Prototype of a Monitoring System Based on the Arduino Platform and the Paradigm of Pan-Tilt Movement

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Received: 3 May 2021/ Revised: 16 May 2021/ Accepted: 20 May 2021/ Published: 31-05-2021

***Abstract*—** *The following article presents the implementation of a low cost property security system through the use of the Arduino Uno board, which has a reasonable processing capacity and the ability to manipulate devices that perform functions of robotics and embedded instrumentation. The programming was carried out through the Servo.h library, which follows the Arduino integrated development environment (IDE) and functions designed to read analog and digital signals. The current prototype is formed by a webcam attached to a Pan-Tilt support, composed by two servomotors and being controlled through a 2-axis potentiometer joystick that allows the vertical and horizontal movement of the prototype. The captured images were recorded using software made available by the camera manufacturer. Consequently, the laptop used in the project played the role of a digital network video recorder (NVR) while discarding the need to use a video monitor. In this way, an electronic monitoring system was obtained, capable of functioning as an effective protection instrument.*

***Keywords*— Prototype, Arduino, Servomotors, Monitoring, Web camera.**

I. INTRODUCTION

In recent years there has been a growing wave of violence in urban centers, which demonstrates the fragility of public services, especially those related to security, which come to be seen by society as inefficient in the task of providing citizens with the security necessary to the guarantee of your physical integrity.

Property security is composed of a set of preventive measures to prevent or reduce the loss of assets of certain organizations. Organizations are understood as companies and institutions, as well as condominiums and homes. Property security services include physical barriers, equipment and human resources for the defense of property and the interests of owners. A security system aims to restrict, control and monitor the access of people in union with the public system, which, with legitimacy, can use force in the imprisonment and harassment of property and individual aggressors [7].

Physical barriers are responsible for preventing access to properties. Its effectiveness can be increased with electronic intrusion detection systems and with the use of security guards. The security system must satisfy a functional aspect, which consists of controlling access points and monitoring the flow of people [7].

In this context, electronic monitoring has been presented as an indispensable tool for society, in an effective way of controlling and combating urban violence [6]. It can be said that property security makes it possible to maintain personal and material security in the face of increased crime and discredit by the population before the state public security authorities charged with containing conflicts and maintaining order in society [4].

The security systems have gradually developed over time and, together with this, the installation of camera modules. Among the different types of modules, the following are highlighted: Closed Circuit Television (CCTV) camera modules, modules with Internet Protocol (IP) technology and modules based on Web cameras. CCTV systems can be digital or analog. The digital CCTV systems present an excellent image quality because they use cameras with IP technology connected through network cables (UTP) to the digital network video recorder (NVR), which makes the images available remotely. Analog CCTV systems are the most used due to their lower cost, despite having a lower image quality. They have analog cameras connected to recording devices by coaxial cables and the images are displayed on specific monitors. Digital equipment usually has higher prices, but the quality of details of the images is much higher, which has made the use of analog systems obsolete [8].

The focus of this project is to present the development of a system capable of providing excellent image quality and low implementation cost. Unlike what happens in CCTV systems, a Laptop was used as a device for recording images at the same time that it replaced a monitor. Thus, with the use of a high resolution webcam, a system that unified the advantages present in each of the modules of electronic monitoring systems was obtained.

This article is divided into sections. The section 2 presents the stages of development of the prototype. Section 3 presents the experimental results. Section 5 conclusion.

II. PHYSICAL ARCHITECTURE

The prototype consists of one camera; one pan-tilt support composed of metallic parts and two servomotors of the Tower Pro 9G models, one Arduino Uno and a two-axis potentiometer joystick. The Arduino Uno is responsible for receiving the signals coming from the joystick, processing them and, based on the conditions present in the implemented code, defining the movement of the servomotors.

The operation of the monitoring system consists of moving the camera in different positions, which occurs due to the response of the servomotors attached to the pan-tilt support. The support is divided into a lower part and an upper part. One of the servos is located in the center of the lower part and the other between the two parts, thus allowing the support to be tilted. The camera base itself was used to fix it to the upper part using a nylon clamp. Logitech, that is the company responsible for the camera used, has its own recording application that can be used on the desktop of any laptop, which makes it extremely easy to check the images obtained by the system.

2.1 Web camera

A camera is a peripheral device that allows the acquisition of images to monitor a space in real time [2]. The items that should be considered when choosing a camera that provides good image quality are the number of pixels and the image recording speed defined in FPS (frames per second) [8]. The webcam used in the optimization of the prototype belongs to the C920 model, presenting 30 FPS and HD resolution of 720P and 1080P.

