МАТЕМАТИКА ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР

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DESIGN OF AUTOMATIC ENGRAVING MACHNIE CONTROLLED VIA COMPUTER

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Түйін

Берілген жұмыста автоматтандырылған қырнау жұмысын атқаратын құрылғының прототипін құрастыру қарастырылған. Компьютер арқылы басқарылатын нақыштау жүйесі ұсынылған. Прототип XYZ координаталық тақта, яғни жұмыс істеу аймағынан құралған. Мұндағы XY нақыштау аймағындағы координаталарды айқындауға, ал Z қырнауды жүзеге асыратын кішкентай құрылғыны орнатуға арналған. Контроллер ретінде Arduino қолданылды. Жүйедегі қозғалыстар stepper motor (қозғалтқыш) арқылы жүзеге асырылды. Қолданушылар жағы Processing бағдарламасымен жазылған.

Кілт сөздер: нақыш жасайтын машина құру, құрылымдық жүйе, двигатель

Резюме

В статье приводится пример сборки гравировальной машины. Данная система управляется при помощи компьютера. Сконструированная система имеет рабочее пространство XYZ, где XY предназначены для предоставления координат, ось Z для установки маленького сверлильного стонка. Arduino используется как контроллер. Шаговые двигатели обеспечивают движение стонка во время гравировки. На Processing была написана программа для пользовательской стороны.

Ключевые слова: сборки гравировальной машины, сконструированная система, двигатели

Abstract. *This work presents development of a prototype for the automatic engraving machine. The proposed system controlled using computer, by setting drawing for engrave. Constructed prototype consists of XYZ coordinates table (working area), where XY for position in the engraving area and Z axis for establish little driller. Arduino board has been chosen as a controller. Movements of the machine are generated by stepper motors. For the user part Processing software was used. Graphical User Interface provided for drawing the desired pattern. The controller takes the coordinates and converts them to the signals for the motors that are moves grind to the given position and engraving the desired drawing. Finally, robot capable of etching the desired drawing that is setting by user using computer was obtained. System is able*

to engrave in plates of area 21x24cm^2. Optimal algorithm for movements of two motors is presented. Proposed algorithm was compare with other well-known ones. Testing was done and evaluation is given in this paper. High performance was achieved. This prototype can be used for engraving different types of materials, by changing the drilling motor to appropriate one.

1. Introduction

Nowadays, robotics is a field of technical science that is interested many researches. Intelligence Techniques are widely applied in the everyday life. The purpose of this work is to model a system that reduces human work and makes automation of milling process. Mechanical engraving was chosen for etching process. Since traditionally used photo engravers are inherit tainting by using chemical products.

A XYZ coordinates table are designed and constructed. Program implements novel algorithm. Detailed explanation is provided in the next chapters. This work directed to solve real problem and give introduction to basic concepts of control CAD-CAM (computer-aided design and computer-aided manufacturing) systems.

