Automatic slider for cinematography with two degrees of freedom

Diego Farinango
Mechatronics Engineering
Engineering Faculty of Applied Science
Technical University of North
Email: dafarinangoe@utn.edu.ec

***Abstract*— The construction of an automatic slider for cinematography with two degrees of freedom, which allows to make a technique called time-lapse, very popular in cinematography and photography to show different motives or events that usually happen to Very slow and imperceptible velocities to the human eye. This automatic slider allows to have two movements, translation and rotation, through stepper motors, which are handled by means of a touch screen, which displays a menu with four motion options, and respectively the variables to be controlled: speed and distance.**

***Keywords*— Time-lapse, speed, position, movement, rotation, translation, cinematography, photography, degrees, engines.**

I. INTRODUCTION

Recognizing that technology is a great help, nowadays time-lapse, is a very popular photographic technique used in cinematography and photography to show different motifs or events that usually happen at very slow speeds and imperceptible to the human eye.
Currently the Ecuadorian cinematography has a lack of precision and accuracy, which influences the veracity and control of the image before its edition for short films and quality films. The lack of an automatic slider due to the high cost of the motion controllers results in a time-lapse of low audiovisual quality, generating lack of precision and accuracy in the film production.

The time-lapse when done with the automatic slider will create a specific narrative with dynamic editing rhythms to obtain an audiovisual perspective of better quality being a unique production status.

II. SLIDER DESIGN

The study of the mechanical system for this prototype will begin with the analysis of the structure and the mechanism, taking into consideration for its design the following: it must support a weight of 80 N and allow a fluid dynamics of the movement when sliding, giving as a place to frames of quality to be edited and have improvements in time-lapse.

A. Cantilever beam condition

The elastic curve is the principle for the study of the deformation of the axis, which is known as the distance that it has from the axis to the curve of deformation that is formed and is called arrow, giving rise to the condition of equation (1) that serves for axes with props in cantilevers [6].

$$f \leq \frac{L}{500}$$
$$f \leq \frac{697mm}{500}$$
$$f \leq 1.394\ mm$$

B. *Calculation of elastic deformation on the slider axis*

The diameter and material of the shaft for this slider must comply with the condition of equation (1), where the value of 1,394 mm should be the limit of the deformation of the shaft to support the weight, but it is preferable that the deformation is as little as possible to avoid fracture of the axles or incorrect slippage of linear bearings to obtain a fluid velocity in the travel of the carriage. For this elastic deformation calculation, the following equation (2) is used, which has as condition 0≤x≥L / 2 when the calculation of the strain curvature is in the middle of the beam, in this case the axis [5] and [7].

$$y_{máx} = \frac{P * L^3}{48 * E * I}$$

$y_{máx}$ =Elastic deformation of the curve
P =Axial weight or force
L =Bar length
E =Modulus of elasticity of the material axis
I =Inertia of the shaft section

$$y_{máx} = \frac{(39.2\ N) * (0.697m)^3}{48 * 210\ GPa * 7.854 * 10^{-9}\ m^4}$$
$$y_{máx} = 0.168\ mm$$

This value of the maximum deformation is smaller with respect to the initial condition of the arrow f = 1.394 mm, because it is an axial load in a single point. In this case the weight will be supported in two linear bearings that alleviates the load because it is supported in two points.

$$y_{máx} = \frac{(19.6\ N) * (0.697m)^3}{48 * 210\ GPa * 7.854 * 10^{-9}\ m^4}$$
$$y_{máx} = 0.084\ mm$$

The value of the force that supports the plate is distributed in four points, which become the linear bearings that allow the sliding on the axis. As a result, the maximum deformation of the elastic curve is less than the condition of supported cantilevered beams, with an axial force of 19.6 N in each linear bearing that is the point of support of the plate that will support the total weight of 78.4 N.

C. Material Selections for the Slider

This standard steel AISI 4340 (705), is a molybdenum steel plus chromium and nickel. Molybdenum has a limited solubility and is a good carbide builder. It exerts a strong effect on the hardenability and in a similar way to the chromium, increases the hardness and resistance to high temperature of the steels [4]. The mechanical characteristics of this standard steel for the slider guide shafts are presented in Table I and are as follows:

Table I
Mechanical properties AISI 4340

Tensile strength	*90–10kg/mm²*
Yield strength	*70 kg//mm²*
Elongation, A5	*min 12%*
Area reduction, Z	*min 45%*
Impact resistance, KU	*aprox. 20J*
Hardness	*270 -330 HB*

This steel is part of the guide for displacement linear ball bearings, supporting the weight of 78.4N.

