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MACHINE VISION ALGORITHM FOR CONTINUOUS COUNTING OF POULTRY IN SLAUGHTERHOUSES

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Abstract. *With the high growth of the refrigeration industries and the need to improve their processes, the use of computer vision techniques combined with the application of image processing has increased. The of these two techniques is able to realize significant production improvements. The correct implementation can result in an improvement in the quality of products, an increase in production, or even provide the identification of losses. At poultry slaughterhouses, in the initial stages of slaughter, the animals are counted, seeking to identify losses occurred at each stage of the process. As this counting must be as correct as possible, and the current solutions do not present a high accuracy, the possibility of implementing a system using computer vision and image processing was proposed. This article consists on the development of an algorithm that is capable of counting the chickens in a continuous flow, aiming the implementation in the slaughterhouses in the future. For the development of this work, we sought to obtain the best possible performance, reaching as a final result 99.94% accuracy.*

Keywords: *Machine Vision, Poultry slaughterhouse, Industrial Application*

1. INTRODUCTION

With the growing development of technology within productive environments, the importance of automated systems is increasingly observed, especially in the food industry (Navarro, 2012).

The Brazilian Association of Animal Protein Report (ABPA, 2021) states that the poultry exports rose, even on the COVID-19 pandemics, reaching 4,2 million tons and US$ 6,0 billion, especially due to China's growing demand in the last years.

According to Marçal *et al* (2013), industrial automation can provide numerous advantages to companies that use it, as better productivity rate, reduced waste, better product quality, and greater control over processes.

In poultry slaughterhouses, the slaughter environment can be basically divided into two sectors: "dirty" area and "clean" area. It is in this first sector where the first stages of the slaughter process occur, namely: hanging; stunning; bleeding; scalding and feather plucking; cutting of feet, heads and carrying out evisceration (Schilling, 2014). It is at these stages that the biggest losses occur in the production line, and quantify it is particularly important for decisions making, seeking to reduce the losses and acting directly on the most critical steps of the process.

Through a study carried out in a chicken slaughter line located in Santa Catarina, it was identified that the highest rate of total condemnations was due to excessive scalding, contamination, delayed evisceration, and inadequate bleeding. It was also observed that such problems occur mostly in the initial stages of the process, thus requiring greater care at this point (Schilling, 2014).

Aiming to quantify the chickens at each stage of the processes mentioned above, some solutions seek to carry out the counting in the most efficient and correct way possible. However, good results are hard to be achieved, due the unhealthy environment, the presence of dirt, dust, feathers, high concentration of moisture, the non-standardization of the hanging process, and especially the speed of the conveyor.

The most common solution available on the market for poultry counting in the conveyor is a mechanical contact sensor. The counting using this type of sensor is performed by the poultry passing through a mechanical structure, which is pressed by its body, compressing an elastic device which results in the sensor being activated.

As mentioned, the non-standardization of the hanging process creates counting problems, as this can result in the non-activation of the mechanical device. In addition, due to the speed of the conveyor, which can reach more than 3 chickens per second, the mechanical wear becomes very high, thus requiring more recurrent maintenance.

With the technological advances in recent years, the use of technologies implementing image processing has growth. Through image processing, problems such as pattern recognition, anomaly detection and prediction are examples of problems that can be solved more efficiently.

According to Filho and Neto (1999), to carry out the acquisition of images a sensor and a digitizer are used. Where the sensor has the function of converting the optical image into an electrical signal, a signal which will be converted into a digital image using the digitizer. Currently, with the use of digital cameras or even cell phone cameras, these processes occur instantly, and these steps are imperceptible.

According to Persechino and Albuquerque (2015) an image can carry numerous characteristics and information, and may represent structures of a physical nature, conceptual artistic, etc. An image can be considered a generally multidimensional signal, often requiring processes that further highlight its characteristics.

