the five cameras used in this investigation for the purpose of validating the algorithm.

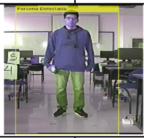
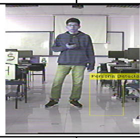
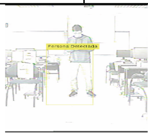
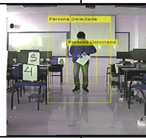
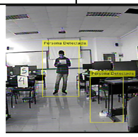
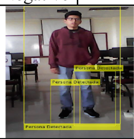
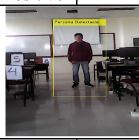
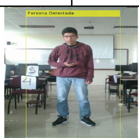
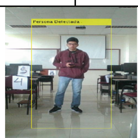
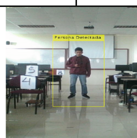
Table 6. Detection time camera effectiveness

Distance (m)	Types of cameras					
	Hilook (s)	Effective	Max (s)	Effective	Turbo (s)	Effective
3	0.4035898	99.0%	0.3966187	100.0%	0.3969076	100.0%
4	0.3996954	100.0%	0.4138642	95.8%	0.4262454	93.1%
5	0.4319552	92.5%	0.4117347	96.3%	0.4056770	97.8%
6	0.4126833	96.9%	0.4128826	96.1%	0.4129655	96.1%
7	0.4101977	97.4%	0.4164330	95.2%	0.4111486	96.5%
8	0.4089741	97.7%	0.4166274	95.2%	0.4148233	95.7%
9	0.4103726	97.4%	0.4115626	96.4%	0.4095482	96.9%

Table 7. Detection time camera effectiveness

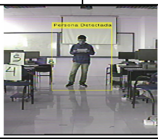
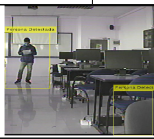
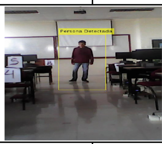
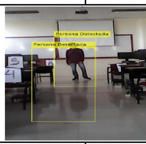
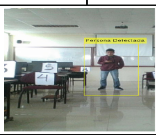
Distance (m)	Types of cameras			
	Genius (s)	Effective	Toshiba (s)	Effective
3	0.3740454	99.5%	0.3778240	99.0%
4	0.3771838	98.7%	0.3748886	99.8%
5	0.3741177	99.5%	0.3747536	99.8%
6	0.3722851	100.0%	0.3741777	100.0%
7	0.3792567	98.2%	0.3813519	98.1%
8	0.3783192	98.4%	0.3798207	98.5%
9	0.3796371	98.1%	0.3774584	99.1%

Table 8. Image detection of a person

Type of cameras	Distance range							
	3m		4m		5m		6m	
	Detection	Effective	Detection	Effective	Detection	Effective	Detection	Effective
Hilook								
	Positive	99.0%	False Negative	100.0%	False Positive	92.5%	False Positive	96.9%
Max								
	Positive	100.0%	Positive	95.8%	Positive	96.3%	Positive	96.1%
Turbo								
	False Negative	100.0%	Positive	93.1%	False Negative	97.8%	False Positive	96.1%
Genius								
	Positive	99.5%	Positive	98.7%	False Positive	99.5%	Positive	100.0%
Toshiba								
	Positive	99.0%	Positive	99.8%	Positive	99.8%	Positive	100%

Similarly, in Tables 8 and 9 images of the detection of a person in real time enclosed in a yellow frame are shown, which were captured using five different cameras through the application of the algorithm to be validated. These visualized images are a sample of the total of 1050 detections made to the same person in a range of 3 m to 9 m with an interval of 1 m, considering that the image of the person in each interval was captured 30 times.

Table 9. Image detection of a person

Type of cameras	Distance range					
	7m		8m		9m	
	Detection	Effective	Detection	Effective	Detection	Effective
Hilook						
	Positive	97.4%	False Positive	97.7%	False Positive	97.4%
Max						
	Positive	95.2%	False Positive	95.2%	Positive	96.4%
Turbo						
	False Negative	96.5%	Positive	95.7%	Positive	96.9%
Genius						
	Positive	98.2%	Positive	98.4%	False Positive	98.1%
Toshiba						
	Positive	98.1%	Positive	98.5%	Positive	99.1%

3.2 Analysis in the Detection of the Image of a Person

Based on the results obtained in the detection of the image of a person considering a distance range of 3 m to 9 m, with the application of the algorithm configured in Matlab and the analysis of the five cameras, it was determined that the Hilook THC-T110-P camera has an effectiveness of 99.0% in the detection of an image in a time of 0.4035898 s, considering that 100% represents a time of 0.3996954 s for its detection analysis within the range of 3 m to 9 m, which is positive at 3 m and 7 m, false negative at 4 m, false positive from 5 m to 6 m and 8 m to 9 m.