Prodax, is a high-strength, hot-rolled aluminum alloy, which is made thermally treated round bars and planks [4]. Prodax has the following characteristics, which make it suitable for various types of tools, especially molds for plastics:

• Excellent machining
• Under weight
• High thermal conductivity
• Good stability
• Good resistance to corrosion
• Suitable for surface treatments

This material is used for the construction of the support parts for the shaft, the supports where the entire slider rests.

Table II
Mechanical Properties Duralumin

Plates thickness	Resist. to tensile N / mm²	Creep limit N / mm²	Límite de fluencia
> 10 – 50	590	550	550
> 50 – 100	570	520	520
> 100 - 150	550	500	500
> 150 - 200	535	485	485
> 200 - 300	430	365	365

D. Arduino Mega 2560 microcontroller card

The Arduino Mega 2560 is based on the ATmega2560 microcontroller. It has 54 digital input / output pins, of which 15 can be used as PWM outputs, 16 inputs analog, 4 UART (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power connector, an ICSP header, and a reset button. You can simply connect it to a computer with a USB cable, an AC-DC adapter or a battery [1] and [2].

Fig. 1 Arduino Mega 2560 R3.

This microcontroller card will be of great help to develop the automatic slider, being compatible with the controller A4988 that allows to have control of the direction and speed of the motors step by step for its application and of the same way the screen TFT LCD Shield for Arduino having a interface with the user in order to have an easy handle of the slider.

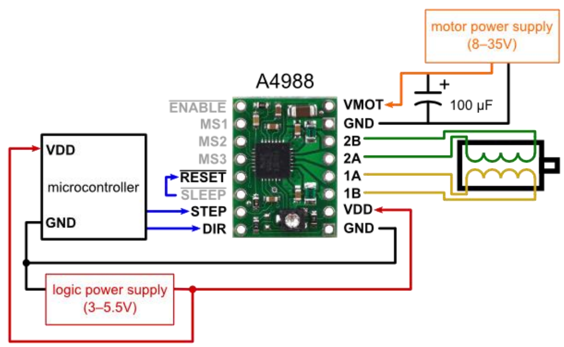

Fig. 2 Connection diagram Driver A4988.

Fig. 3 2.8” TFT LCD Shield.

As shown in Fig. 1 stepper motors connect the coils to the A4988 driver pins, to stop that 2 motors are used; the one is 9kg-cm for the sliding movement and the second motor is 5kg-cm, for the rotating movement [2].

Fig. 4 Bipolar step motor.

With the aforementioned elements, the connection diagram of the electronic part is presented below.

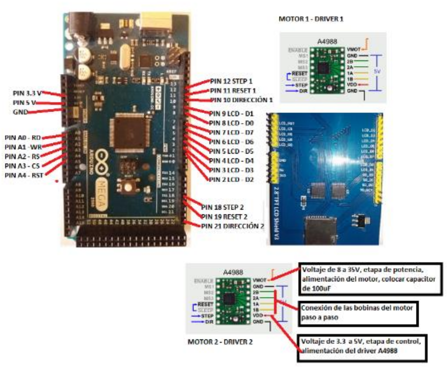

Fig. 5 Connection diagram of the electronic system.

E. Feeding system

The main observation, is the power of the A4988 controllers and the touch screen, which will be through the Arduino with a voltage of 5V. Then power the motors through the pololu controller, which has a voltage range of 8V to 35V. With the voltages that work the A4988 drivers touchscreen drivers, the Arduino Mega 2560 R3 and the motors, the power supply of the entire electronic system can be powered by two options: the first by an AD-DC adapter as shown in FIG. 6; and as a second alternative a rechargeable Lipo battery shown in Fig.7.

Fig. 6 SKYRC adapter.

Fig. 7 Lipo 3S 30C battery 11.1V 4500mmAh.

F. Company Slider vs. Company Comparison. Designed

This table III of comparison of the slider of the company with the designed slider represents the difference of the main characteristics for its correct operation, thus fulfilling the quality of cinematography works.

