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TECHNICAL MECHATRONIC SOLUTION FOR FILMING EFFECTS FOR DSLR CAMCORDERS

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Abstract: *The article presents a solution for developing the "travelling" effect on short distances (1 m). The paper presents aspects directly related to the mechanical parts, the control unit and the software written for a microcontroller. The tested device includes a guided path similar to the ones used in numerical command machines that have the gliding trailer powered by step motors with a linear geared rack. The device can displace the camera with a high precision and makes a direct correlation between the travelled distance and the time passed so that it can create high quality effects of time-lapse travelling.*

Key words: *mechatronics, stepper motor, cinematography, DSLR, Dolly system.*

1. Introduction

The new developing market for image and video devices is constantly trying to offer new and improved solutions for products that can offer comparable performance with professional devices used in cinematography [1]. An impressive filming effect is that of time-lapse picture that can be made with any type of DSLR camera mounted on a special displacement device.

This filming effect technique requires that the frequency at which the frames are captured (frame rate) to be much smaller than the frame rate used when showing the final movie [7].

The effect is seen when the captured images are presented at regular speed so that the viewer has the feeling that time passes by very fast. As example when capturing frames at a 1 second interval and exhibit the film with a rate of 30 frames per second the viewer will have the impression that the video runs 30 times faster than the real life events familiar to him [3].

The time-lapse effect is therefore considered the reverse of the high speed effect [4].

The combination of the time-lapse effect with the travelling effect is possible only in the case when the camera is moved with a very slow speed of less than 100 mm/min at constant speed [5].

The actual technical solutions proposed for the development of such a device will be presented in the following paragraphs [2].

2. The Developed Devices and Methods of Checking

The device was projected and manufactured using equipment from Advanced Mechatronic

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Systems Department. Figure 1 represents the whole system, from which: the profiles guide (8) on which the gliding slide will move, the gliding slide it is mounted the holder (1) for the DSLR camera. The step motor (3) command is made through micro-stepping by the controller (6) powered by the battery (5). The rotation movement from the step motor (3) is converted through transmission in linear displacement with the help of the rack-pulley system (9). The rack is a toothed belt fastened on the tensioning elements (2). The entire system is supported on 3 placement points (10) in order to have a higher stability. Two of the placement points are at the edges of the rotational arm (4), and the third is at the edge of the left end of the guide support. For an easy manipulation of the device a textile carrying belt (7) was foreseen.

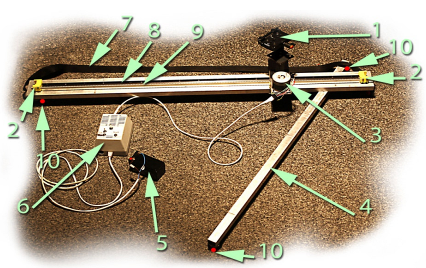

Fig. 1. *Guiding system with electric driving slide: 1 - mounting holder for the DSLR camera; 2 - tensioning elements of the toothed belt; 3 - step motor; 4 - rotational arm for stability of the device; 5 - power battery of 12 V and 700 mAh; 6 - microcontroller with user interface; 7 - carrying textile belt; 8 - profile guide; 9 - toothed belt representing the transmission rack; 10 - the three placement points of the device*

The operation diagram of the studied technical solution is presented in Figure 2.

In Figure 3 it is presented the driving element and the pulley-rack transmission. The step motor (1) is mounted on the guide slide. The displacement of the slide is made

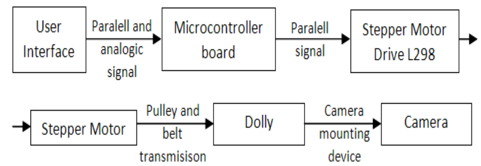

Fig. 2. *Operation diagram of the device*

by the pulley rotation (2) that comes in contact with the toothed belt (3). The two wheels (4) aim to guide the belt in a parallel position with the guide. In order to minimize the friction, the wheels are foreseen with ball bearings [8].

