Blink Detection for Residential Control

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***Abstract*—Domotics is the study that involves the fusion of the words "domus" (which means home in latin) and "robotics", linked directly to the act of automating something. Using facial recognition, by detecting the blink of eyes and its movements, we can make it possible to perform various domestic tasks, such as turning on and off a lamp, opening windows and other activities. In this scenario, an application was developed for the Android platform that connects to the Particle Photon micro controller that is focused on the Internet of Things and is also responsible for the modularization of Wi-Fi functioning as embedded communication channel, making it possible to control the functions that triggered the routine tasks of the residence. In order for image processing to take place, we adopted an Open-Source library called OpenCV. The application contains the Accessibility Mode that is selected by default and enables the blink recognition functions that can be used by all people, in addition to the traditional way of touch screen.**

Keywords—Domotics; image processing; computer vision; artificial intelligence

I. OBJECTIVE

Given the need that the physically disabled face in daily life, came with the idea of automate a home in a practical and accessible way in order to facilitate tasks of people. The Internet of Things allows us to integrate an application with hardware and it presents improvement for our field of study, the home automation. Thereby, we will adapt residences for people who have locomotor deficiencies such as Amyotrophic Lateral Sclerosis, paraplegia, tetraplegia, among other problems that affect the body movements. Therefore, our goal is to generate a more accessible world for people, thus eliminating barriers and prejudices, because as human beings we all have the same rights.

II. BACKGROUND/MEANINGFULNESS

Today, with the 4th industrial revolution, people reinvent processes and technologies for ease and simplicity for everyone. However, people with physical disabilities also have dependencies of third parties. Currently in Brazil, according to a research from IBGE (Brazilian Institute of Geography and Statistics), around 6,2% of people have some kind of deficiency and this factor in our country is aggravating, since we lack accessibility and focus on these people [1]. Starting from common sense, it is a usual thinking that people in these conditions cannot live a healthy and independent life, and is highly necessary to act from third parties to support them. Our research aims to bring a change in this common notion and focuses on automation by using the recognition of the blink of an eye. The principle of this article is to describe a solution that aims to help them perform the basic activities of everyday life such as open and close windows, among other tasks. Hence the idea of automating a house focusing on recognition of the blink of an eye, so that they can carry out activities that are limited due to their conditions, in a simple, practical and above all accessible to this public. However, anyone can use it, having mobility problems or not.

III. METHOD

A. Functioning of the Algorithm

The tablet's camera captures the images then the face detection algorithm using the Haar Cascade classification algorithm is triggered [3]. From there, the face characteristics that are stored in an xml file are loaded. This file contains the positive image, which represents only the object, which in our case is the face and the negative part is the background, or everything that is not object [5].

After training, each frame of images is captured by the camera, the algorithm searches for characteristics in the image based on the ones found in the database. So, it consists of making comparatives of different sizes of the image to find such aspects. The process repeats itself several times in order to reduce the error of not being found [4]. After face recognition, coordinates of the face are returned and by symmetry the eyes can be detected. After being found, it is necessary to verify if the person has blinked, with that, the sum of the black pixels in this region is obtained. If it is too

high it means that the person is with closed eyes, if it is very low it shows that they are open.

In order to find the object in an image, it is necessary to analyze each attribute that we are trying to obtain, for this it is necessary to divide the image into small rectangular pieces that are called window. The difference between the sum of the rectangular white pixels and the sum of the black rectangular pixels is made [2]. Therefore, to extract all the characteristics of the image it is necessary that these rectangles are seen in different diagonals as shown in Fig. 1.

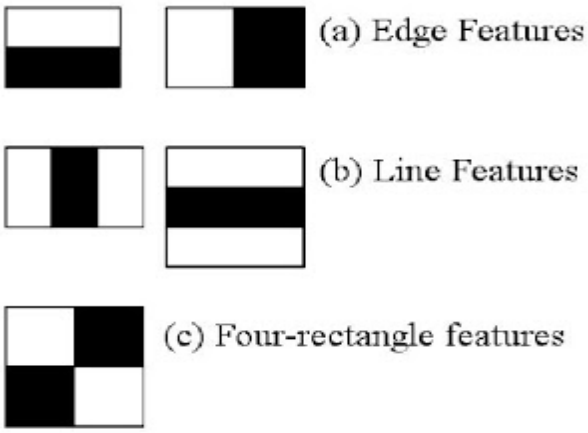

Fig. 1. Diagonal sequences (docs.opencv.org).

As the sum of all the attributes of each white and black rectangle is made, the calculation of the image integral is used. The formula came to simplify the summation where:

II(x,y) is the image integral, containing the pixels summation.

i(x,y) is the original image.

$$ii(x, y) = \sum I(x^1, y^1)$$

With all the attributes of the image captured, we can execute a machine learning algorithm called Adaboost [7]. For the code to be used, first we have to give as input some examples, which in our case are all the characteristics of the figure of our database. The code runs several times in a row, so there is a weight distribution for each of the training data.

In each training cycle a hypothesis is generated, based on their weights to be able to order the data. This is done to generate a new hypothesis so that errors can be reduced.

This algorithm aims to recognize a pattern between the positive and negative images of the database, using the characteristics that were captured. After this step, we then have a vector containing the boundary of the desired object [8].