According to Backes and Junior (2016), computer vision consists of capturing images, improving them (for example, removing noise, increasing contrast, etc.), separating the regions or objects of interest in a scene, extracting various information depending on of the analyzed image, such as shape, color and texture, and, finally, relating the images to other previously seen images. One of the tools that allows a better understanding of the worked images is the histogram. This tool is responsible for finding a numerical coding that represents a certain image, as a kind of “fingerprint” that allows to identify it.

Many studies using computer vision seek to solve different problems present in slaughterhouses. As an example of this, the study by Park *et al.* (2007) proposed to identify and classify through images, different fecal contaminants present in chicken carcasses. The identification of these contaminants, according to the authors, is extremely important, due to the serious problems that the consumption of these contaminants can bring to human beings. Ren *et al.* (2020), reports the use of computer vision in many others agricultural applications.

Seeking new alternatives to solve the mentioned problem, this paper proposes the counting of poultry by visual inspection, using computer vision and image processing.

2. METHODOLOGY

2.1 Image capture e selection

The image bank used for this work was acquired in a slaughterhouse in the city of Chapecó, Santa Catarina, Brazil. It was decided to acquire these images on the real slaughter production line, due to the need for a better representation of the future implementation environment.

The images were taken with a 12.3 Mega pixel cellphone camera. The photos and videos were taken at approximately 1.5 meters and an angle of 45° in relation to the rail, using a tripod as support for better stabilization and standardization of images.

A total of 810 photos and 7 videos were made, which later were performed the removal of inappropriate images and videos. As a basic selection criteria, videos and images that flickered or those in which people or objects were crossing the image were excluded. The photos were used for manual adjustment and visualization of the image processing algorithm, after being applied on continuous video, frame by frame for more realistic conditions testing.

It’s important to highlight that no modifications were made on the slaughterhouse environment for the images and videos recording, and, in case of a real application of the system, a special “restricted area” avoiding those disturbances should be created.

2.2 Image processing

After completing the acquisition and selection of images for the database, the next step is the image processing.

Among the most used tool for image processing is the library developed by Intel, OpenCV. One of the advantages of using this library is that it is open source and multiplatform, which allows its continuous improvement and implementation in various programming languages, such as: Java, C, C++, Python and many others (Cunha, 2013). In the present paper it was used the OpenCV with Python Anaconda IDE. The Python language also was selected due to its multiplatform capability, being easier to develop and test on different hardware and operational systems.

Analyzing the captured images, it was identified that the region of greatest contrast was present in the upper part, where the animal's feet are located. Based on this observation, it was decided to partition the image in this region of interest, thus avoiding that the movements that occur in other parts of the animal interfere in the results (as movement of the head, the flapping of the wings, etc.).

Figure 1 shows the image in full size and in Figure 2 the same image after performing the partitioning.

Figure 1. Full captured image.

Figure 2. Interest region image.

Applying filters in image processing is routine, as it provides smoothing of images and noise removal. To perform this smoothing, several techniques can be applied, such as smoothing by: average, Gaussian, median, bilateral, among others.

To perform the noise removal and smoothing of the images obtained in this work, it was used smoothing by Gaussian filtering. Such smoothing is obtained through the generation of a Gaussian matrix, which is used as a mask in the image convolution (Jesus and Junior, 2014). Figure 3 shows the image after the application of smoothing by Gaussian filtering.

Figure 3. Filtered image.

It was identified that the use of the Red (R) channel, evidenced some essential characteristics for the identification of the poultry feet. The differences between the use of the R, G and B channels can be seen in the profile plotting in Figure 4, it is observed a better performance in the R channel, being easier to identity the peaks that represents the poultry feet. For the construction of the profile, the entire sectioned image was used, Figure 3, thus, decreasing the pertinence of noises caused by the occurrence of some anomaly in the image.

To perform the count of poultry, each peak value present graphic was used, values which represent the presence of an animal's feet.

