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# THE HEMISPHERICAL SPATIAL SCANNER

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**Abstract**

The model of the hardware and software complex for 3D volumetric scanning is considered in the article. The system is important as the consumer grade decision for the design of engineering systems, such, as fire and protection systems. Design and production of this complex in low price range is actual for the market during next few years because buying opportunity of customers decreases but volume of projects to make with a 3d-scanner is invariably.

## THE PROBLEM

By developing of complex systems which functioning requires laying of cables, pipes and equipment installation in rooms, employees come up against the difficulty with calculation of the quantity of necessary materials and installation works. Firstly it is connected with the difference between floor-by-floor plan and real planning, secondly, with already installed equipment. It is not infrequent that on the way of the designed pipeline of the fire protection system there are racks with the network equipment, fixed on ceiling. Considering the need of transfer of such equipment, the implementation of the project can be late for indefinite time. It is necessary to pay attention to specifics of modeling – buildings inside consist of figures: the plane, the curved plane. It makes difference of simplicity building and transportation systems [1] modeling from modeling, for example, cars or objects of sculpture[2] and also gives a market niche for production of the consumer

grade device meeting the pointed specifics.

## Theoretical solution

The following necessary steps of modeling follow from the simplicity of the model: measuring of points in corners of rooms, measuring of points on bends of walls if those are, covering of points by the planes, creation of the curved planes on an average point, converting into the format of the editor in which distributing of communications, for example, AutoCad is conducted.

Let us break this process into two stages: a stage of measurement and data processing stage. For measuring of points the specialized equipment is usually used depending on price opportunities and on needs for speed and accuracy of measurements. It is possible to select two types of used devices:

1. Electronic tapemeasures, thus record of indications often occurs manually
2. 3D scanners of different price ranges with different extent of automation

The negative attribute of use of both types of the equipment is complexity. In the first case because of the large number of handwork directly with the tape measure, in the second with processing of a set of points for receiving of simple forms.

We will consider the main requirements which the new device has to satisfy, allowing simplifying modeling process.

- Accuracy. For modeling of rooms it is enough in 1cm.
- Speed. It consists of speeds of definition of the necessary point in space and speed of measurements. The higher, the better.
- Coverage. The opportunity to pass the greatest possible volume by means of the device. Similar to speed, maximum.

It is expedient to divide the development into two parts: the hardware including directly the device for measurements of space and the software – the handler of the received indications.

The hardware of work is based on the laser range finder fixed on a mobile construction, giving to the sensor of distance 2 degrees of freedom for 180 degrees round two perpendicular axes.

As there is rather small amount of the points demanded for modeling, it is possible to execute manual control by the device, however, by carrying out of large volumes of works it is labor-intensive. It is offered to optimize measurement process by means of intellectual algorithm of search of contours of the room. The advantage of the automated approach is reduction of number of manual skills of the operator at the same output result. As for disadvantages it is necessary to point out that the system requires to control the automatic

process and, if necessary, to correct as the part of contours can be missed.

The most difficult and expensive device of the hardware of the scanner is the laser range finder – the device measuring the distance to a point in space. Use of the optical sensor working in a visible range of radiation (650 nanometers, red) is supposed. A point to which the distance will be measured, is easy to see. The system of targeting of a beam has to consist of servo-drivers on the basis of step electric motors and mechanical accessories. One of servo-drivers has to rotate the mirror located at an angle of 45 degrees to a beam of the laser, round the axis which is set by the falling beam. Thus, the laser beam can be directed in the range of 360 degrees, however, due to design features of installation, it is impossible because of presence of a framework on which there are the range finder and the drive located, that is why the restriction of 180-250 degrees is quite appropriate. This construction has to be located on the basis rotating round a vertical axis, and be set in motion by the servo-driver. For control of servomotors, reading indications from a laser range finder, indication and management of power supply of the device the microcontroller has to be applied. Also, on its basis it is supposed to carry out the analysis of obtained data for allocation of contours. The development of the system on the basis of the storage battery and the power supply from the alternating current main 100-240B is supposed due to necessary mobility of the device.

The software part of the scanner has to work at the portable personal computer with OpenGL technology support. The main functions of the software part have to be executed by means of Qt's, and software language of C++.

It is possible to execute communication of hardware and software in two time keys: the real time and the postponed data processing from the device. In the first case the connection should be carried out by means of a stack of the TCP/IP protocols through the standard network 802.11g/n - compatible or by means of the USB interface. In the second case the preservation on SD/SDHC memory card, and the subsequent unloading of data on any computer is possible.

## The implementation. The pilot model.

Earlier the device prototype was created via research and advanced development, however, another mechanical knot was used in it. The manipulator of two servo-drivers was designed, providing two degrees of freedom for 180 degrees. There was a laser range finder fixed on the manipulator. In the design construction there were used the servo-drivers Tower Pro MG996R with metal mechanical elements, and also, a laser range finder IFM Electronic 01D100. The mechanical part gave small efficiency due

to insufficient accuracy and speed of servodevices.

