Low Cost Xy Positioning System using Arduino

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ABSTRACT

The goal of this project was to develop a XY Scanning stage to translate the motion stage along the X and Y axes of the gantry and to use this information as the output for a microcontroller that can modify the commanded position of the stepper motor as the input data provided. While implementing such methodology a close loop control must be developed which results in increased complications along with the cost of system integration. Also to obtain positioning feedback, position sensors are used along with laser interferometers which again generates the additional costing. But with the close loop control implementation one can achieve better positioning resolution along with accuracy. Another approach towards the micromanipulation is a flexural mechanism which also results in a finer resolution up to nanometers. It comes with the micrometer level travel range with nanometer level positioning resolution but the cost of drive mechanisms such as piezoelectric actuators or voice coil motors generates additional costing with close loop controller. Also in the case of pulley and belt drive based gantry one can have micro stepping but motor step error, belt slop, and the dynamics of the support structure frequently introduce large errors.

Keywords : Arduino plotter, Low Cost Positioning System, XY plotter etc

INTRODUCTION

3D printing is an additive manufacturing process for creating objects directly, by adding material layer by layer in a variety of ways, depending on the technology used. The starting point for any 3D printing process is a 3D digital model, which can be created using a variety of 3D software programmed. The model is then ‘sliced’ into layers, thereby converting the design into a file readable by the 3D printer. The material processed by the 3D printer is then layered according to the design and the process. The printer must be able to position the hot-end at any point to be able to precisely extrude material within the layer being printed. For this reason a special type of motion mechanism, a gantry (XY stage) is used which moves the material extruder in the X- and Y-axes, while the bed moves only in the Z-axis. Generally, in 3d printers NEMA-17 stepper motors are used to power their stages. These motors are driven by integrated-circuit motor drivers with peak currents in the range of 1 A per phase, step-direction interfaces to the host controller, and 8X or 16X micro stepping capabilities. 3D printers typically use The gantries are moved by stepper motors, which use digital pulses to move and track the gantry. The stepper motors allow for high resolution movement by allowing the pulses to move the motor at a small fraction of a rotation. The gantries hold up the printer head as it moves along the build platform.

PROBLEM STATEMENT

The goal of this project was to develop a XY Scanning stage to translate the motion stage along the X and Y axes of the gantry and to use this information as the output for a microcontroller that can modify the commanded position of the stepper motor as the input data provided. While implementing such methodology a close loop control must be developed which results in increased complications along with the cost of system integration. Also to obtain positioning feedback, position sensors are used along with laser interferometers which again generates the additional costing. But with the close loop control implementation one can achieve better positioning resolution along with accuracy.

Another approach towards the micromanipulation is a flexural mechanism which also results in a finer resolution up to nanometers. It comes with the micrometer level travel range with nanometer level positioning resolution but the cost of drive mechanisms such as piezoelectric actuators or voice coil motors generates additional costing with close loop controller. Also in the case of pulley and belt drive based gantry one can have micro stepping but motor step error, belt slop, and the dynamics of the support structure frequently introduce large errors. On the other hand stepper based XY stages with the application of lead screw and Arduino microcontroller provides cost effective way to achieve the positioning requirements with ease.

OBJECTIVES

The objective of this project is the development of XY Scanning Stage for micro positioning through PC based interfacing with Arduino microcontroller. The study incorporates the following implementations:

1. Design modeling of XY scanning stage in modeling software CATIA V5.
2. Manufacturing of finalized design.
3. System interfacing with PC via Arduino board.
4. Motion control of the XY stage with Arduino programming.
5. Experimental testing by tracing X and Y direction.

