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Implementation of an Intelligent Application based on Ambient Intelligence for Spider Bites in Children

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Abstract. This paper presents a model for integrating an intelligent mobile application for the detection of spider bites as well as the recognition of arachnid species. It is worth mentioning that there are very few studies dedicated to the analysis of the detection of arachnids worldwide. And, in the country, there is no known research work to date whose objective has been to identify the bite of a spider, its species and what to do in the face of such a situation for its prompt recovery without collateral damage to children. The importance of environmental intelligence within this study is related to the fact that it is in charge of solving problems related to daily life. Therefore, it is feasible to use this innovative application, which combines applied deep learning techniques, and a model based on a mobile device, to make possible and determine the places to go in case of an accident caused by an arachnid bite in infants in the city of Misantla. The reason for this paper, however, is the detection of arachnid bite accidents, especially in children, in the Misantla region, as these are often severely damaged by the venom of a spider bite. For all these reasons, an application is required for the citizens of the city of Misantla. Then, citizens would have more information about possible arachnid accidents and which medical centers to go to before an arachnid accident occurs.

Keywords: AmI, spider bites, deep learning, CNN, smart application.

1 Introduction

According to the literature, it is feasible to use a mobile application to determine the possibility of a spider bite accident, using the data associated with the most frequented areas. Users will then be aware of the locations within the city of Misantla where such incidents occur, as well as what to do before an accident. The use of technological tools [1], would reduce the chances of infants suffering an accident caused by arachnids. The objective of this project is to create a classification model that uses these tools about accidents by the main poisonous spiders (black widow spider, violinist spider, hobo spider, brown widow spider and golden silk weaver spider), of Misantla [2]. An exhaustive analysis of other similar research was carried out, the only similar context is explained in [3], where the authors created a geographic viewer, a tool for the prevention and care of accidents caused by arachnids, which allows the community, health workers, and other actors in general to be kept informed about aspects related to the origin and dimension of health problems caused by accidents caused by spiders and scorpions; As well as on the effects obtained from the actions oriented to the protection and prevention of these toxicological accidents and their best alternatives of treatment and mobility for their opportune attention; and in this way to guide, support and improve the management of the health services, but this investigation does not consider its development in application if not, simply in a web tool besides that it is not developed in Mexico, if not in Colombia.

This paper was developed as a proposal to improve accidents in infants since they are more affected in summer seasons when children are exposed to the environment [4], thus causing an incident regarding an arachnid bite, since, in those seasons, these insects go out to hunt or to reproduce, or if the spider has just moved, eat or mate, then the venom will have a greater effect on the infant [1]. All this, through the classification of personalized images by training a simple model of deep learning with the help of an online tool from Google [5]: teachable machine, and then exporting the model to the TensorFlow Lite version that is compatible with the Android device. Finally, this model was implemented on an Android device. The tool, which consists of three different stages, is the result of an analysis and research carried out as part of a master's program in Computer Systems at the ITSM from Misantla. The objective of this experiment is to identify how the proposal works, using a large number of images and making use of the Neuronal Convolutional Networks (CNN) and TensorFlow Lite [6]. Through this experiment, a beta application was used [7], so that volunteer users could make use of it and recognize with the application from their gardens or in the environment where they encounter a spider, what type of species it is or in case of suffering from an arachnid accident, know who caused it and where to go for its case study. This application is still in the development phase and not in a final version. To qualify the project as successful, the application had to be taken to field practices to provide an accurate identification of some of the species to be identified.

2 Implementation of the Intelligent Application

There are several aspects to consider when designing mobile applications: both limited screen size, different resolution and screen sizes between devices. Therefore, the designer must develop the interface in a uniform way to fit most of the devices to be used. In addition, the number of users using Android has had a clear growth of 87% in recent years [8].

For this work, the Android Studio platform for the Android API was used. The programming interface we worked on is XML with the Java-based language.