With the Max 250 camera, image detection is 96.4% effective with a time of 0.4115626 s, considering that 100% equals 0.3966187 s. The detection is positive in the range of 3 m to 7 m and 9 m, at 8 m the detection is false positive.

The Turbo HD DS-2CE16D0T camera, has a 97.8% detection effectiveness with a time of 0.4056770 s, 100% being in relation to 0.36969076 s and the image detection is false negative at 3 m, 5 m and 7 m, positive at 4 m and from 8 m to 9 m, false positive at 6 m.

The 99.5% effectiveness was considered with a time of 0.3740454 s with respect to the Genius camera, 100% being the equivalent of a time of 0.3722851 s and the positive detection of 3 m to 4 m and 6 m to 8 m, false positive at 5 m and 9 m.

Finally, the Toshiba Webcam HD camera detects the image, with an effectiveness of 99.8% in relation to a time of 0.3747536 s, considering that 100% represents a time of 0.3741777 s and the detection is positive in the range of 3 m to 9 m.

Considering the five cameras and establishing the shortest detection time of each camera, it was determined the Genius Camera was the best with a time of 0.3722851 s and 100% in the detection of the image according to data in Table 6.

It is established that the most Effective Camera in the detection of the image is the Toshiba with a time of 0.3741777 s and an effectiveness of 99.5%. In relation to video surveillance cameras, it is established that the Max camera has an effectiveness of 93.9% with a time of 0.4117347 s and a positive detection in the range of 3 m to 7 m and 9 m, false positive at 8 m.

3.3 Results with the Mathematical Model

The result is the speed in the detection of the image of a person, by substituting a value assigned to d in the integral (3), starting from 3 m to 9 m. For which the distance is considered to calculate the speed of each camera, substituting the values in t according to the distance and in which the calculation is made with the described values.

The speeds were obtained by clearing the values as variables in the integral and applying the property of the exponent in the resulting integral. Subsequently, the integral is evaluated considering the values from 0 as a constant in the lower limit and from 3 m to 9 m in the upper limit. Applying the definite integral (4), the speed was obtained in relation to distance and time.

$$\vec{v} = d/t \Rightarrow \int_{0}^{d} (dx)/dt \tag{4}$$

As a result of the calculations developed below, the obtaining of the speed in relation to the different cameras used is described considering the range of distances from 3 m to 9 m. The calculation of the speed in the detection of the image of a person in the Hilook Chamber considering a limit of 0 to 3, allowed to obtain as a result the speed of 11.149935 in m/s, in the distance range of 0 m at 3 m. In relation to the Max Camera, the limit was considered as 0 to 3 meters, for which the speed of 11.345910 in m/s is obtained as a result, in the distance range from 0 m to 3 m.

Considering a limit of 0 to 3, a speed of 11.337651 in m/s was determined, in a distance range of 0 m to 3 m with respect to the Turbo Camera. The result is the speed of 12.030625 in m/s, in relation to the Genius camera in the distance range of 0 m to 3 m. and finally, the speed of 11.910307 in m/s is the result with respect to the Toshiba Camera considering a limit of 0 to 3, in a distance range of 0 m to 3 m.

Table 10. Image detection speed in m/s

Distance (m)	Types of cameras				
	Hilook (s)	Max (s)	Turbo (s)	Genius (s)	Toshiba (s)
3.00	11.149935	11.345910	11.337651	12.030625	11.910307
4.00	20.015242	19.330012	18.768531	21.209819	21.339673
5.00	28.938186	30.359355	30.812691	33.411945	33.355250
6.00	43.616982	43.595928	43.587176	48.350041	48.105486
7.00	59.727297	58.832994	59.589161	64.600045	64.245124
8.00	78.244564	76.807238	77.141279	84.584658	84.250279
9.00	98.690800	98.405443	98.889459	106.680828	107.296592

Table 10 shows the results obtained, in relation to the calculations developed considering a lower limit of 0 m, up to an upper limit of 4 m to 9 m.

Figure 3 displays the relationship between the speed in "m/s" and the x-axis and the distance in "meters", of the five different cameras used for the detection of a person's image on the y-axis.