LITERATURE REVIEW

XY Micro positioning stages

Kuang-Chao Fana, YetaiFeia, XiaofenYua, WeiliWanga, Yejin Chen[1] were developed an innovative CMM design, including the arch-bridge, the co-planar precision XY-stage, the spindle, the motion actuator and feedback system, and the autofocusing probe. This micro-CMM is designed for the measurement of mesoscale parts to the accuracy of nanometer range. It is aimed at achieving 1 nm resolution and 30 nm accuracy within a measuring range of 25×25×10 mm. Conventional XY stage is stacked up by two linear stages composing of many components, such as ball screw, bearing, linear slide, etc. The long travel of each axis is activated by the piezoceramic ultrasonic motor with its AC drive mode. The fine positioning is achieved by the same motor with its DC drive mode, which can perform nanometer steps proportional to the input voltages. A linear diffraction grating interferometer (LDGI) is developed as the position feedback sensor with the resolution to 1 nm after the waveform interpolation.

Chien-Hung Liua, Wen-YuhJyweb, Yeau-Ren Jengd, Tung-Hui Hsud, Yi-tsung Li.[2] presented a Dual-Axis Long-Traveling Nano-Positioning Stage (DALTNPS). In order to extend the traveling and increase the accuracy, the two sorts of stages, a traditional ball-screw stage and a three-degrees-of-freedom (3-DOF) piezo-stage, were composed. The traditional ball-screw stage which is composed of two guideways and a ball-screw at each axis is a long-travel stage, and the 3-DOF piezostage, which is composed of three piezoelectric actuators and four translation–rotation mechanisms, is a high precision stage. In addition, a 3-DOF measuring system and a PID controller are composed of a 3-DOF closed-loop controller and applied to implement the DALTNPS. The measuring system which is composed of two laser interferometers and two plane mirrors is a 3-DOF optical measuring system.Thus, the position at the x and y axes and the rotation around the z axis can be obtained and they are the responses of DALTNPS.The travel range of the stage approached 300mm×300mm, and the linear and the angular positioning accuracy achieved 10nm and 0.1”, respectively.

WORKING

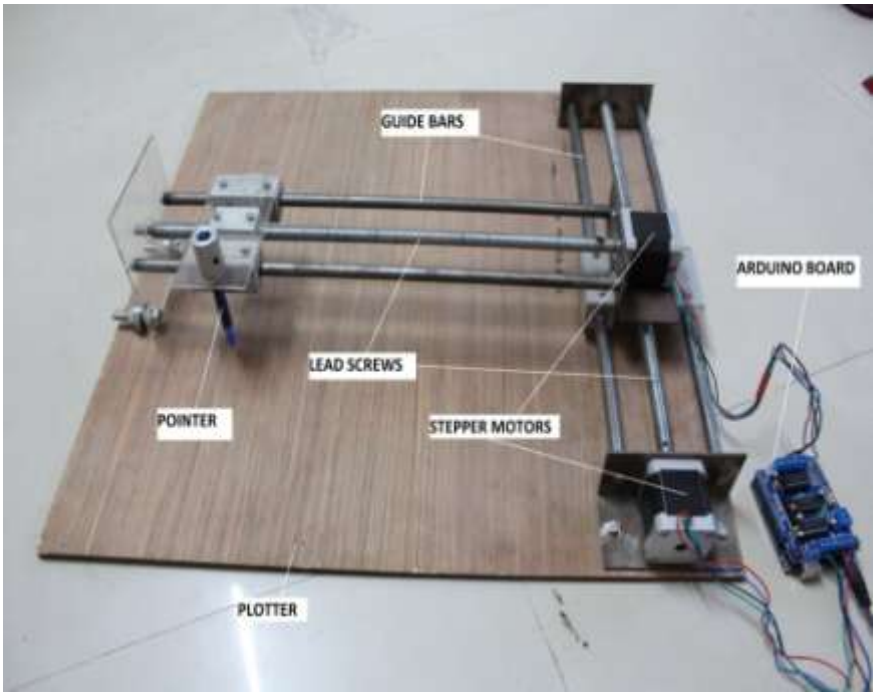

Figure show, the X-Y scanning stage consists of two motion stages. The Y axis stage sits upon three rods located in between the two side support plate, here the three rods are the two guide rods and the lead screw, the lead screw located at the middle of guide rods allows linear motion of the X stage along the rods axis. A stepper motor drives a shaft that is coupled to the lead screw with a motor coupler on one side of the Y axis, allowing it to move the Y stage platform along with the X stage mounted on it. The X axis stage consists of three rods as two guide rods and lead screw. Here, the X stage is located in between the two side plates to restrict the linear motion of X stage through X axis which are mounted on the Y stage platform. Another stepper motor drives the lead screw along with the X stage along the X axis. The entire XY stage assembly is resting on the support rods of squared and grooved cross section made of Aluminium.