Table III
Main features of the sliders

Company Slipper (Movo WMS80 37 ")	Designed Slider
- It has manual control to move the slider, always pressing the steering lever	- Two types of control, manual and automatic
- To set the speed, it is done by turning a knob and thus select the speed	- Touch screen interface for better management of the filmmaker
- You have few speeds to move the slider	- Four movements that are: sliding, repetitive cycles in horizontal, rotational and combined (sliding and rotating)
- You do not have an automatic position control	- Manual and automatic position of the carriage on the axles
- It has direct current and battery power.	-Various speeds, which correspond from the lowest to the fastest
- Heavy structure	- It has two stepper motors for precision movements
- Does not have	- Power supply of direct current and rechargeable battery with longer duration
- Does not have	- Voltage control for rechargeable battery
- Too slow	- Flow of the carriage on the guide shafts
- Heavier	- Lighter structure

Fig. 8 Company slider (Movo WMS80 37 ")

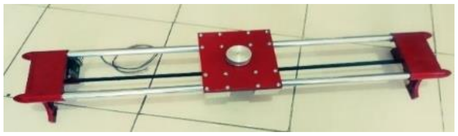

Fig. 9 Slider designed

These photographs made by the automatic slider are in the Quito social circus of the Reina de Quito Foundation. After being edited and used in a video, we have a vision of the time-lapse process, having the quality required for the work done by the slider and edited by the company HOMO DEMENS FILM.

III. CONCLUSIONS

The risk factor taken by this mechanical system in terms of precision and accuracy is that the carriage has to slide through the guide shafts, which are made to withstand the load of 80 N and avoiding a deflection of the shaft for the bearings to perform its course with fluency.

The support brackets are fundamental for the balance of the slider to avoid a fall of the same and above all give a certainty of security for the camera with which the cinematographic companies work.

It has a greater ease of communication between user and control system, to perform different movements with a touch screen, which allows visualizing the options for the slider.

The design of the automatic slider allows two ways of user, that is to say, autonomously and manually, in order to always have the same utility and at the same time dismantle for easy transport.

The quality of the time-lapse, made with this automatic slider, are of great relevance, since the main purpose is to offer quality works with the precision and dynamic flow of the frames or videos, made by this automatic slider, comparing the frames of the two sliders and watching in the videos with the movements offered by this automatic slider.

IV. ACKNOWLEDGMENTS

The author thanks God for allowing me to have dreams very high, the Technical University of the North for being the great house where I have acquired the bases and knowledge to train academically, as a leader of society and future entrepreneur.

To my parents for being the sustenance and giving me emotional support every day, to be a better person and give me the opportunity to be a competent professional, my brothers and friends for being part of this process to fulfill a goal in my life; being a professional of success and human warmth. Likewise to my tutor, for his total commitment to comply with this research plan.

V. REFERENCES

[1]. Arduino. (2016). *Arduino*. Obtenido de https://www.arduino.cc/en/Main/ArduinoBoardMega2560

[2]. Pololu. (2001). *Pololu Robotics &Electronics*. Obtenido de https://www.pololu.com/product/1182

[3]. NBS, Sistemas lienales. (1 de Agosto de 2012). Obtenido de https://www.interempresas.net/FeriaVirtual/Catalogos_y_documentos/2623/Sistemas-Lineales_NBS.pdf

[4]. Bohman, I. (2016). Catálogo de productos. Quito, Pichincha, Ecuador.

Books*:*

[5]. Gere, J. M., & Goodno, B. J. (2009). *Mecánia de materiales.* México: Cengage Learning.

[6]. Goldenhorn, S. (2015). CALCULISTA DE ESTRUCTURAS. Hormigón armado, hierro, madera. Buenos Aires: S.E.

[7]. Gonzálvez, A. J., & Chuliá, F. V. (2016). *Diseño de máquinas.* Valencia, España: UNIVERSITAT POLITÈCNICA DE VALÈNCIA .

[8]. Ramírez, e. G., Jiménez, G. S., & Carreño, J. M. (2014). *Sensores y actuadores.* México: Patria.

VI. BIOGRAPHY

Diego Farinango was born in Tulcán on May 1, 1989. He performed his secondary studies at Instituto Tecnológico Superior Bolívar. I study in the Technical University of the north in the career of Mechatronics Engineering year 2017.