A pan-tilt camera has a motorized device attached to the camera itself, allowing its rotation according to two different axes. Varying the values of the pan and tilt angles, the camera is theoretically allowed a view from any point around it, but in practice, a limitation is observed due to constructive aspects that limit its movement by 180 ° for each servo.

Softwares can be used to perform the movement of the set composed by the camera, tilt-pan support and servomotors with the intention of keeping an intruder or predetermined mobile target within the frame of the camera, just as the device can be designed so that this movement is carried out manually through the action of patrimonial surveillance [5].

2.2 Pan-Tilt Support

The mechanical articulation used in the assembly of the prototype is of the pan-tilt model, which confers two degrees of freedom of movement. The term “Tilt” refers to vertical movement and the term “Pan” to horizontal movement, in other words, there is a panoramic and tilt control that allows mobility similar to that of a human head.

Each degree of freedom represents a possible axis of movement with the Cartesian system being one movement on the x axis and another movement on the y axis. Each axis receives its respective servomotor, which is responsible for executing the movement and positioning the parts [2].

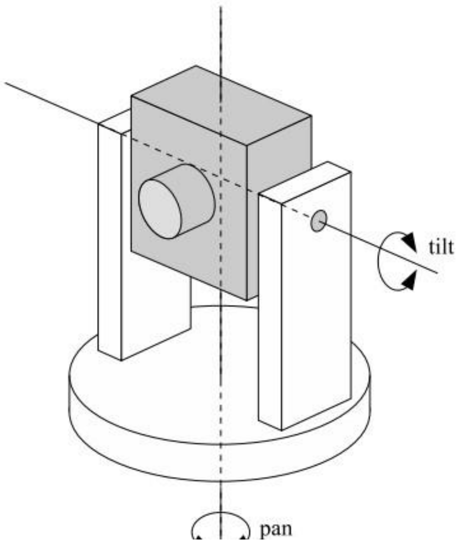

FIGURE 1: Pan-tilt scheme and its rotationaxes [5].

When the base servo moves, it causes the top servo to rotate, and when the top servo moves, its arm swings back and forth [3].

2.3 Servomotors and Potentiometer Joystick

Servomotors are used in applications that require precise and controlled movements. The servomotor is basically made up of five different elements: control circuit, potentiometer, motor, gears and the servo box.

- The control circuit is responsible for monitoring the position of the motor shaft and its activation;
- The potentiometer is used for monitoring and maintaining the position of the servomotor shaft;
- The motor is the element responsible for converting the incoming electrical energy into mechanical energy, which results in torque and shaft movement;
- The gears that make up the servo motor are reductions responsible for reducing the rotation of the shaft, transferring greater torque to the main output shaft. When attempting to forcefully move the positioned and properly powered servo motor, an opposite torque appears in order to maintain the axis position;
- The servo box is the housing that holds all the elements of the servomotor.

A servomotor has three wires: a red that must be connected to the positive 5 V, a black or brown that must connect to the ground and a white, yellow or orange, which must be connected to a digital pin on the Arduino Uno. The manipulation of the servo motor is performed through a signal in pulse width modulation (PWM), which is a technique used to obtain analog signals through digital devices. A voltage ranging from 0V to 5V can be simulated by changing the amount of time the output remains at high level (on) and low level (off).

The Arduino has pins that perform the PWM function by sending a square wave that can have different pulse widths. It can be understood that the signals coming from the pins oscillate between on and off very quickly. Pulse width is defined as the length of time that an output remains at a high level. The duty cycle (or power cycle) is used to describe the fraction of time that a system is in an "active" state and is given in percentage values [3].

The signal in PWM assumes discrete values because it is digital and in the case of the servomotor, it assumes values that vary between the values of 0V and 5V. The period of time that the signal pulse remains is what defines the command for positioning and not the voltage value. The monitoring performed by the servo control circuit is for a total period of 20 milliseconds, where a 5V signal for 1 millisecond corresponds to the axis position at 0° degree, a 5V signal for 1.5

milliseconds corresponds to the axis position at 90 ° degrees and a 5V signal for 2 milliseconds corresponds to the axis position at 180 ° degrees [2].