MANUFACTURED PARTS

1.Motion motor mounting plates

Dimensions=55×55×5mm

Material - Mild Steel

Quantity - 2

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2.A lead screw

Dimensions=Lead screw M8×1.25, length 340mm(Y Stage) and 170mm(X Stage)

Material – Stainless Steel

Quantity - 2

The motion stages are moved by means of lead screw and nut. The nut is fastened by Allen bolts with the motion stages so as to translate in a direction of advancement of lead screw.

3. Guide rods

Dimensions=Ø8×292mm and Ø8×140mm

Material – Stainless Steel

Quantity - 4

These are the guide rods for the motion stage which allows the sliding motion of platform. These are mounted and bolted between two side plates for each axis.

4. Stepper Motor

Quantity-2

It is the driving member of XY Scanning Stage. It is mounted on the motor mounting plate whose shaft is coupled with a lead screw by mean of flexible aluminium coupler.

5.Linear Ball Bearing

Model: LM8UU

Size: 8 × 15 × 24 (inner diameter ×diameter ×height)

Quantity – 4 It sits inside the motion stages where the guide ways are allowed to pass from motion stages. It avoids the misalignments while the stage translates as the motor rotates the lead screw.

SYSTEM INTEGRATION

Mechatronics Interfacing

A stepper motor is a DC motor in which the rotation can be divided up into a number of smaller steps. This is done by having an iron gear-shaped rotor attached to the shafts inside the motor. Around the outside of the motor are electromagnets with teeth. One coil is energized, causing the teeth of the iron rotor to align with the teeth of the electromagnet. The teeth on the next electromagnet are slightly offset from the first; when it is energized and the first coil is turned off, this causes the shaft to rotate slightly more to toward the next electromagnet. This process is repeated by however many electromagnets are inside until the teeth are almost aligned with the first electromagnet, and the process is repeated. Each time an electromagnet is energized and the rotor moves slightly, it is carrying out one step. By reversing the sequence of electromagnets energizing the rotor, it turns in the opposite direction. The job of the Arduino is to apply the appropriate HIGH and LOW commands to the coils in the correct sequence and speed to enable the shaft to rotate. This is what is going on behind the scenes in the stepper.h library.

