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Automated digitizer of cinema tapes

Abstract

This article presents the construction, control system and automated control system software for a cinema tapes scanning system. The control interface and software have been developed at the Department of Automation and Robotics of Maritime University of Szczecin, with participation of an experienced employee of film industry. The purpose of development of the control system and software is to conduct automated scanning of frames, and copy them into computer in order to digitize the individual frames and improve their quality.

Keywords: robotized scanner, celluloid tape, stepper motor, microprocessor.

1. Introduction

Modern cinematography is growing very quickly and, in recent times, the development of this field of knowledge has evidently accelerated. Although there were several crucial moments in the history of film that have changed the nature of transmission of motion pictures to the public, i.e. introduction of sound to videos, coloured picture, and different screen formats (i.e. panoramic screens), which were admired by current customers, for modern customers these are not enough. An increase in the needs of modern viewers, craving for more and more impressions has caused the creation of, among others, digital technology for staging effects and recording picture in High Definition (HD) quality, and the greatest achievement of the last years is 3D movies.

Until the appearance of digital medium technology, the primary medium for videos was photosensitive film of different widths, i.e. 8 mm, 16 mm, 35 mm. These are now used to a lesser extent in TV and cinema, however, usually each audio-visual work has its digital version copy.

Of course there are videos which are recorded only in one copy on cinema tapes and can be played only with the use of film projectors. It is not, however, the only problem of records, sometimes priceless ones, recorded on celluloid tapes. These lose quality over time. Time destroys video media irreversibly so the records are lost. Converting video material into digital version stops this process, the quality remains unchanged comparing to original copy. In addition digital records can be easily played on not only DVD players, but also on computers, mobile phones etc. [1].

The robotized scanner for videos recorded on celluloid tape, which are to be reconstructed digitally, was designed, and the control system was built with participation of an experienced employee of film industry at the Automated Manufacturing Systems and Quality Engineering Division of West-Pomeranian University of Technology in Szczecin. The automated scanner is not equipped with an ultrasonic system for removing dust and a system for deformed tapes yet, but meets the basic needs within the scope of practical use of automatics in the field of film industry. The purpose of development of the control system and software is to conduct automated scanning of frames, and copy them into a computer in order to digitize the individual frames and improve their quality.

2. Design of a cinema tape digitizer

The digitizer, being the subject of the analysis, is characterized by a simple mechanical solution shown in Fig. 1. The construction of the device is a monolithic structure in the form of a box with dimensions: 1250×370×400mm.

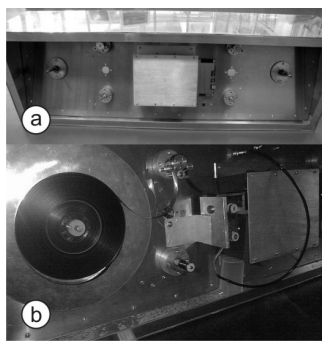

Fig. 1. Analogue video digitizer, a) the appearance of the case, b) the scanner with a celluloid tape

The box is made of duralumin with a separating front panel. On the front panel the following are placed: a film to be scanned rolled on a reel, moving rolls for films with perforation, Nikon photo-scanner and an empty reel, on which the scanned video is to be rolled. Rotating plates for mounting reels with film. Moving and pulling elements are mounted on the plate with the use of ball bearings. On the back panel the following are placed: electric power supply, control systems, driving gears with stepper motors transmitting rotation movement to neighbouring rolls through the toothed belts, shown in Fig. 2.

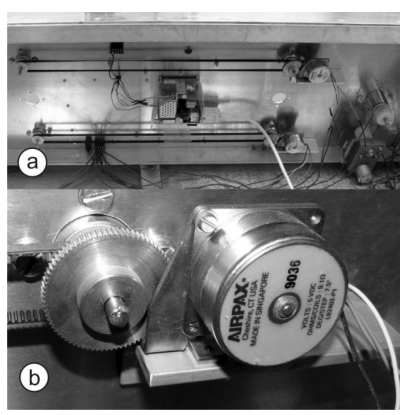

Fig. 2. Analogue video digitizer, a) the appearance of the drive mechanisms, b) stepper motor

3. Control system of the digitizer

The control system for controlling and monitoring operation of the device was developed for the automated device. The control system of the automated scanner is shown in Fig. 3.

The control system consists of a central control computer with an installed program for automatic operation and a program for scanner operation purchased together with the device.