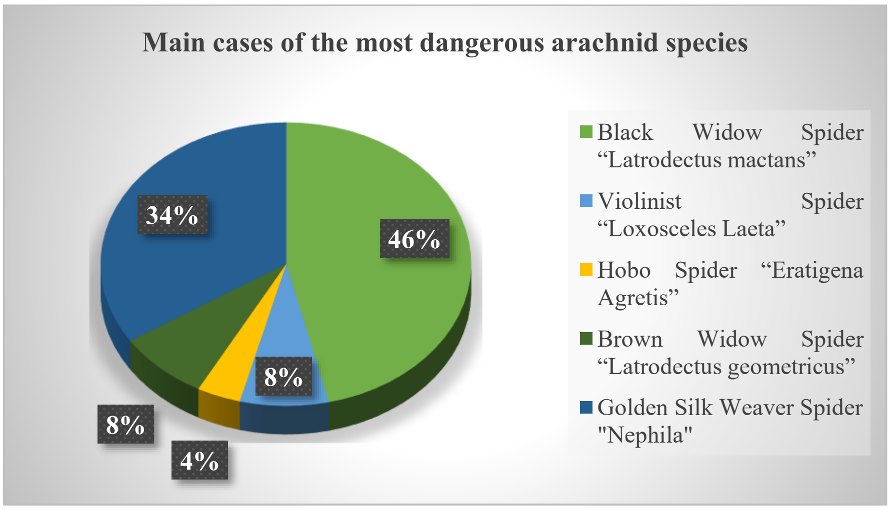

Fig. 1. Most dangerous arachnids in Misantla, Ver.

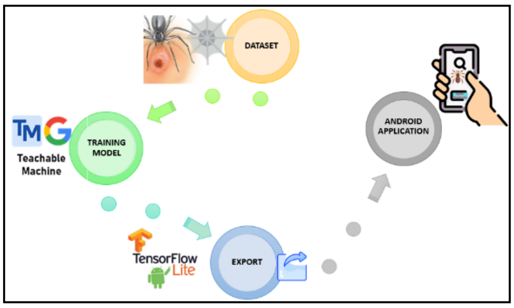

Fig. 2. Proposed classification model.

With respect to the choice of the five different species of arachnids [9], selected for this paper, these were chosen because they are the most dangerous in the Misantla region and because they concentrate the largest number of bites as they are the most common (see Figure 1).

On the other hand, a classification of images or image recognition was required since it is a concept in which you show an image to the device's camera sensor, and it will tell you what is present in that image or tell us what class it belongs to. Therefore, through the classification of hundreds of images by training a simple model of deep learning you get an intelligent application which identifies the types of arachnid species and their bites, from an Android device (see Figure 2).

The proposed classification model, as can be seen in Figure 2, as a first step you must have hundreds of images of what you want to classify, that is, a varied dataset of images, in this case you download images of three types; arachnids, spider webs and their bites, of at least five types of the most poisonous arachnid species of the city of Misantla. After that, the images are loaded from Google's Teachable Machine platform in which the classes to be classified are labeled and after that, the model is trained. Thirdly, the trained models are exported as TensorFlow Lite and, finally, they are

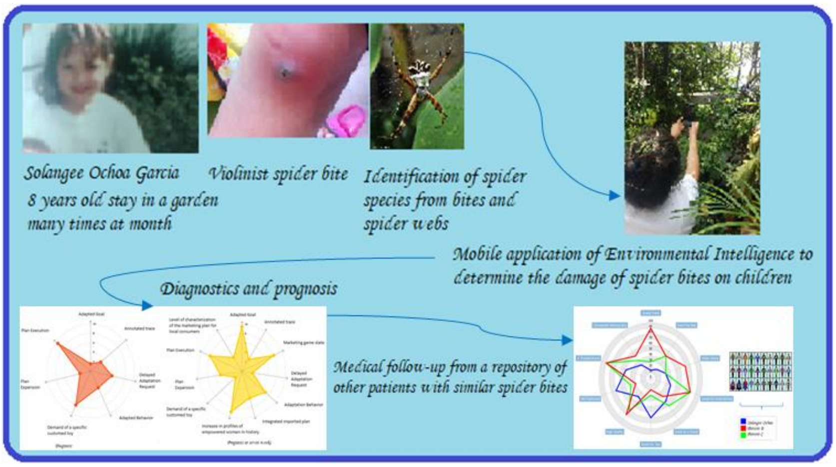

Fig. 3. Proposal of the model associated with research.

migrated to the mobile application developed from Android Studio for its correct operation.