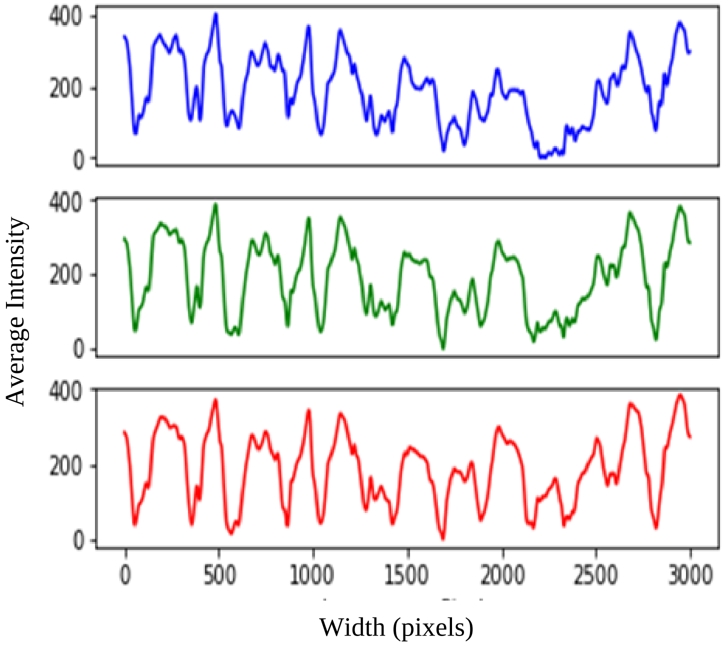

Figure 4. Comparison on separated channels profile

When observing the profile in Figure 4, it was observed a high number of noises, which may directly interfere in the counting. In order to reduce these disturbances, a moving average was applied to the data, obtaining significant improvements. Also, a minimum width between the peaks and minimum peak value were empirically defined to remove false counting and to avoid multiple counting of the same feet in different frames, a “crossing line” was used, counting only the rising edges of the matchings. Figure 5 shows the result of a frame with 13 feet, pointing to 13 peaks identified with the red dots.

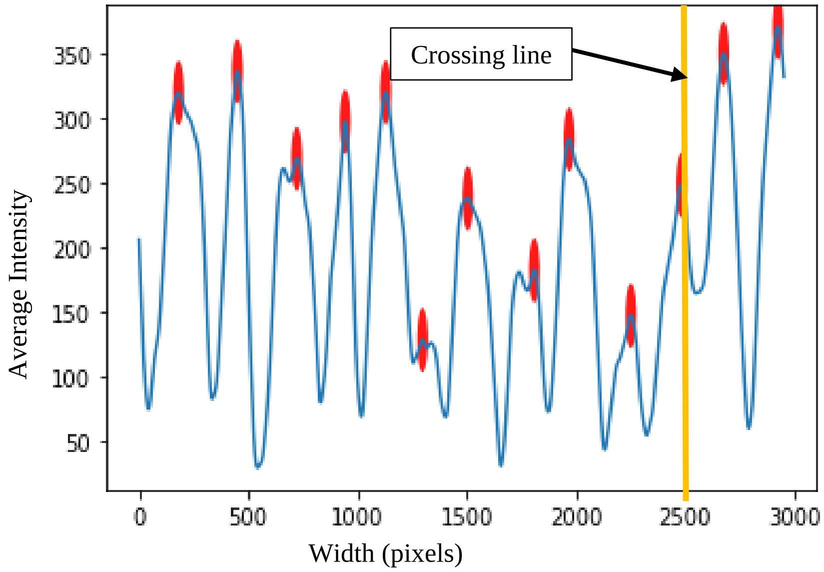

Figure 5. Result of peaks identification

For the totalization of poultry, eq. (1) was used, where **NP** represents the total number of feet counted and **NT** the number of total animals.

$$\boldsymbol{NT} = \boldsymbol{NP}/2 \quad (1)$$

2.3 Tests and validation

Since the algorithm were adjusted and seems to work with the pictures and frames, it needs to be tested on the real environment conditions, running in an embedded system in real time.