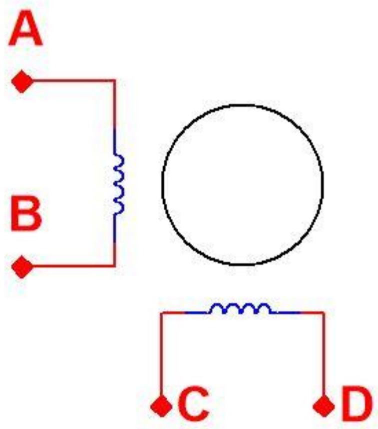

FIGURE 2: 9G Stepper motor configuration [11]

As there are 2 stepper motors for precise positioning of the capture camera, mathematical and physical analysis of the stepper motor composition becomes necessary. Physically, the stepper motor is composed of 4 primary coil windings with a magnetite magnet in the center as shown in figure 2. As we connect the Arduino, the coil energizes and transforms the winding into an induced magnet, generating a constant magnetic field, because the current we adopt for operation is continuous. In this way, we inject pulses and direct current over a specific period of time.

A potentiometer joystick can be understood as a joystick formed by two potentiometers, positioned at right angles. The axes of the potentiometers are connected to a bar that can be moved in two directions, using the joystick, and which returns to its central position, thanks to a set of springs. The connection is defined on the external pins of the two potentiometers that must be connected on the 5V and on the ground and the central pins that, in this case, were connected to the analog pins of the Arduino UNO. This joystick model does not have a pin to receive the signal obtained when pressing the push button contained in it [3].

2.4 Arduino Platform

Arduino is an open source microcontrolled platform based on the ATmega328P that was created in 2005 by students from the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. The Arduino UNO is a board that has 14 pins of digital input / output (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power connector, an ICSP connector and a reset button [10].

The connection to a personal computer (PC) or Laptop takes place through a USB port and provides outputs of direct current voltages of 3.3 V, 5 V and 9 V (when the power is supplied through an external source) and that can be used in low consumption auxiliary circuits. The board is not just a passive data acquisition interface, being able to operate in the control of devices that interact with the environment and in the execution of applications related to robotics and embedded instrumentation [9].

The Arduino UNO integrated development environment (IDE) has open source tools, that is, they are available for editing by experienced programmers and the programming language used can be expanded through libraries in C ++. Arduino boards are relatively inexpensive compared to other microcontroller-based platforms and feature a Creative Commons license, which authorizes circuit developers to create their own versions of the module, extending and improving it [10].

III. EXPERIMENTAL RESULTS

The prototype presents the expected results and is able to meet the needs required in the process of monitoring assets. The camera was attached to the top of the metal support as shown in the figure below.

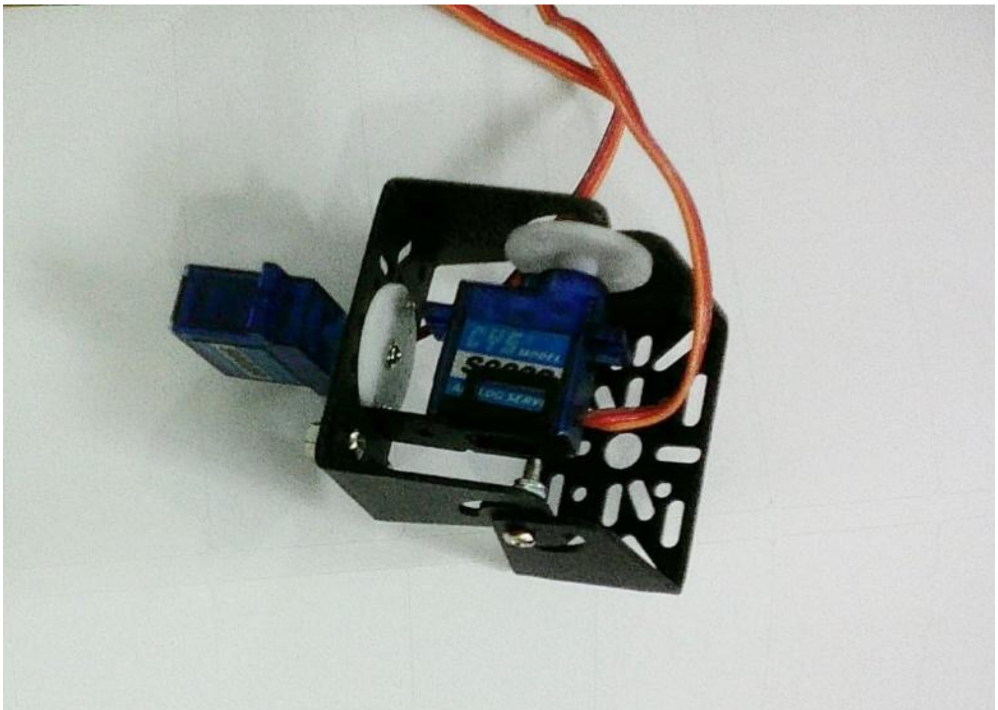

FIGURE 3: Pan-tilt support and 9G servo motors [11].