B. Device Operation

The signal receiving device will be scattered in different parts of the house, as shown in Fig. 2, so when the user is in a certain location, as already programmed, the device will try to connect at certain intervals with the tablet by the Mac Address of which it has been configured.

Fig. 2. Image merely illustrative of how the devices will be distributed.

If there is a connection, it will be possible to know in which room the user are, and soon the functions that are available for each location (previously configured) will appear. Once the icon corresponding to the desired function is selected, a Wi-Fi signal is sent through the HTTP protocol to the server that responds with the execution of the task. The device will be in listen mode by the server to receive some notification of which function to activate [6].

This made the application smarter because it will only show the configured functions of that particular room. With the advancement of the Internet of Things concept and appliances that are each more connected, it will be possible to control each item of the residence with an eye blink.

It's important to mention the existence of three fundamental tasks in the execution of the application. The change of images in a certain interval of time; the multi-request tasks via HTTP, whose commands that will recognize the blinking eyes are sent to the database, and also, the capture of the images and their face recognition classifier and eyes blinking. These real-time tasks are essential and must be in perfect sync for proper operation, as Fig. 3 describes, showing the system architecture. If synchronization does not occur, failures and delays at time of capture may happen, generating an unexpected response.

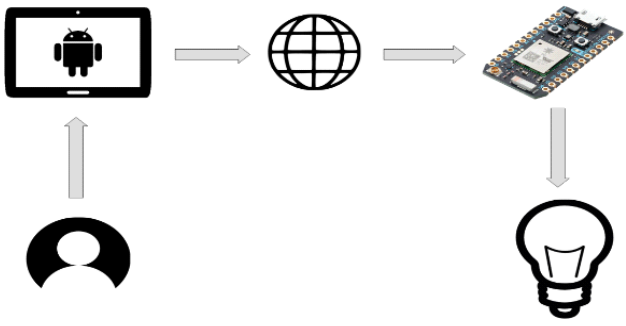

Fig. 3. System architecture.

IV. Results

The application consists of determining a function from the built-in menu when the user blinks as a way to select it. There are several functions that are performed when selecting, such as lighting a light bulb or opening windows. An icon shows each function and it is inserted every 3 seconds.

Fig. 4. Blink recognition and prototype.

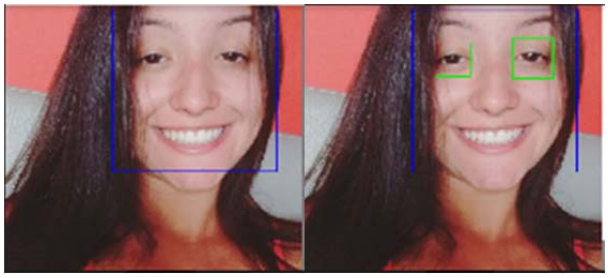

Fig. 5. Algorithm detecting the face and then the eyes.

By default, the application starts in Accessibility Mode that performs the functions described above. If disabled it is possible to use it by the touch of the device.

During the tests, it was possible to notes that Particle Photon make the server connection more stable, in addition to reducing the size of the device, replacing the Arduino board and ESP8266 module, which took up a lot of space.

With 18 kinds of analogic and digital input, we could control all other peripheric devices in the project; the same responsible to turn on a lamp, or open a door, etc. [2].

Besides the hardware, Internet of Thing can make things easier in a lot of aspects and fields of action, like science, engineering, medicine, among others. The prototype shows how important all functions are to people with locomotive deficiencies and lack of accessibility.

V. Conclusion

With the use of technology, we can do things that improve our lives and well-being of the population. Residential automation is one of them that promotes greater comfort and ease of access in all houses. It has been possible to understand, through researches and interviews with people who have certain physical limitations, that even the world is more adapted to them, is still not perfect and even in their residences there is still great difficulty to perform everyday tasks considered simple by people that do not present physical limitations.

Taking advantage of the fact that today the world have a huge amount of smartphones, we have been able to unite the practicality of automation with actions that can be controlled directly by the screen of the cell phone, by capturing the blink of an eye for people that almost do not have mobility, or even using the touch screen, for those who want to enjoy more technology.

The Internet of Things brings greater accessibility to people by causing barriers to be broken, thereby providing greater social inclusion.

For tests and demonstrations, a small-scale model (Fig. 4) was created that presents the basic functions that we proposed in our research, turning on and off lights, opening and closing a door and even a small fan. They all are triggered by an application built for Android and using a tablet's camera, recognizes when we blink.

Actually, we are working on a device that can be placed in each room of the house that the user wishes to be automated.

This device will recognize the person's presence, opening in the application the desired action options for that space itself, bringing greater autonomy and accessibility (Fig. 5).

Based on our studies, it was possible to determine that lightning is a crucial factor for a good use of the detection algorithm. If there is a lack of light in the environment, blink detection is faulty and may lead to malfunction of the solution, as the pixels end up not being classified correctly due to the low incidence of illumination.

Another point is the use of accessories such as glasses. They can also cause malfunction on blink detection. These points are to be corrected in order to bring a better version of the final solution.

Once this topic is quite comprehensive, new ideas for work and improvements can be added to this study, such as the inclusion of voice commands, the integration of wheelchair technology, among other great possibilities.

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