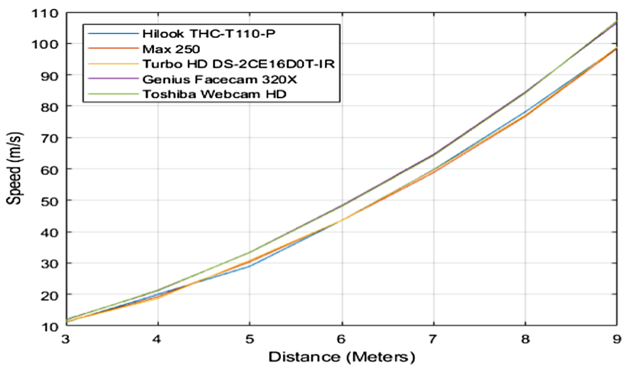


Fig. 3. Speed in relation to distance

3.4 Analysis of the Application of the Mathematical Model

Considering the results obtained in Table 10, applying as a mathematical model a definite integral equation in relation to the speed of the detection of the image of a person, it was determined that, for the Hilook camera in a distance range of 3 m to 9 m, the Average detection speed is 48.6261 m/s.

The Max 250 camera detects the image of the person at an average speed of 48.3824 m/s in a distance range of 3 m to 9 m.

With the Turbo camera, the detection of the image in a range of 3 m to 9 m, the average speed is 48.5894 m/s.

The Genius Camera detects the image in the range of 3 m to 9 m, with an average speed of 52.9811 m/s.

Finally, with the Toshiba camera, the detection of the image of the person was performed in the range of 3 m to 9 m and its average speed of 52.9289 m/s.

The speed and distance parameters of the frame in Fig. 3 are considered in relation to the detection of the image in a range of 3 m to 9 m. The strokes shown in the figure allow the Toshiba camera to be the most optimal because of its average speed of 52.9289 m/s, but it must be considered that this camera works with the computer processor and the algorithm runs without any interface.

This allows to establish the Hilook video surveillance camera with an average speed of 48.6261 m/s. It is considered optimal with the application of the algorithm, considering that in this investigation a device was used as an interface for the detection of the image of a person.

4 Conclusions

The contribution of this research work is related to the detection of the silhouette of the image of a person in contribution to security through video surveillance, considering that the studies that exist are focused on the face of a person. So, the implementation of the algorithm for the detection of the image of a person using multiple cameras, allowed to validate its effectiveness by obtaining as a result a positive detection in the functional field at the time of being used. The validation of the algorithm was carried out with five different types of cameras in their size and class, for which the brand or specifications that limit this research were not considered.

The use of the algorithm in the cameras determined that the video surveillance camera Max detects the image of a person with a 93.9% effectiveness in a time of 0.4117347 s and considers the Toshiba camera as the most feasible with a time of 0.3741777 s and an effectiveness of 99.5%. Therefore, the Max camera is considered the best in detecting the image of a person when using the algorithm and a device in the detection interface in relation to the Toshiba camera, which works with a direct interface with the computer.

The values obtained were validated through the mathematical model and allowed to determine that two of the five cameras used in this investigation show a higher speed than the others, demonstrating that they are the fastest at the time of capturing and detecting the image of a person.

In this research the application of the algorithm in the computer through a device, allowed the interface with the Hilook video surveillance camera, which is considered as an optimal displacement based on an average speed of 48.6261 m/s, faster in relation to the Max and Turbo cameras, in a distance range of 3 m to 9 m. The Toshiba camera with an average speed of 52.9289 m/s, is faster than the Genius, considering that the

Toshiba camera is integrated in the computer and allows the application of the algorithm to be direct and more optimal.

Applying the algorithm in the detection of the image of a person through the cameras allowed to determine that the fastest camera in the detection reduces the detection time and optimizes the software as well as the hardware used, being a contribution to video surveillance and a feasible energy efficiency in the use of materials.

These results obtained and analyzed strengthen the research developed for the validation of the algorithm and its subsequent implementation in contribution to the safety of people through video security, considering to link its application with the Internet of Things in a Smart Grid Home in the future.