3 Spider Bite Recognition

3.1 Methodological Proposal for the Recognition of an Arachnid Bite

According to the evidence, it is feasible to use a mobile application to identify the bite of a spider and know which has been the aggressor, using photographs in real time for the cases. This investigation tries to recommend the patient with this problem, to the place where it is necessary to resort to this type of emergency and with it, to avoid amputations or even the death by the bite of a poisonous spider in some children. Since, it is impossible to know what type of spider has been the aggressor, to the moment in which this one bites and the idea of not knowing which species has been is one of the main problems for this work. That is why with AmI, a series of tools arise to achieve this problem, which in this case is technology, information, image processing, among others (see Figure 3).

The case study presented of the model proposed to this research, leads to children under 12 years, suffer from the bite of a spider in one of the extremities of the body, which requires then the identification of the species as the bite of this and through the proposal to develop a mobile application of environmental intelligence to determine the behavior of the spider bite in children. Focused on a diagnosis and prognosis for medical follow-up through a geolocalized repository of other patients with similar spider bites, it will be feasible.

From the analysis of the different conditions that cause skin necrosis, it can be concluded that it is very important that a doctor, when faced with a skin necrosis syndrome, thinks about and identifies the causes that can cause this similar clinical manifestation, since the beginning of an adequate and timely therapy will avoid

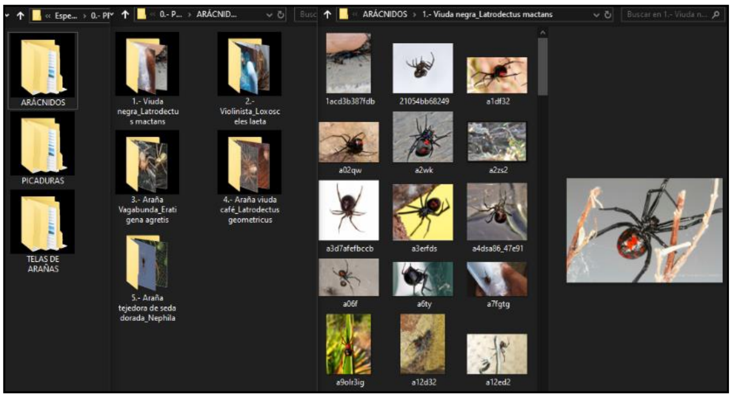

Fig. 4. Dataset built with images from the web, arachnids, bites and spider webs.

complications and favor the patient's prognosis. Most of these conditions require hospitalization in more complex units, since they can evolve rapidly with multi-organ failure. The role of the dermatologist and dermatopathology is of special importance, since the skin biopsy can be fundamental to determine the early diagnosis.

4 Test Development

The data with which the model was trained was prepared. For this purpose, about 1500 images were downloaded from the web (see Figure 4) of five different types of spiders, among them; the black widow spider, violin spider, hobo spider, brown widow spider and the golden silk spider (100 images for each species mentioned), as well as their bites of each of these species and their webs, for each of the objects that are required to be detected.

On the other hand, in terms of image processing and resizing, these are left at a fixed size of 400 wide by 350 high. Three folders were created, one of the arachnids and, within this one, five more folders of the five types of spiders, another folder of the spider webs and its five more folders of the five different species of webs and finally the third folder of the bites and, within these, five more folders with their bites of the different species to work with.

Next, the characteristics to be taken from each type of spider, its bite and the web it weaves are described, which was taken into account for its pre-processing in the classification model (see Table 1).

Once the convolutional neural network takes into account the characteristics described in the table above, a model is obtained that can be migrated to the application. Therefore, the CNN was used to carry out the training. From Google's tool, Teachable Machine, for Machine Learning, this allowed to abstract the definition of the model, algorithm and data processing, since it focuses the deployment of the model to be generated. This tool works in the browser, in this case, with files that are hosted on the computer, and in a few minutes, you can quickly understand how a model learns through a simple demonstration of classification. To start training the classification model, first of all, the categories or classes to teach it must be created (see Figure 5).

Table 1. Characteristics that the CNN model takes into account in the classification.