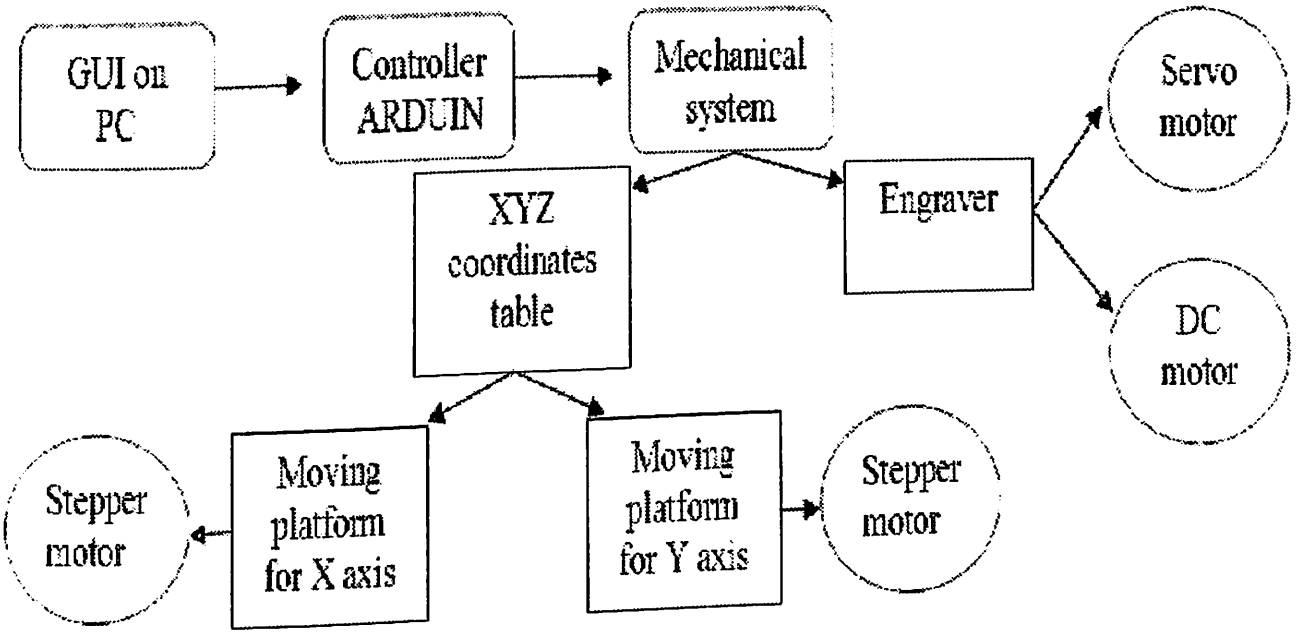

Figure 1.1 - Block diagram of the engraver system

2. Structure and working principle

Figure 2.1 demonstrates final view of constructed engraver machine using Arduino controller. Main components of the system are working area (that has rectangular shape), motors (in general, for motion generation) and

engraver (that has main function of the system, which is milling the figure on the given area). Engraver depends on the task, it moves up and down.

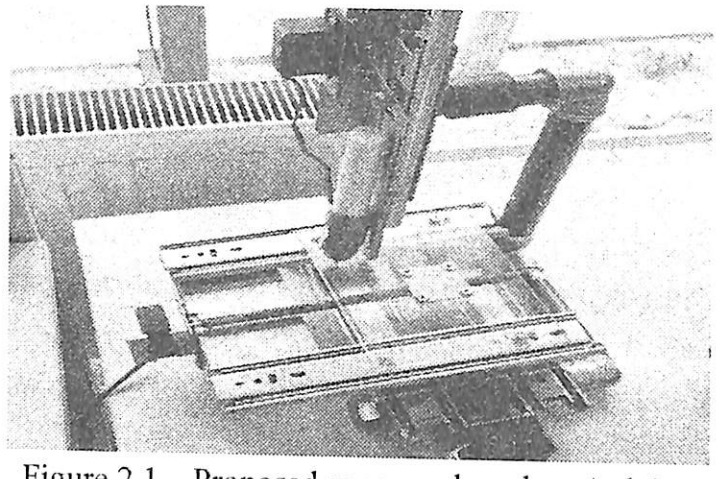

Figure 2.1 – Proposed engraver based on Arduino

The desired figure is drawing by user on the GUI (Figure 2.2). Drawing contains lines. To draw a line left mouse button is used. Painting of the desired figure continues until another command reaches the Arduino. Right mouse button click sends command to start milling process. XY coordinates are sending to the Arduino. Controller gives commands to the engraver to take initial position, and then starts movement according to the taken coordinates. Pseudo code of function that responsible for the engraver motion is given below. For the movement generation used 4 motors: 2 stepper motors for moving two platforms for X and Y axis, servo motor and DC motor for engraver movements. (Figure 1.1)