Both the joystick and the servo motors were connected to the GND and VCC pins on the Arduino board. The joystick pins responsible for moving the x and y axes, respectively, were connected to digital ports 7 and 8 of the microcontroller. The servo motor located at the base of the support was connected to the analog pin A5 and the servo responsible for tilting the upper part of the support, and consequently the camera, to pin A4. The programming was carried out through the Arduino IDE and using the "Servo.h" library. As shown in figure 4.a, two objects (servox and servoy) were defined, one for each axis and through the "attach" function, digital pins 28 and 29 were defined to receive the provenient signal from each of the servos.

```

const int xPino = 1;
const int yPino = 0;
const int servoxPino = 28;
const int servoyPino = 29;
int xValor;
int yValor;
int X_pos = 90;
int Y_pos = 90;

void setup() {
  pinMode (xPino, INPUT) ;
  pinMode (yPino, INPUT) ;
  servox.attach(servoxPino);
  servoy.attach(servoyPino);
  servox.write(X_pos);
  servoy.write(Y_pos);
}
```

FIGURE 4 (a): Code implemented in the project [11].

The values of the potentiometers that make up the joystick vary as the component is moved to any side. As each axis of the potentiometer has been assigned an analog pin, these values were continuously read using the "analogRead' 'function and assigned to position variables. Using the "write" function, these variables were used to define the position of the servos as shown in figure 4.b.

```


void loop() {
  xValor = analogRead(xPino);
  yValor = analogRead(yPino);

  if (xValor < 400) {
    if (X_pos < 10) {

    }
    else
    {
      X_pos = X_pos - 5;
      servox.write(X_pos);
      delay(50);
    }
  }

  if (xValor > 600) {
    if (X_pos > 100) {

    }
    else
    {
      X_pos = X_pos + 5;
      servox.write(X_pos);
      delay(50);
    }
  }
```

FIGURE 4 (b): Code implemented in the project [11].

It was observed that at the starting point the value of each of the potentiometers that make up the joystick had a value of approximately 517 in each of the ports. Based on this characteristic, four conditions were defined, two for each axis, so that the servos could be moved through the continuous increment of values to each of the position variables as shown in figures 4.b and 4.c.

```


  if (yValor < 300) {
    if (Y_pos < 10) {

    }
    else
    {
      Y_pos = Y_pos - 5;
      servoy.write(Y_pos);
      delay(50);
    }
  }

  if (yValor > 600) {
    if (Y_pos > 100) {

    }
    else
    {
      Y_pos = Y_pos + 5;
      servoy.write(Y_pos);
      delay(50);
    }
  }
}
```

FIGURE 4 (c): Code implemented in the project [11].

The flowchart described in figure 4 describes the data flows, the processing and the decisions that allow the reading of the acquired data by means of the signals coming from the joystick potentiometer and execution of the movements of the servomotors.

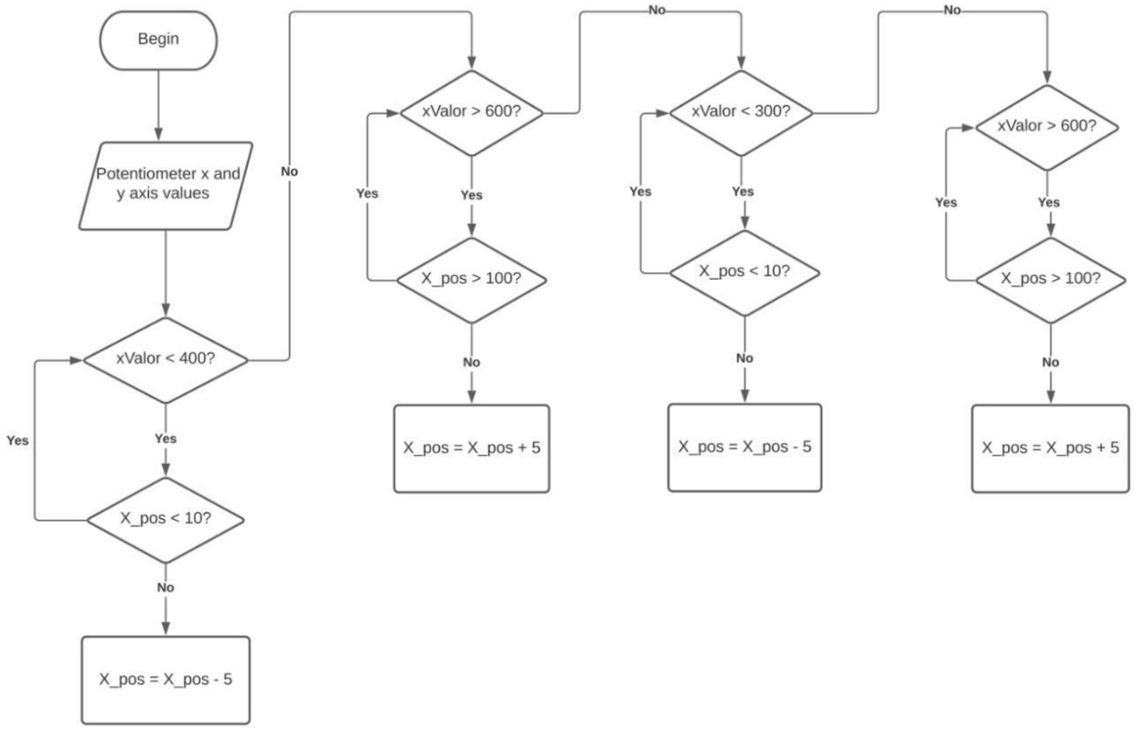

FIGURE 5: Flowchart of the developed code [11].

Thus, it was possible to position the camera in fixed positions even if the joystick returned to the initial value. Figure 4.4 shows the final assembly of the project.

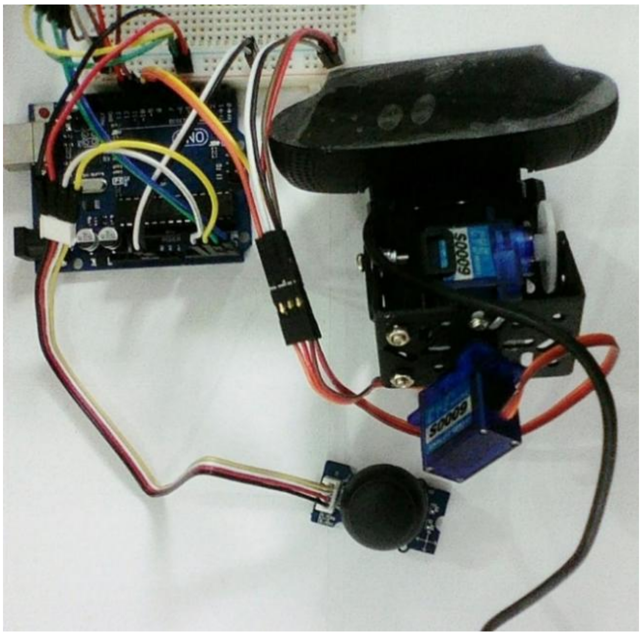

FIGURE 6: Assembled prototype [11].

IV. CONCLUSION

The purpose of the prototype developed in this article was to implement a low-cost and a easy-to-handle property security system. For this purpose, the Arduino UNO platform and its ability to control servomotors through a code developed by the authors were used. The servomotors, as they are coupled to a pan-tilt support, allowed mobility in two different axes through the manipulation of the potentiometer joystick. The camera used has an excellent image capacity and when attached to the pan-tilt support, it described a movement similar to a human head, which allows it to efficiently monitor an environment. The images are recorded on a laptop using software provided by the camera manufacturer.

In order to improve the prototype presented in this article, the intention is to use image processing, giving more autonomy to identify incompatible elements with a pre-realized mapping of a given space. In addition, the implementation of communication between Arduino and external components in order to design integrated devices that can function as alarms or to perform the sending and storage of data when the devices are connected to the internet or locally.

The results presented were promising, contributing satisfactorily to the surveillance systems.

ACKNOWLEDGMENTS

The authors would like to thank the Control and Automation Laboratory (Laboratório de Controle e Automação - LACA) and the Technology and Innovation Research Group (Grupo de Pesquisa em Tecnologia e Inovação - GPTI) for their support in the development of the Monitoring System Prototype Based on the Arduino Platform and the Pan-Tilt Movement Paradigm.

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