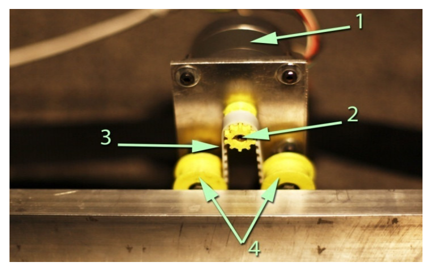

Fig. 3. *Driving system: 1 - step motor; 2 - pulley mounted on the motor shaft; 3 - tooth belt; 4 - belt guide wheels with ball bearings*

In Figure 4 it is presented the controlling box with the ports that can be modified, the power switch (3) that allows the system

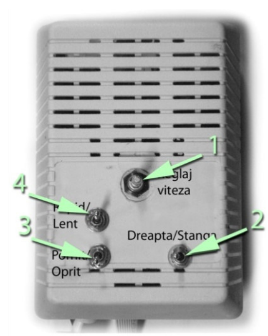

Fig. 4. *Controller box: 1 - potentiometer for fine adjustment of speed; 2 - switch to set the movement direction (left/right); 3 - power switch (on/off); 4 - switch to set the speed level (high/low)*

to receive energy. By using the potentiometer (1) it can be adjusted the moving speed of the slide with the DSLR camera mounted on it. To increase the belt speed but also maintain the precision of the setting, the switch (4) allows the use of two speed levels "fast" or "slow". The switch (2) is meant to allow the user to set the movement direction from left or right.

3. Controller Description. Optimization of the Electronic Part

Following the requests of the project it was chosen the microcontroller ATmega8 that could provide command for both the step motor used to move the camera on the guide and realize the interface of the user settings.

The first tests were made using the standard solution shown in Figure 5, were the microcontroller sends tact and direction signals to the circuit L297. The circuit L297 realizes the command sequence on the inputs of the H bridges from the amplification circuit L298 how's outputs are connected to the two phases of the step motor.

To achieve an optimized printed circuit for the electric assembly, the electronic schematic was improved by replacing the L298 circuit with a complex algorithm implemented in the microcontroller that commanded the step motor [9].

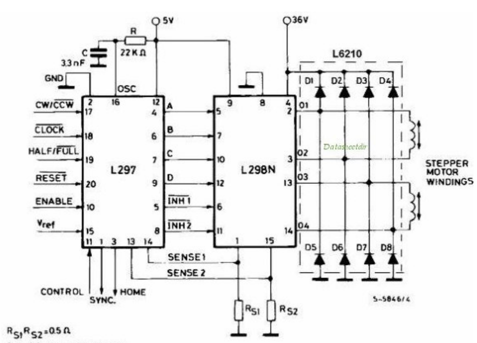

Fig. 5. *Standard schematics of the step motor command using the L298 driver*

4. Elimination of the Problems Related to the Accelerations Induced to the Camera when Moving with One Step

The camera displacement system must provide a movement of the filming device in such manner that the beginning of the movement must be made with a foreseen acceleration that will ensure a uniform displacement and the stopping of the movement must be made with a precise deceleration.

Initial calculations showed that the linear displacement distance required for one step is 0.25 mm used at the simple command of the step motor. This displacement rotates the driving pulley with an angular displacement of 1.80 degree.

For the situation of the mix command of the step motor, the step distance is reduced by half to a linear length of 0.125 mm.

Even so, the step of 0.125 mm is not small enough for the requirements of the image quality desired in filming effects. Since the accelerations and decelerations during the displacement of one step are high, the fixing of the camera on the glide requires a special attention. In the first tests the fastening of the camera and the slider was made by using a support made of aluminium sheet with thickness of 3 mm. Since large accelerations are developed during the displacement of one step and the elasticity of the holding system for the camera on the slider, the value of the amplitudes of the camera oscillations were often larger than the displacement step. This problem was solved by modifying of the holding system by using a rigid steel fastening system.

The rigid fastening system improved greatly the behaviour of the system but the further improvements were needed by shrinking of the step distance and increasing the step resolution. This request was possible by implementing the following methods:

Mounting of the gear box will allow the shrinking of the step value with 1/5th of the 0.125 mm distance.

5. Command the Step Motor to Work with Micro-steps

Since gear box mounting would involve a growth in the production time and costs of the product the second method of micro-step command of the step motor was chosen as the reliable solution.

By a micro-step command it can be divided the step distance of 0.25 mm in 16 intervals resulting into a step of 0.0156 mm.

The first obstacle in implementation of micro step algorithm is the generation of a sinusoidal wave using an 8 bits microcontroller. The math.h library made available by the avrlibc proofed to be not reliable to this application. During the tests made using the function *sin()* some computation errors were encountered. For the solving of the problem an Excel table was created with values of the sin function from 1 to 255. The table was included in the program as a vector, and so the values of the sin function were available with a minimum processor computation power.

This method was tested by using and open loop algorithm so that the two H-bridges connected to the two phases of the motor are activated through the PWM signals. Each step is executed after the previous by evenly divided steps in 16 levels. The drawback of this solution is that the control is made on the current and this leads to an imprecise working. For a small speed of 16 micro steps per second the solution is acceptable but for higher frequencies of larger steps vibrations are induced in the filming system similar to the mix command system.