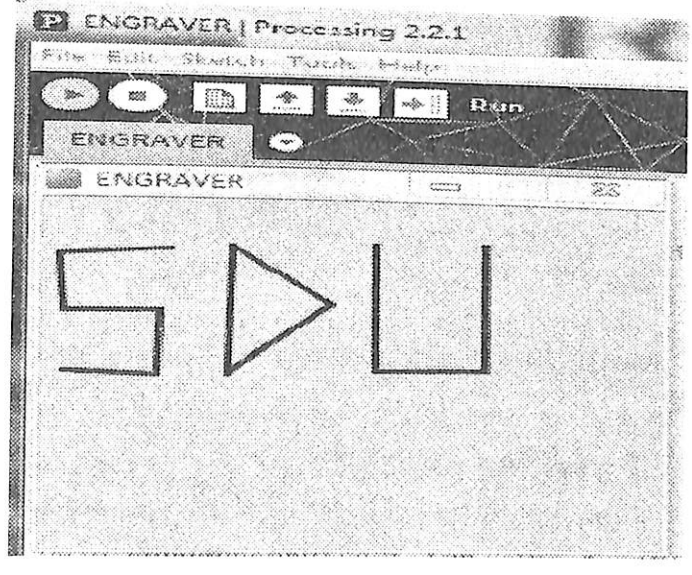

Figure 2.2 - GUI of the Engraver machine

GUI for the Engraver machine was developed by Processing. This software allows manipulating devices through COM PORT, also it gives opportunity to create GUI in easy way. Figure 2.3 presents the process of etching.

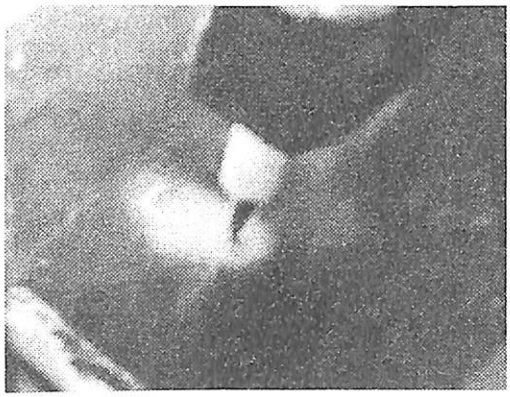

Figure 2.3 - Example of engraving done by proposed engraver system

Drawing that is etched by engraver machine and its size is the same with the figure that was given by user on the GUI (Figure 2.2).

3. Algorithm

Algorithm for the optimal movement of engraver is proposed in this work. Pseudo code of the algorithm is given below.

```
function move_to_the_next_point
    calculate diffX = next_X – current_X
    calculate  diff_Y = next_Y – current_Y
    compare absolute values of diffX and diffY;
    if diffX is greater than diffY then
    find ratio of absolute values of X to Y;
    assign max_steps to diffX;
    esle
    find ratio of absolute values of Y to X;
    assign max_steps to diffY;
    if diffX is greater than diffY
    if diffX > 0, move forward along X axis
    else move backward along X axis
    if diffY is greater than diffX
    if diffY > 0, move forward along Y axis
      else move backward along Y axis;
```

Main idea of the given algorithm is to find main axis on each movement step and continue motion along defined axis. Depends on sign of the difference between coordinates decides movement direction, forward or backward. Each time when system has new task, coordinates sets to initial position. Function initial() is responsible for the setting of engraver to the (0;0) coordinates on the working area. Method that was described above is a way of engraving of the proposed system.

4. Testing and evaluation

Testing of the presented engraving machine has been done. 10 different figures have been set to the system. Engraving time for each figure recorded and presented in the Table 1. For the good testing, figures with the approximately same size have been chosen. Figures contain 10-12 lines. All engraving figures have the same dimensions and places as original figures that have been painted by user. Drawings with bigger sizes also were tested by proposed machine. Engraving time depends on the complexity and size of the desired drawing.