Species	Characteristics to be identified
Black widow spider (*Latrodectus Mactans*)	It is distinguished by its black color and a red hourglass on the abdomen. Its web is irregularly shaped, tangled and sometimes funnel-shaped. When it bites, it leaves a reddening of the skin, a swelling. A central blister forms at the site of the bite, extravasated blood under the skin (like a bruise). The lesion may enlarge into deep, pus-filled ulcerations.
Violinist spider (*Loxosceles Laeta*)	It can be distinguished by the violin in the central part of the body. Its web has a disorderly and irregular design, and is located in right-angled profiles (corners), where it weaves a horizontal net in the shape of a short hammock. When it bites, it leaves a red or lilac coloration in a circle that will be in the middle of the bite, or it creates an ulcer in the first hours of the bite.
Hobo spider (*Eratigena Agretis*)	It is distinguished by its brown body with yellow spots on its abdomen, as well as having slightly longer legs and a hairy body. Their web is funnel-shaped, they do not climb vertically, they usually build their webs at ground level or under the floor in basements. When they bite, they leave a small red bite that looks like a mosquito bite, and within the first few hours, blisters will appear around the bite, then burst leaving open wounds.
Brown widow spider (*Latrodectus Geometricus*)	It is distinguished by its brown or beige color with a spotted pattern and by having grooves on its legs. It also has an hourglass on its lower abdomen, but it is bright yellow or orange. Its web is three-dimensional (instead of flat) and these create sticky webs. When it bites, it leaves a small red mark in the area of the bite, causing an infection, such as a rash, pus, or sores.
Golden silk spider (Trichon*ephila*)	It is distinguished by the shape of its body, its abdomen is like a rigid, elongated armor with combinations of dots or stripes in black, white and gold. Their web is distinguished by the color of the silk they produce, the threads of their web shine like gold in the sunlight. When chopped, it leaves a slight reddening of the skin that will disappear completely over time.

For this training, classes were given on the types of arachnids to be identified, as well as the stings that these insects generate.

Once the labels are well defined, the samples for each class are uploaded from the local area so that training can begin. And creating the training with the classes would look like this (see Figure 6).

The model takes time to train, sometimes it gets stuck, but the result is quite good. And, after the model training phase is finished, the models are exported as TensorFlow Lite (see Figure 7), of two different types; the first as *model.tflite* and the second as *model_unquant.tflite*, and the third as *labels.txt*.

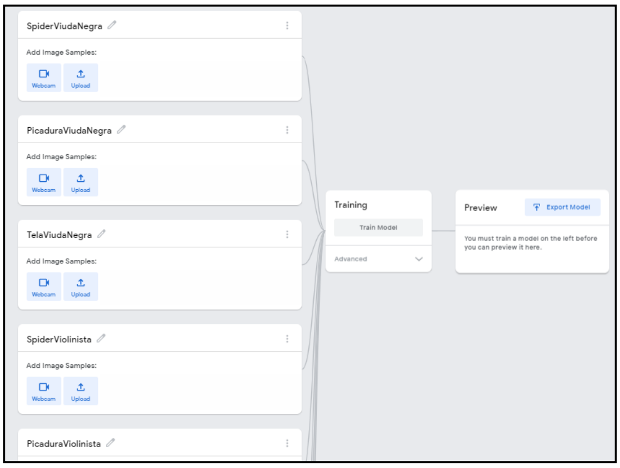

Fig. 5. Starting to train the model for a classification.

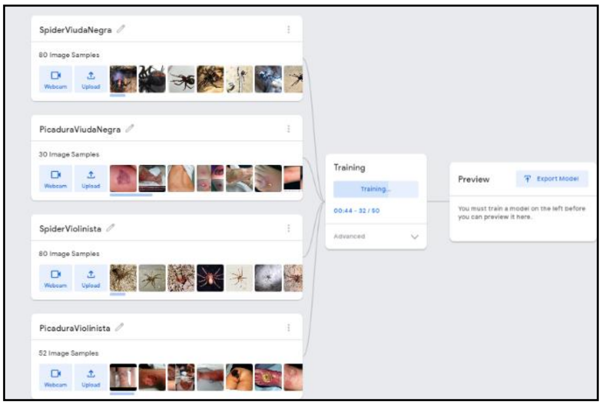

Fig. 6. Classification model training.

On the other hand, making the development of the application on the Android Studio platform, it is as follows (see Figure 8).

The model label.txt, contains all the classes for the training of the CNN so that there is a correct identification of what is intended and are used to be called from the Android mobile application (see Figure 9).

4.1 Module for the Recognition of Arachnids and their Bites

Convolutional Neural Networks (CNN) are the algorithm to give the computer the ability to "see". Thanks to this, it is now possible to classify images, detect various types of tumors automatically, teach autonomous cars to drive and a host of other applications. The inputs are images, which allows to code certain properties in the architecture, allowing to gain in efficiency and to reduce the number of parameters in

Fig. 7. Exporting the TensorFlow Lite model.