In Figure 6 it is presented a logical structure of the algorithm. For the Next step function the logical structure is presented in Figure 7.

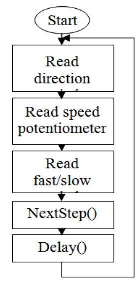

Fig. 6. *Logical structure of the main algorithm*

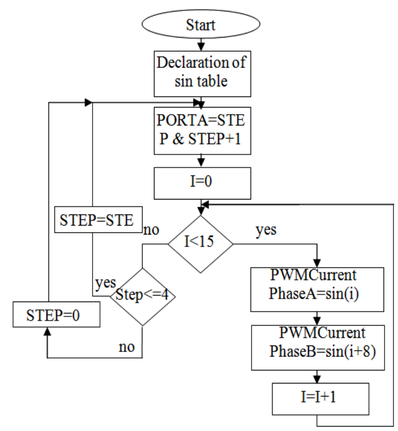

Fig. 7. *Logical structure of the micro stepping function*

6. Research Methods

The experimental research started with tests made on the controller using simple commands of the step motor and it was seen that vibrations occurred in the filming system reflected in poor image quality. A possible cause for these vibrations was identified in the activation of the internal lens stabilizer of the CANON 24-105 L cameras that lead to a very low image quality [6].

The tests made in similar conditions without the stabilizer showed that the captured images had a higher quality than previous tests but still unacceptable for the final purpose of the project. In order to develop a performance classification based on the system displacement it was used an optic sensor to measure the distance during the displacement with the following properties:

- Measuring method: optical triangulation;
- Precision: 1 µm;
- Laser class: 3 R;
- Number of points per second: 2000.

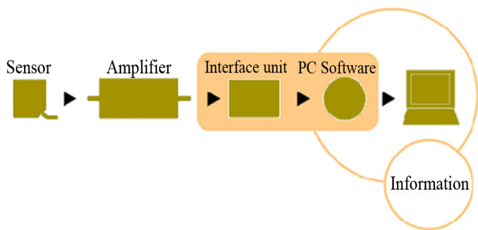

Fig. 8. *Signal acquisition of the optical sensor*

In Figure 8 it is presented the measuring mode. The electric signal that comes from the sensor that works based on triangulation is amplified, converted in digital signal and sent to the RS232 serial interface to the COM1 port with the transfer rate of 9600 bits/sec without party bit. The Smart Monitor software that runs of the computer is capable of developing an average of the signal and exports the date in a data table.

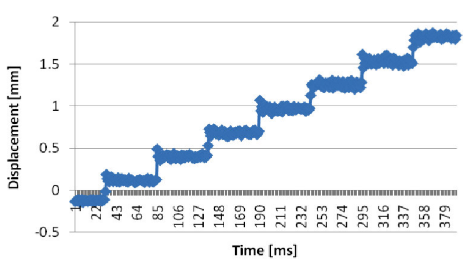

Fig. 9. *Distance time diagram for the half step command of the step motor*

Comparing the two diagrams of the displacement (Figure 9 and Figure 10) over time by monitoring the movement using the Omron Laser sensor it can be seen that in the case of the micro-steps command a more smooth displacement is achieved resulting in a more fluent movement of the filming camera.

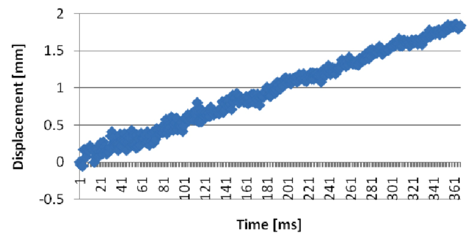

Fig. 10. *Distance time diagram for the micro-stepping command of the step motor*

7. Conclusions

Based on our research we achieved technical solutions in the development of guiding devices on a single axis for the DSLR cameras.

From the mechanical point of view the solution offers an enhanced stability of the guide since it is foreseen with three placement points. By optimization of the command solution of the driving device has led to the minimization of the controller box and a decrease of the production costs of the device.

In terms of main mechanical improvement over existing systems is that the guide is based on three points are very stable. Time status (control) is very short. To use the device is required placement of three points of support on a stable surface to the other systems where the four points of support where necessary adjusting support points every time the device is placed on another surface. L297 chip was replaced by the microcontroller algorithm development leading to design a smaller wiring. Microstepping command was made by the software algorithm, performs a continuous flow device which determines a high quality of footage.

Finally it could be concluded that the future in the image industry will provide manipulation devices that will make the DSLR cameras becoming more and more intelligent resulting into better imaging effects as well as better picture quality adapted to the filming environment.

Acknowledgements

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