Table 1 - Testing of the proposed engraving machine

Testing	Engraving time, sec	Result (1-100)
Sample 1	45	100
Sample 2	60	100
Sample 3	50	100
Sample 4	40	100
Sample 5	55	100
Sample 6	57	100
Sample 7	43	100
Sample 8	61	100
Sample 9	64	100
Sample 10	60	100
Average	53,5	100

The presented line drawing algorithm efficiency was compare with Bresenham's line algorithm. It is one of the earliest algorithms that were used in computer graphics. Bresenham's algorithm draws lines and circles

by determining which point should be plotted between two given points in order to be closer to straight line.

As can be seen from Figure 4.1 engraving time of the proposed algorithm is less. Efficiency of the given algorithm is high. From the done work can be concluded that methods and tools that have been used have high quality and accuracy.

5. Conclusion

The system efforts in a very good way. It does all functions that were planned by using right tools. The engraving machine can etching desired drawing on different types of material. Advantages of the given system: fast engraving time, mechanical engraving, that is cheapest type of etching and with minimal pollution.

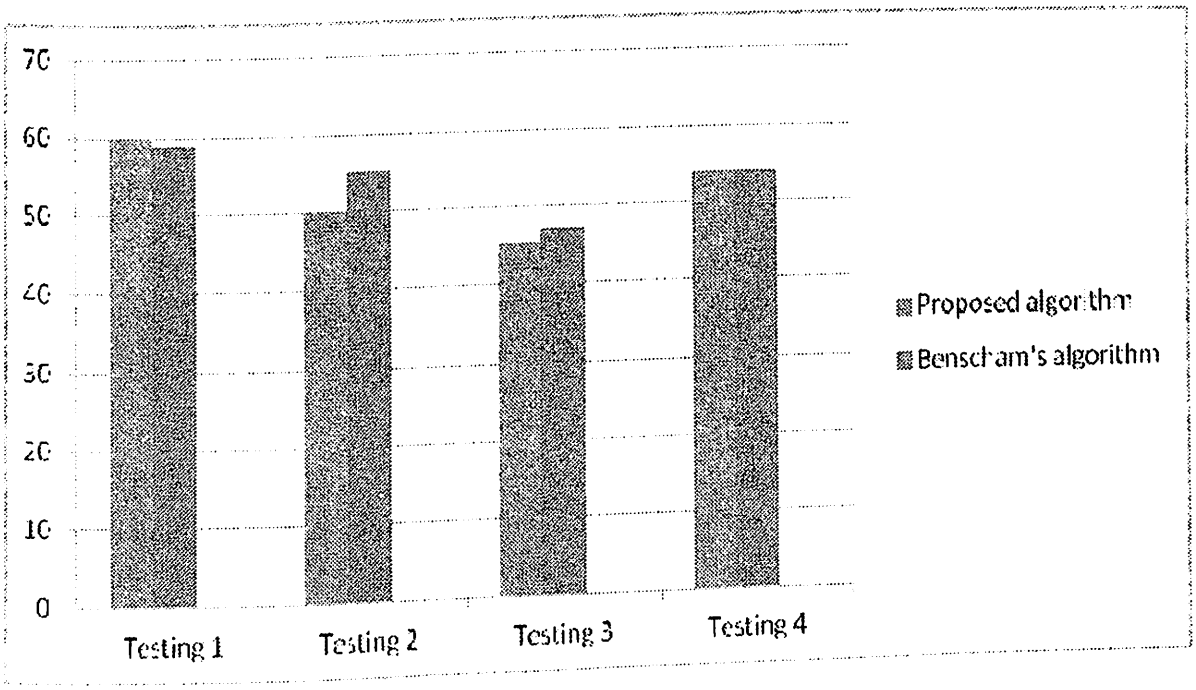

Figure 4.1 - Engraving time comparison of two algorithms