As the main objective of this work is the future implementation in slaughterhouses, the validation and testing stage was initially scheduled to be carried out in a real slaughter line, but due to the current scenario of access restrictions to slaughterhouses, due to the worsening of the Covid-19 pandemic, it was not possible. As an alternative, the videos obtained on site were used to carry out the validations.

According to Gulo *et al.* (2012), with the continuous growth of technology, the emergence of increasingly faster processors enables the feasibility of solutions that require high-performance processing.

Seeking a high processing speed, the algorithm was implemented in an NVIDIA Jetson nano, hardware, which is compatible with the project objectives and has smaller dimensions than other devices of the same specifications, which makes it easier to install in industrial environment.

A camera model Imx219 with 8Mpx was used directly coupled to the hardware to perform the recognition and counting. Initially, the use of the camera model Imx477 with 12.3Mpx was planned, having the same specifications as the camera used for image acquisition. But due to its momentary unavailability for purchase, it was opted the lower resolution model, which satisfies the project's needs.

To test the system as close as possible to the real application, the videos were broadcasted to a 43-inch television, thus being able to test the real performance of the system in real time acquisition and processing. Figure 6 demonstrates a representation of the environment used to perform the system validations.

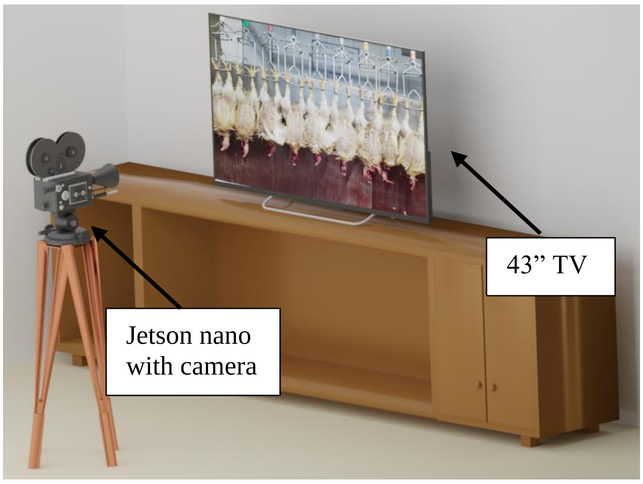

Figure 6. Experimental structure mounted for system evaluation.

3. RESULTS AND DISCUSSION

After the structure was set up to carry out the tests and validations, 3 videos were analyzed with duration of 53s, 75s and 10 min. The results obtained can be seen in Table 1.

Table 1. Experimental results.

Video length	Feet (un)	System counted feet (un)
53 s	260	260
75 s	370	369
10 min	2942	2941

Analyzing Table 1 results, a total of 3572 feet that passed on the conveyor, only 2 were not counted, thus obtaining an accuracy of 99.94%, that is, only 1 chicken out of 1786, which is acceptable considering the actual scenarios.

It is noteworthy that the applied algorithm does not include the count of the feet that are not hanging on the rail hooks, therefore, for the error calculation this situation is not included. The solution to this problem can be studied and improved by future works.

At the time of obtaining the images and videos on site, no changes were made to the environment. To make the algorithm even more assertive, modifications such as: placing a more adequate lighting in the place and applying a background with a higher contrast can result in a better performance of the algorithm.

4. CONCLUSION

The solution of counting the poultry feet using the red channel of the images seems to be a simple but effective way of automating the process.

The results were satisfactory since the algorithm error was very low in the tests performed, compared to other solutions on the market. The error represents a small number of uncounted animals, even on large slaughterhouses. Given the restrictions of the environment and the high speed of the animal's transport conveyors, the system exceeded expectations, showing a processing speed above what is necessary for the application and running without freezes during all performed tests.

One of the difficulties found was to verify the accuracy of the algorithm, as the counting is performed at high speed, thus requiring slow motion videos to be used for manual counting.

This work presented a prototype for counting chickens. There is still a lot of work to be done to be considered a final product, such as implementing the checking if the poultry is hanged by two feet and develop a special enclosure for the hardware, capable of handle the adverse environmental condition a 24h operation slaughterhouse

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE