Simple Harmonic Motion: First project from Digital Images Processing Course

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***Abstract*—Simple harmonic motion is the repetitive motion that a mobile follows on a fixed trajectory and during a defined time interval. Through the implementation of a homemade simple pendulum and the use of a digital image processing tool such as the python OpenCV library, it is verified that the simple pendulum meets the conditions of simple harmonic motion. The following describes the process carried out, the findings obtained and the conclusions that this academic practice leaves.**

***Index Terms*—Digital images processing, Python, OpenCV library, Simple Harmonic Motion**

I. Introduction

The oscillations of a system in which the net force can be described by Hooke's law are of special importance, because they are very common. They are also the simplest oscillatory systems. Simple Harmonic Motion (SHM) is the name given to oscillatory motion for a system where the net force can be described by Hooke's law, and such a system is called a simple harmonic oscillator. If the net force can be described by Hooke's law and there is no damping (by friction or other non-conservative forces), then a simple harmonic oscillator will oscillate with equal displacement on either side of the equilibrium positions [1].

As a part of a course in digital images processing we performance a project in order to demonstrate the characteristics of simple harmonic motion in a homemade simple pendulum using the resource provides from python and the library OpenCV.

II. Description

1) Making a pendulum: For the elaboration of the pendulum, a dark blue anti-stress ball is used, supported by a thread from a support separated from the wall approximately 20cm.

2) Recording a video: The video was recorded through the 64MP camera of a Xiaomi Mi 11 Lite cellphone. The video was recorded 50 cm from the ball. As background there was a white wall and in the lower part there was a ruler on the support table in order to have a spatial relationship and have a point of reference.

3) Processing the video: Video processing was done through the OpenCV python library using Skyper as development environment (IDE).

- Uploading video: The video was loaded using the method load the video, the VideoCapture() method was used, which allowed the video to be separated into frames (30 frames per second).

- Processing each images: In order to determine the center of mass of the ball in each frame, a processing was carried out on each image. Initially, each frame was cut so that the support table and the rule were not included, then basic expansion and erosion operations (3 of each one) were made as a prior treatment to determine the contours and the center of mass through from the findContours() and moments() methods.

- Transforming variables: After defining the rule() method and carrying out its application, it became clear that one centimeter was equivalent to 8 frames. With this relationship, the transformation of the position variables in x and y in centimeters was made. In addition, using methods to find the minimums of the variable x and the maximums of the variable y, a conversion of the values was made so that all the variables had the point 0.0 as a start.

- Creating graphics: Through the plot() method of the pyplot library of matplotlib, the graphs that related the positions in x and y with time were made. To graph the speed and accelerations vs. time, a method was carried out to calculate the delta of the position changes of two frames and thus obtain a vector and its magnitude.

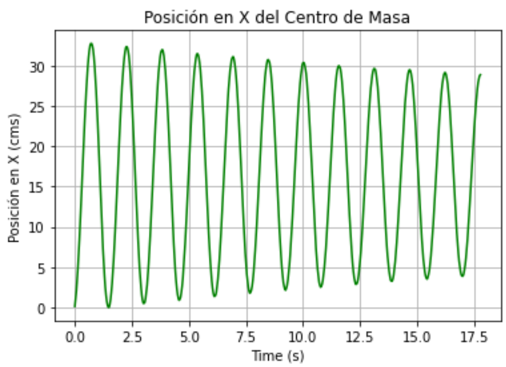
- Values on screen: To draw on the screen the center of mass and the values of velocity and acceleration, a method called upload_video_and_paint() was created. This method computed the parameters and then drew them at position (80,50) on the screen.

- Main method: The execution of the application starts with the main() method, which in turn calls the methods to load the video, process and transform the variables, and graph the relationships of position, velocity, and acceleration over time. Finally, it calls the graphic_mas() method where a graph is presented that supports that the movement of the pendulum is a simple harmonic motion.

III. Result

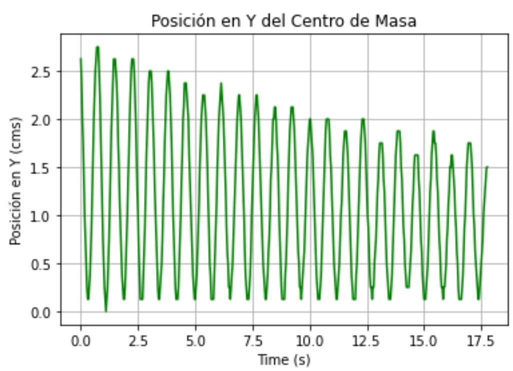
When executing the main() method of the program, 5 graphs were generated. Position in x and in y, velocity and acceleration all related to time (s). Also the graph of movement in x vs time of the first 4 seconds of the video.

1) Position in x vs time: : It shows the relationship of the position in x in centimeters vs the time in seconds.



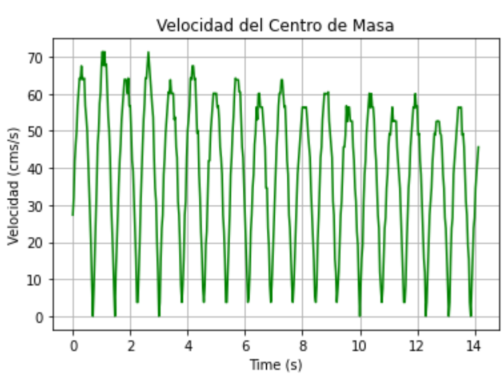
Position in x vs time

2) Position in y vs time: : It shows the relationship of the position in y and the time.



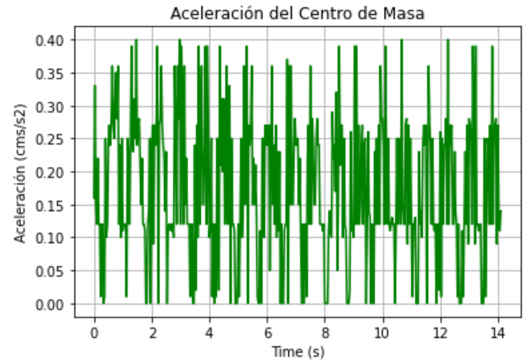
Position in y vs time

3) Speed vs time: : It shows the relationship of the speed and the time.



Position in y vs time

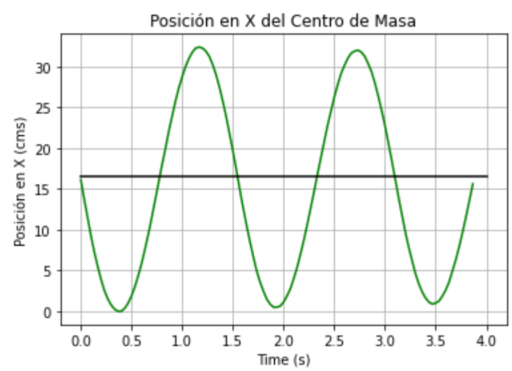
4) Acceleration vs time: : It shows the relationship of the acceleration in y and the time.



Position in y vs time

5) Position in x vs time: : It shows the relationship of the position in x vs the time in the first 4 seconds, in order to show the characteristics of harmonic simple motion:

- The amplitude of the magnitude that oscillates, that is, the maximum displacement with respect to the equilibrium position, is constant.
- The position ”x” as a function of time ”t” and denoted as x(t), is described by a sinusoidal function.



Position in y vs time

IV. Analysis

Reviewing the graphs obtained, compliance with the characteristics of the simple harmonic motion in continuous frames and with a duration of less than 4 seconds is evidenced, given the friction of the air, gravity and other physical phenomena, the pendulum made shows deceleration and changes in its amplitudes. and periods until reaching a rest position. The video is only 17.5 seconds long, therefore the arrival to its state of rest is not evident.

If the necessary conditions to carry out an experiment can be ensured by excluding the aforementioned variables, perhaps all the characteristics of the HSM could be observed.

V. Conclusions

- The simple pendulum describes the characteristics of a simple harmonic motion.

- The use of openCV library allows video processing and generates through various methods the necessary variables to make physical calculations of simple harmonic motion.
- It is possible to improve the experiment taking into account all the physical factors involved in it.

References

[1] U. of Iowa Pressbooks, “Simple Harmonic Motion: A Special Periodic Motion.”