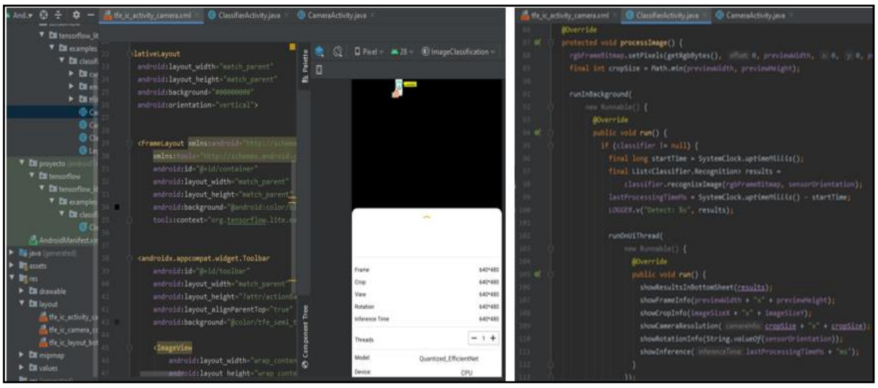

Fig. 8. Development of intelligent application for the recognition of arachnids and their bites.

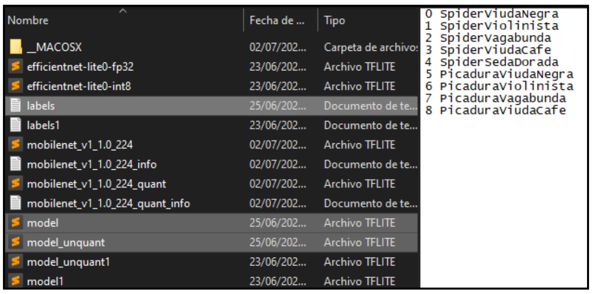

Fig. 9. Models exported and migrated to the Android Studio application for identification.

the network. Convolutional neural networks are efficient because they scale well for high definition images [10].

What a convolutional neural network does is too simple, you pass it an image, and it classifies it for you (see Figure 10).

In order to make the convolutional neuronal network functional, a dataset of images of five different arachnid species of spider webs and of the bites that each one of these species leaves after biting a person, was provided to it. Then, a new image that is not found in the dataset representing a bite or a spider was passed to it, so that the convolutional neuronal network was able to know which species corresponds to that image.

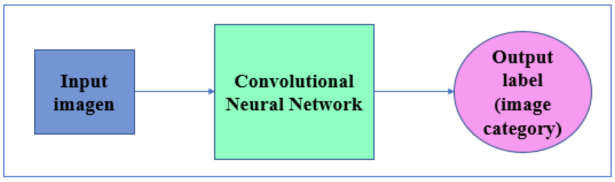

Fig. 10. Process performed by a convolutional neural network.

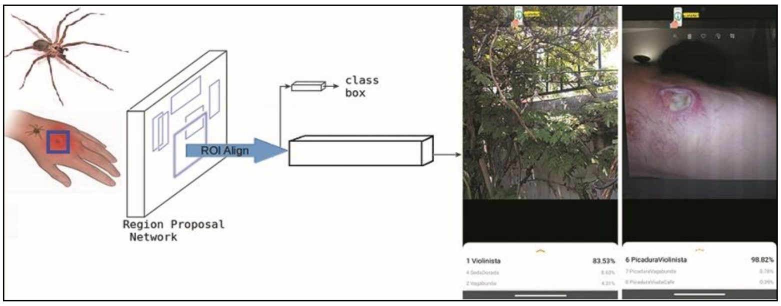

Fig. 11. Simplified diagram of the CNN used for the classification/segmentation of images. *In the diagram, the network generates three types of output, the box where the arachnid is located, a binary mask that delimits the arachnid and the type (genus) of arachnids found or, failing that, the type of bite to which it corresponds.*

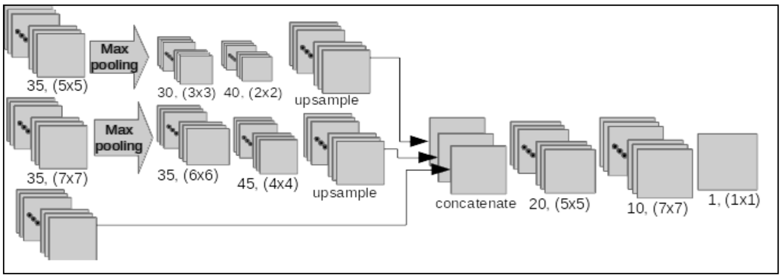

Fig. 12. Proposed architecture for the module. It consists of three channels of convolutional layers that are concatenated to have a good feature map with information at different scales.