For increase of accuracy and speed of work of mechanical part, there was an own servo-driver of step motors designed [4].

Characteristics of the servo-driver:

- accuracy (micro step) 1/16
- maximum current 1.2A
- supply voltage of motors 8.2-45V
- supply voltage of the operating elements 3-5.5V
- support of 2 end-stop/incremental sensors
- control interface SPI + IRQ (1 line)
- non-volatile memory of storage of settings (EEPROM)

Available operating modes:

- with the order of a mode of step, speed and quantity of steps
- with the order of quantity of steps/turns and static speed
- with the order of quantity of steps/turns and smooth adjustment of speed (smooth transition to a micro step mode and back during the braking and dispersal)
- Mode of deduction of the engine in static status
- Mode of an emergency stop
- Mode of engine stop
- "Sleeping" mode with lowered power consumption

Servo-driver consists of the STMicroelectronics STM8S003F3P6 microcontroller, power IMS Texas Instruments DRV8825 and passive components.

Practice of use of a laser range finder of IFM Electronic 01D100 confirmed the indicators of accuracy and measurement speeds declared by the producer (50 measurements a second with accuracy of 1mm). The expediency of use of production of IFM for this work is confirmed. Due to need of increase in distance of scanning, the laser range finder 01D106 is chosen. The disadvantage of this device is lack of the digital interface for removal of indications. At the device output the signal is modulated in the form of voltage 0-10B, in proportion to the measured distance. It corresponds to ten thousand various values of level of voltage. ADC chip is necessary for the guaranteed accuracy of analog-digital transformation with the minimum digit capacity of 14 bits and the speed of 100 samples a second (according to the theory by Kotelnikov). It is logical to use 16-bit ADCs for coordination of a range finder with the microcontroller.

During the development of a prototype various tasks to productivity, memory size, the list of interfaces of the operating microcontroller were offered. A number of microcontrollers with various

peripheral modules, such, as the hardware two-dimensional graphic accelerator and adapters of the FSMC bus and Ethernet was tested [5]. After carrying out a number of tests and the analysis of the market it was established that there is no need in providing the graphic user interface on the device, the small monochrome display for display of a charge of storage batteries and a condition of the device will be quite enough. Also there is no need in the Ethernet interface when using Wi-Fi adapter. STM32F4 microcontrollers by STMicroelectronics showed productivity and security good results from hindrances in power-supply circuits. The following criteria to the microcontroller for further development were put forward:

- up to 12 GPIO lines
- 2 x UART
- 3 x SPI in the Master mode
- SDIO
- USB OTG
- FSMC
- 11x IRQ lines
- compatibility with TTL levels
- tolerance to short-time increase of supply voltage to 4.5V

So, for the further prototyping the STM32F407ZGT6 microcontroller installed on a payment of Olimex STM32-H407 was chosen.

For the power supply of a prototype it is planned to use the accumulator battery with the increased capacity of the HP G6 laptop. It is possible to use the battery from almost any modern computer as the majority work similarly: information on a charge and physical wear is available from the operating controller on the bus bar SMBus (Smart Battery standard). Charging is provided at first with constant voltage and without restrictions on current, then, with restrictions on voltage and on current. All values of voltage and currents are available in documentation on service of the concrete laptop. The main advantage of use of accumulator battery for the laptop is safety: all indicators of life cycle of lithium cells are stored by the special controller, it independently provides protection against overvoltage, overheat, short circuit, overloads on current. It is expedient to carry out power supply from a network via the charger, with current to 4.5A and of 19V. The Lenovo CPA-A090 model will approach.

The software for this model is realized in the form of the module for the graphic editor Blender 3D in the Python language, supports connection to the scanner on a local network through TCP socket. So, for testing the control facility in language C ++ with use of means of QT was realized.

## CONCLUSIONS

Described changes will allow to increase efficiency of operation of the model of the device, and will increase the accuracy of targeting of a beam of the laser to 0.05 degrees. Also the device for the first time during development will become autonomous.

## REFERENCES


1. Nas, S.; Jucan, S. Aspects regarding 3D laser scanning surveys for road design. Agric.: Agric. Pract. Sci. J. 2013, 85, 140–144.
2. Mahdjoubi, L.; Moobela, C.; Laing, R. Providing real-estate services through the integration of 3D laser scanning and building information modeling. Comput. Ind. 2013, 64, 1272–1281.
3. Adel Haddad, N. From hand survey to 3D laser scanning: A discussion for non-technical users of heritage documentation. Conserv. Manag. Archaeol. Sites 2013, 15, 213–226
4. Gourab Sen Gupta et al. “A Project-Based Approch to Teach Mixed-Signal Embedded Microcontroller for DC Motor Control” Proceedings of the Third IEEE International Workshop on Electronic Design, DELTA’06, 2005.
5. Zhadnov V, Polessky S, Yakubov S. "Assessment of quality components of computer equipment" , Keliabilityю 2008. 3