References

1. Lin, X.J., Wu, Q.X., Wang, X., Zhuo, Z.Q., Zhang, G.R.: People recognition in multi-cameras using the visual color processing mechanism. Neurocomputing **188**, 71–81 (2016)
2. Mathworks: Image category classification using bag of features (2016)
3. Sinhal, K.: Object detection using deep learning for advanced users (2017)
4. Santos, M.Y., et al.: A big data analytics architecture for Industry 4.0. In: Rocha, Á., Correia, A.M., Adeli, H., Reis, L.P., Costanzo, S. (eds.) WorldCIST 2017. AISC, vol. 570, pp. 175–184. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-56538-5_19
5. Matai, J., Irturk, A., Kastner, R.: Design and implementation of an FPGA-based real-time face recognition system. In: Proceedings of IEEE International Symposium on Field-Programmable Custom Computing Machines, FCCM 2011, pp. 97–100 (2011)
6. Alyushin, M.V., Lyubshov, A.A.: The Viola-Jones algorithm performance enhancement for a person's face recognition task in the long-wave infrared radiation range. In: Proceedings of the 2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2018, Janua, vol. 2018, pp. 1813–1816 (2018)
7. Aydin, I., Othman, N.A.: A new IoT combined face detection of people by using computer vision for security application, p. 5 (2017)
8. Duffy, D.G.: Advanced Engineering Mathematics with MATLAB, 4th edn. Chapman and Hall/CRC, New York (2016)
9. Kamaruzaman, F., Shafie, A.A.: Recognizing faces with normalized local Gabor features and Spiking Neuron Patterns. Pattern Recogn. **53**, 102–115 (2016)
10. Wang, L., Tan, T., Ning, H., Weiming, H.: Silhouette analysis-based gait recognition for human identification. IEEE Trans. Pattern Anal. Mach. Intell. **25**(12), 1505–1518 (2003)
11. Su, C., Zhang, S., Xing, J., Gao, W., Tian, Q.: Multi-type attributes driven multi-camera person re-identification. Pattern Recogn. **75**, 77–89 (2018)
12. Nefian, A.V., Hayes, M.H.: Face detection and recognition using hidden Markov models, pp. 141–145 (2002)
13. Baca, A.: Methods for recognition and classification of human motion patterns – a prerequisite for intelligent devices assisting in sports activities. In: IFAC, vol. 45, no. 2 (2012)
14. Mahapatra, A., Mishra, T.K., Sa, P.K., Majhi, B.: Human recognition system for outdoor videos using hidden Markov model. AEU - Int. J. Electron. Commun. **68**(3), 227–236 (2014)
15. Jurafsky, D., Martin, J.H.: Hidden Markov models. In: Speech and Language Processing, chap. 9 (2017)

16. Lu, Y., Boukharouba, K., Boonært, J., Fleury, A., Lecœuche, S.: Application of an incremental SVM algorithm for on-line human recognition from video surveillance using texture and color features. Neurocomputing **126**, 132–140 (2014)
17. Kleinsmith, M.: Zero to hero: guide to object detection using deep learning: faster R-CNN, YOLO, SSD (2016). http://cv-tricks.com/object-detection/faster-r-cnn-yolo-ssd/
18. Kasim, S., Hassan, R., Zaini, N.H., Ahmad, A.S., Ramli, A.A., Saedudin, R.R.: A study on facial expression recognition using Local Binary Pattern. Int. J. Adv. Sci. Eng. Inf. Technol. **7**(5), 1621–1626 (2017)
19. Viola, P., Jones, M.: Robust real-time face detection. In: Proceedings Eighth IEEE International Conference on Computer Vision, ICCV 2001, vol. 2, p. 747 (2001)
20. Yolanda, L., Martín, M., Gutiérrez Mendoza, L., Mary, L., Nieves, A.: Guidelines to design of virtual learning objects (VLO). Application to the Teaching-Learning Process of Area under the Integral Calculus Curve Lignes directrices pour la conception d' objets d'apprentissage virtuels (OAV). Application au processus d' ense. Rev. Científica Gen. José María Córdova, vol. 14, pp. 127–147 (2016)
21. Sun, S., Zhao, J., Gao, Q.: Modeling and recognizing human trajectories with beta process hidden Markov models. Pattern Recogn. **48**(8), 2407–2417 (2015)
22. Klette, R.: Concise Computer Vision. Springer, London (2014). https://doi.org/10.1007/978-1-4471-6320-6
23. Tavallali, P., Yazdi, M., Khosravi, M.R.: An efficient training procedure for Viola-Jones face detector. In: Proceedings of the 2017 International Conference on Computer Science and Computational Intelligence, CSCI 2017, pp. 828–831 (2018)
24. Rodavia, M.R.D., Bernaldez, O., Ballita, M.: Web and mobile based facial recognition security system using Eigenfaces algorithm. In: Proceedings of 2016 IEEE International Conference on Teaching, Assessment and Learning for Engineering, TALE 2016, December 2017, pp. 86–92 (2017)
25. Gabriel, F., Julián, C., Reyes, M.V., López Sánchez, A., Alberto, C., Ríos, J.: Reconocimiento Facial Por El Método De Eigenfaces. Pist. Educ. **127**(04), 66–81 (2017)
26. Febrero, P.: Adaboost con aplicación a detección de caras mediante el algoritmo de Viola-Jones Néstor Paz, Febrero de 2009 (2009)