This module for the mobile application (see Figure 11), has an exchange with the spider image recognition and the rest of the data. The arachnid identification stage consists of a deep learning architecture. An input image of the bite or arachnid is then segmented into several groups which are then classified as the recognition of the type of spider or the type of bite. The architecture is based on the convolutional neural network for the recognition.

In this paper, it was already proposed that the network will focus only on the recognition of arachnids and to identify what species the bite was from, simplifying the module to make it easier to train and less computationally burdensome. The proposed architecture consists of three convolutional channels, where each channel aims to select different feature sizes: a large channel with 11x11 size cores, a medium size channel

Fig. 13. Intelligent application developed to determine the most poisonous spider bite accidents in infants in the Misantla region.

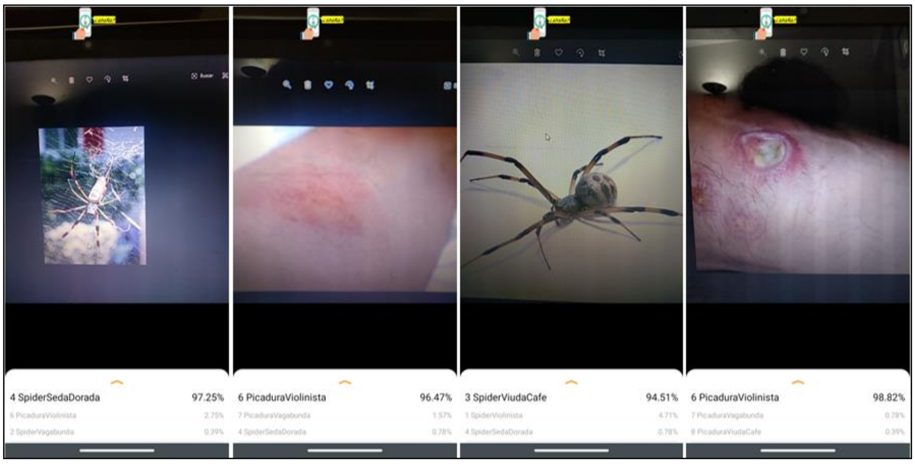

Fig. 14. Results obtained that are shown in the application once the generated Tensorflow Lite models are exported.

with 4x4 size output filter and finally a small channel with 2x2 output filters. The outputs of the different channels are concatenated into a feature map that contains information at different scales of the input image, so for concatenation, the output of the medium and small channels is sampled so that the output of all three channels is the same size. Then the output is fed to a couple of convolution layers to recover the size of the original image and finally a 1x1 filter size convolution layer to have an image of the spiders or their bite effect. The details of the architecture described are shown in Figure 12.

4.2 Results

The beta version of the application called Spider Bite, was developed based on the minimum requirements, which were the delivery of a very basic application with the ability to interact with the user using a simple but practical interface, where the user

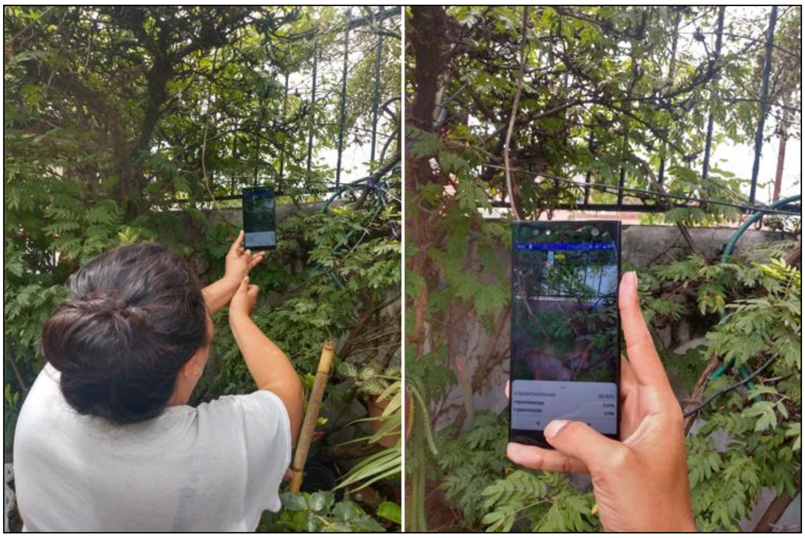

Fig. 15. Mobile application used in a garden for the identification of arachnid species.