The program for automatic operation controls the operation of a microprocessor system to which the output modules of the stepper motors responsible for precise moving of the scanned video frames are connected as well as a DC motor responsible for providing appropriate tension of the scanned video and an electromagnet module (a break) for fixing the video tape during scanning. The installed program, sending and receiving control signals to/from the output modules, controls the appropriate operation of all actuators. This program is used also to exchange control signals with the program controlling operation of the scanner.

All the control system bases of the appropriate number of output modules (controllers) are coupled together in parallel order.

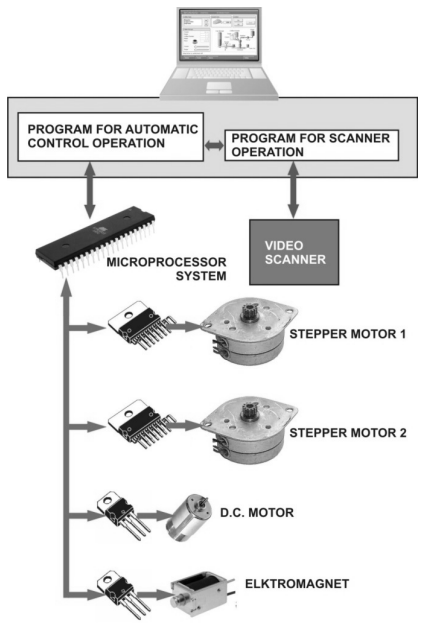

Fig. 3. Block diagram of the control system

The main task of the control system is to guarantee the operation of particular output modules as well as the video scanner in the appropriate order. The sequence and duration of operation of particular output modules depend on the characteristics, above all – the width of the scanned film. All elements of the output modules, excluding the video scanner, are placed in the back of the control cabinet plate.

3.1. Central control computer

There are three programs to guarantee the appropriate operation of the automated video digitizer installed on the central control computer, as shown in Fig. 4.

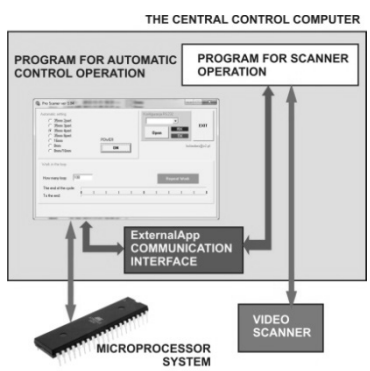

Fig. 4. The central control computer

It was necessary to develop a flexible program for control the output modules, controlling all stages of operation of the video scanner and exchange the control signals needed for the purchased program controlling the video scanner. The issue of controlling of the program for video scanning from outside was solved by development of an additional ExternalApp communication interface. The interface enabled access to and operation of the virtual buttons of the scanner program and regular exchange of control signals to/from the program for automatic control operation.

3.2. Microprocessor system

The microprocessor system is the most important element for the actuators' control. The system is based on Atmel's 8-bits ATmega32 microprocessor, as shown in Fig. 5.

Thanks to RISC architecture, the processor of frequency of 16 MHz operates stably the program implemented to the memory. The programmed microprocessor reads the orders sent by the control computer and controls the output modules through the security module.

Each module, after performance a specific sequence of operations, sends a feedback signal which next is sent by the microprocessor to the program for automatic control operation. The microprocessor system guarantees correct exchange of control signals between the program for automatic control operation and the output modules. The microprocessor system is also responsible for the defined sequence of the actuators' movements [2].

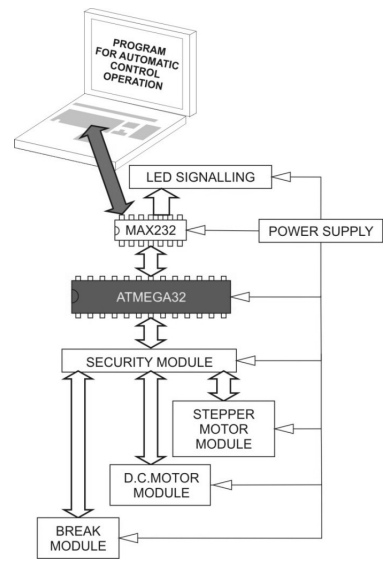

Fig. 5. The microprocessor system

3.3. Stepper motor modules

The STMicroelectronics L298 monolithic integrated circuit was used for construction of the stepper motor modules, as shown in Fig. 6.