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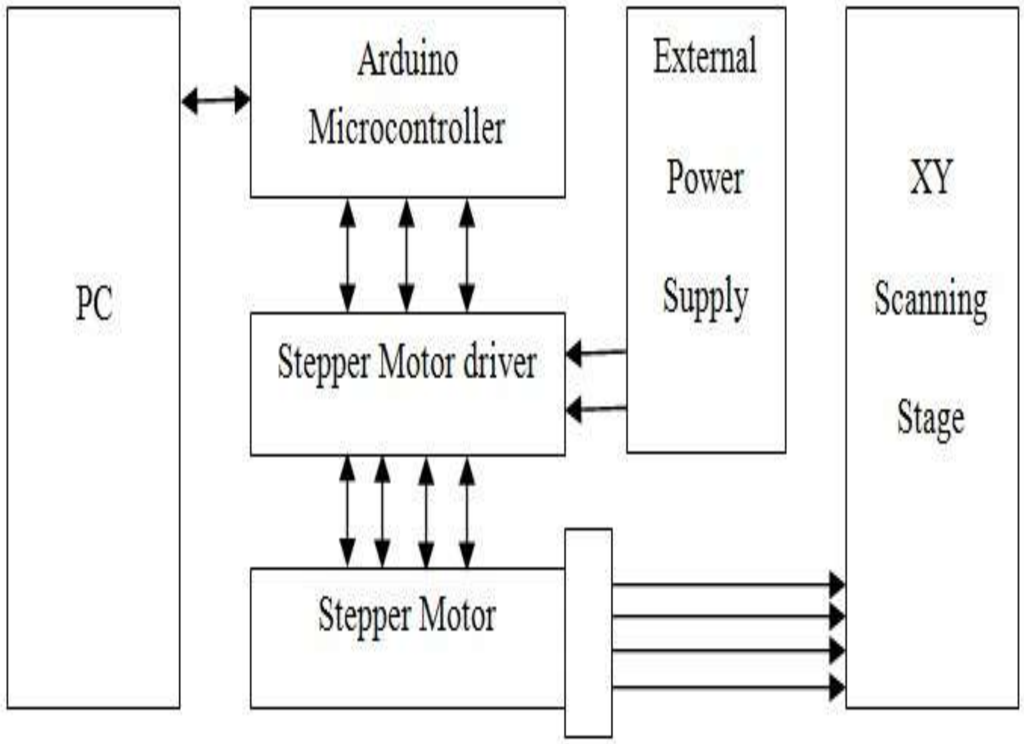

The NEMA 17 stepper motor is connected to an easy driver motor controller board which is controlled by an Arduino Mega2560 microcontroller by means of wire connections as shown in block diagram of fig.5.1. The Arduino program is uploaded in the microcontroller which controls the number of pulses to be generated for the stepper motor provided with a required amount of voltage level by means of easy driver circuit. Fig.5.2 shows the XY stage interfacing with PC.

CONCLUSION

1. The XY Scanning Stage is micro-positioning stage which is driven by two bipolar stepper motors and controlled by Arduino Mega2560 microcontroller. We have designed and developed this XY Scanning Stage to precisely position the motion stage platforms along the predefined directions given by the special programs developed using Arduino software. Here, the two basic programs are developed to test the motion of the stages. The first program translates the motion stage in forward and backward motion at given delay time to reverse the direction. It uses the Easy Driver circuit and controls the single stage motor at a time. Second program is based on the Arduino shield board which controls the two motors one by one under a micro stepping mode with a speed control.
2. Experimentation is done to measure the X and Y motions with a dial gauge at the speeds varying from 200 RPM to 1000 RPM and varying steps from 100 to 2000. The results obtained are within the acceptable limits. The accuracy within 10 microns is achieved.
3. This work is beneficial in many micro-positioning and precision applications especially in 3D Printers. It also provides the cost effective way for system interpretation and electronics.

REFFERENCES

[1]Kuang Chao Fan YetaiFei, Xiaofen Yu, Weili Wang, Yejin Chen, Study of a noncontact type micro-CMM with arch-bridge and nanopositioning stages, Robotics and Computer-Integrated Manufacturing 23 (2007) 276–284

[2]Chien-Hung Liu, Wen-YuhJywe, Yeau-Ren Jeng, Tung-Hui Hsu, Yi-tsung Li, Design and control of a long-traveling nano-positioning stage, Precision Engineering 34 (2010) 497–506

[3]Jooho Hwang, Chun-Hong Park, Chan-Hong Lee, Seung-Woo Kim,Estimation and correction method for the two-dimensional position, errors of a planar XY stage based on motion error measurements, International Journal of Machine Tools & Manufacture 46 (2006) 801–810

[4]Yuki Shimizu, Yuxin Peng, Junji Kaneko, Toyohiro Azuma, So Ito, Wei Gao, Tien-Fu Lu, Design and construction of the motion mechanism of an XYmicro-stage for precision positioning, Sensors and Actuators A 201 (2013) 395– 406.

[5]Chih-Liang Chu, Sheng-Hao Fan, A novel long-travel piezoelectric-driven linear nanopositioning stage, Precision Engineering 30 (2006) 85–95