enters automatically without the need to log in and run it, This has the option of processing the image taken in real time in the case of seeing an arachnid species so that the application can define, by means of the camera, what type of species it is, or, in the case of an arachnid bite accident, suggest a nearby health center to go to immediately (see Figure 13).

In Figure 13, you can see how the application is composed, which has a dataset of the species that are being addressed, its operation is basic, then, the user enters, choose the option to upload an image from your gallery to process it and that the app throws the species or bite that is, or capture it in real time with the device's camera in the event of encountering the arachnid or having been stung at the time and thus this application gives us what we expect and also shows us the location of the person and the health center closest to him/her in Misantla.

The function that has the option of processing images within the application, is that, with the camera of the device, it shows an image and in automatic the application will say what is present in that image, the species of the arachnid, as well as the bite to which type of arachnid it corresponds (see Figure 14).

One more example of the application's functionality is shown (see Figure 15), in which the application was taken to field tests where it was presented with an arachnid species in a garden, which our intelligent application recognized as the next species.

Finally, the mobile application developed in the Android Studio platform gives feasible results of the model exported by TensorFlow Lite, which is called from the application, since it achieves 95% accuracy in terms of correct identification of arachnid species.

5 Conclusions and Future Work

It is through this whole validation process that we learned the potential of this intelligent application. According to the experiment, it is confirmed that it is possible to implement a technology platform for the recognition of arachnid stings in infants in real time using a mobile device that captures the part of the sting, and this application will be able to identify which has been the arachnid to act immediately avoiding a misfortune in the affected part. Similarly, the lenses meet the following specifications: the use of a mobile device, Sony Xperia XA2 Ultra, with the 23Mpx rear camera, f/2.3 with LED flash and 4K recording. The Android 8.0 Oreo operating system and a Qualcomm Snapgragon 630 Octa-Core 2.2 GHz Cortex-A53 processor.

The result of this could be used, in this case, to focus strategic measures to prevent accidents in conflict areas. If the measures are implemented in areas where a higher probability of accidents is predicted, the impact of the measure will be greater. This provides a very good sense of how useful and practical the proposed methodology can be. With the use of this innovative application that combines Deep Learning and a mobile device-based model, it is possible to determine the places to go in the event of a child spider bite accident in the city of Misantla. The most important contribution is the possible prevention of future infant deaths in the city caused by spider sting accidents. We believe that this innovative technology has a promising application in other Latin American cities with similar problems of severe arachnid bites.

This project is very important for the city of Misantla because of the type of region, since it is mountainous and its climate is warm-humid-regular, and the children, being in the middle, are the most exposed to suffer from this problem because of the great diversity of species that live there. In addition, there is no intelligent system in place to help citizens regarding an arachnid bite. And, until now, no work like the one presented above has been carried out in the country. On the other hand, the contribution that we have is the inclusion of image pre-processing techniques, in addition to the study in the fields of Deep Learning for the case study, as well as convolutional neural networks, the incorporation of three datasets into one and the creation of the classification model which uses images from three datasets, which are in one. The different methods and techniques used during the development of systems to recognize images have been explored. During the development several of the original decisions were alternated such as considering the recognition of objects within the image.

It was possible to confirm the great importance of the performance of a neural network, since it does not lie exclusively in its architecture but, in the set of data available it alters the result. The two main complications that were presented more relevant in this work were: the model and image processing by how they are treated.

As future research to be incorporated into this project in terms of the mobile application, it is recommended that more existing arachnid species be added for recognition in terms of the arachnid bite. At the same time, this application should be implemented to detect and recognize other types of stings, such as those of poisonous snakes or even scorpions, and not only to recognize spider bites. That the application can provide recommendations for the surveillance, prevention and care of accidents by the various types of bites according to the species to be detected. And, that it is developed in iOS devices, that it is multiplatform.

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