The integrated circuit is an H-type dual bridge for control stepper motors which, cooperating with the L297 circuit, enables fluent change of velocity, change of direction and operation mode of the stepper motor (single-step and half-step operation).

The greatest advantage of L298 system is a large range of the motor power supply voltage (up to 50 V), and high max. permissible amperage acting on motor windings – (permanent current of 2 A and momentary power consumption of even 3 A). It is also possible to adjust the current for the stepper motor module. With so large values of momentary currents it is necessary to use a separate security in the form of Schottky diodes.

The stepper motor module makes it possible to control the bipolar stepper motor (the 4-wires one). Due to specific angular displacement resulting from perforation of analogue films, the AIRPAX 9036's motor was used. The motor is supplied by 5 V power supply, resistances of 9.1 Ω per motor winding and unusual unit stroke of 7.5°, which was required in order to guarantee the appropriate operation of the scanner [4].

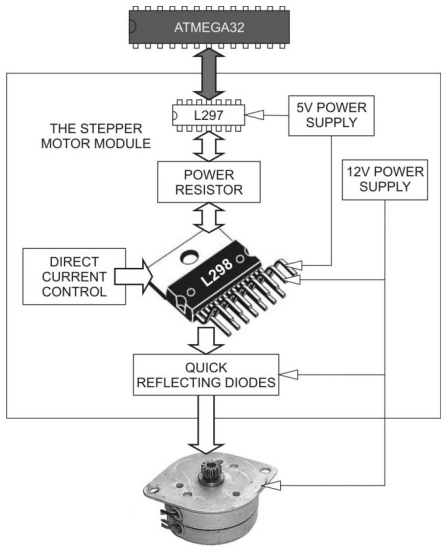

Fig. 6. Stepper motor control system

Since operation of the automated scanner involves precise inserting of the frame to the video scanner, and after scanning, removing it outside the scanner, it was necessary to use double stepper motor modules.

3.4. D.C motor module and electromagnet module

Other modules, which are subjected to control of the microprocessor system, are DC motor module and electromagnet module. The method of operation of the DC motor module is shown in Fig. 7.

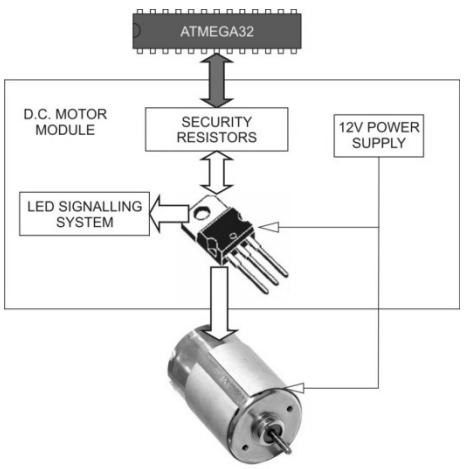

Fig. 7. D.C. motor module

Fig. 8. DC motor drive

The module is controlled by a single field effect transistor of MOSFET type, allowing for step-by-step control of the DC motor's velocity as well as direct control through microprocessor systems.

The task of the DC motor module is to roll the scanned part of the film onto the plate and to conduct the appropriate tension of the film with the use of dedicated coupling, as shown in Fig. 8.

3.5. Video scanner

A device responsible for scanning of a single frame is the NICON's COOLSCAN 5000 ED video scanner as shown in Fig. 9.

Fig. 9. Video scanner

The original enclosure of the purchased device was dismounted, and the scanning device was mounted in a central location in the front panel of the automated digitizer in order to obtain an axial position with relation to the operated film.

The video scanner is used by professional photographers, who demand both good quality and speed of operation. The device is characterized by true optical resolution of 4000 dpi and 16-bits analogue-to-digital conversion. The video scanner provides extraordinary quality and incredible scanning speed of single frame up to 20 seconds per frame. Functionality, quality and speed provided by the video scanner make it a perfect solution for the professionals working with digital images. The video scanner is characterized by high-quality CCD 2-line transducer and a new, advanced algorithm for processing images of colored negative films [5].

4. Software

The program for automatic control, developed in Delphi 7.0 software environment, was implemented to the control system of the automated digitizer. A user, prior to starting the program for automatic control, inputs data regarding the width of the frame to be scanned, and then turns on all the output modules. The appearance of the main screen of the program for automatic control, available for the user, is shown in Fig. 10.

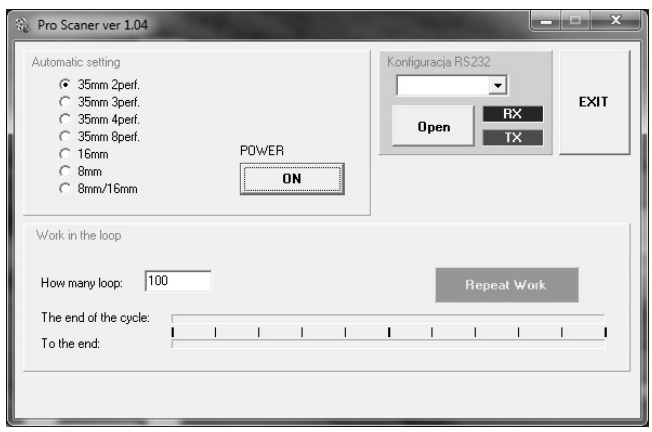

Fig. 10. Main screen of the program for automatic control

The operator communicates with the programme through appropriate input fields and buttons, where it is possible for example, input the number of frames to be scanned, pause and resume the scanning process, etc. At the same time, during operation, the program communicates not only with the microprocessor system; it also sends and receives control commands to/from the program for scanner operation. The concept of the program for automatic control is based on the main control algorithm, as shown in Fig. 11.

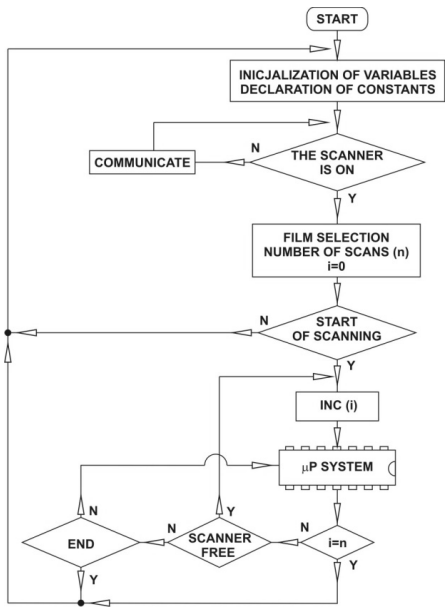

Fig. 11. The main algorithm of the scanner program for automatic control

After starting the program for automatic control, the main control algorithm will ask for turning on the video scanner in order to conduct calibration and reference positioning and then will wait for orders of the operator. The operator shall input the width of the film to be scanned and number of read-outs (scans) of the frames to be done. When pressing START, the automated process of film frames scanning will launch [3].

In parallel with the main scanner program for automatic control, it runs the Scan Image Enhancer program responsible for proper operation of the frames scanning device.

This program is to control the Nikon's scanners through a computer, preview images and adjust settings of the scanner prior to commencement of the scanning process. This allows the user to control the advanced functions supported by video scanners. The Scan Image Enhancer software enables multiple scanning (known as multitasking) and fast autofocus as well as graphical correction of the scanned frames. Thanks to in-built Digital ICE4 Advanced™ image-processing technology the video scanner makes it possible to achieve high quality and quite fast scanning [5]. An example of the scanned frame before software processing and after the digitizing process is shown in Fig. 12.

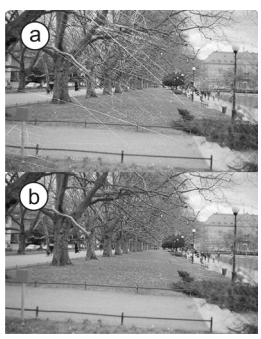

Fig. 12. Example of a frame, a) before scanning, b).after the digitizing process

5. Summary

The purpose of the robotized device designed and constructed with participation of an experienced technician of film devices is to digitize old, celluloid films in bad condition. It may also be used for montage of a movie by combining of other family mementoes (video tapes, audio tapes, photos, slides, documents). The automated scanner for digitizing cinema tapes makes it possible to conduct fast conversion of analogue to digital system together with quality improvement. The presented concept of construction of the robotized device and control system for digitizing films creates many possibilities of further development with additional modules in order to improve e.g. dusted, dirty and mechanically broken films.

Application of automatic control makes it possible to achieve better quality for a moderate price of the process conducted with professional devices for analogue film digitizing. The scanner currently operates in a private filming place, where the operator tries to save old, archive movies about Szczecin, meeting basic requirements within the scope of practical use of automatic control in the field of film industry.

6. References

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