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## 3-D Printing with an Electrifying Difference

### Authors:

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### NI Product(s) Used:

PCI-7344: 4-Axis Stepper/Servo Controller  
UMI-7764: 4-Axis Universal Motion Interface  
SC68-C68-S cable to connect UMI-7764-to-PCI-7344  
(2) P70350 1-Axis, 300W Stepper Drives  
NEMA 23 Stepper Motor: T23NRLH-LDN-NS-00 Step Mot, P70530, NEMA23, 380oz-in, dual shaft  
NEMA 17 Stepper Motor: CTP10ELF10MMA00 Step Mot, P70530, NEMA17, 43oz-in, dual shaft

### Category:

Advanced Control Systems

### The Challenge

Develop a LabVIEW based 3D Printer that will be used to validate the theory that aligning the particles of print media material yields stronger finished printed products.

### The Solution

The integration of the NI motion hardware with LabVIEW and the NI FlexMotion toolkit made the creation of this custom Stereo-Lithography program possible.

### Introduction

Data Science Automation (DSA) is a premier National Instruments (NI) Alliance Partner that specializes in automating and educating the world leading companies. Clients choose DSA because of DSA's deep knowledge of National Instruments products, disciplined project development process, its staff of skilled Certified LabVIEW Architects and Certified Professional Instructors, and its unique focus on empowerment through education and co-development.

DSA was selected to create a new software application to control a 4-axis motion system that had to be resurrected from being mothballed. We were selected due to our experience with various third-party motion systems along with utilizing NI motion hardware and software to integrate the system into a cohesive package.

The system was built to allow testing of a new method of building stronger 3D printed objects through use of fiber alignment technology. Our customer is pioneering research into this area for possible patenting of the technology in the future. Existing 3-D printers do not have this technology built into the systems, and our customer was reluctant to buy an expensive new system only to tear it apart for modification. In addition they did not want to give the new technology to existing 3D printer vendors. In this system the material used in the 3D printing system would be aligned by an electric field generated between two probe tips mounted on a rotary stage suspended above the working fluid bath. The orientation of the probe tips is adjusted to match the direction of travel to align the material particles just prior to their solidification by the system laser.

The old components that were being reused consisted of a Z-stage having an old stepper motor with a missing motor drive, and the X-Y gantry where the new rotary stage that would set the orientation of the electric field by changing the probe alignment would be mounted. The existing X-Y gantry was built using screw drives and older Pittman DC motors running through Copley 300 motor drives (circa 1998) that had to be integrated with the rotary head driven by a M17 stepper and Newark rotary drive and with the new Z-axis vertical stage motor.

The old Z-axis motor was replaced with a new NEMA 23 motor and the P70530 DC Stepper Drive both purchased from NI. This motion axis is used to raise and lower the printer's fluid bath tank. The available NI wiring kit to interface the P70530 to the UMI 7764 saved us time and money during the physical system build.

The NI PCI-7344 combination Stepper/Servo controller allowed the system to be integrated and controlled through a single motion control board for all 4 axes in the system. The UMI-7764 provided by NI allowed for connection of the existing Pittman DC motors and Copley 300 drives along with the NI stepper motors and drives in a compact footprint. The ability to use only one motion card meant a smaller rack mount PC could be sourced – this saved money in the overall system design as well.

### **One Software to Control Them All**

National Instruments LabVIEW was the chosen programming language for the 3D printer system. The FlexMotion palette allows for a single API to tie all 4 axes of motion together in the system.

The system was designed to run simple profiles in the X-Y plane as defined by profile files. These profile files consist solely of a list of points for the X, Y, Rotary and Z stages. Velocities for the motion are entered through the graphical user interface (GUI). Operators are responsible for creating their own motion profiles outside of the system, however the program does allow them to load and preview the motion profiles. Figure 1 shows the main GUI screen seen by the operator and the Profile Preview tab is the main tab from where a motion profile can be previewed and run.

The operator can preview a motion profile by selecting the motion profile file, which is a simple ASCII text file. A layer consists of all moves made on one Z-level target plane – only one target plane layer of motion can be plotted at a time. After the file is loaded, the table displays the selected layer targets for the X, Y, Z, and Rotary stages. If desired, the operator can preview the motion layer on the XY position graph by pressing the "Graph" button next to the Table profile indicator. In Figure 1 a simple triangle profile is plotted for the single layer motion profile.

Once the operator is happy with the motion profile file, they can set the speed of the X-Y cross-head (x-head) to be used for the build. The vertical fluid motion and rotary head motion only occur when the X-Y gantry is stationary.

Progress of the build is displayed on the XY Position Graph. At the start of each layer the graph is cleared and the operator can watch a visual representation of the path traveled. The current system motion state can be viewed at any time in the section below the XY Position Graph. This field contains indicators for the X, Y, Z (listed as depth) and Rotary Angle in the first column of data and the corresponding velocities in the next column. The XY Position Graph and current motion indicators are visible on the main screen regardless of which operational mode tab is displayed.

### **"I want to do it!" – Manual Motion Control**

If the operator does not wish to run a profile in the automatic mode the system can be run in manual mode. Figure 2 shows the manual motion tab on the main GUI panel. This contains controls for setpoints for position targets and target velocities for the XY cross-head and the Z and rotary stages. The axes can move concurrently if the operator desires.

In manual mode, the system can also be controlled using the keyboard arrow keys to direct the cross-head motion. A User Event Structure in the main application monitors for the arrow key button presses and fires off an event request to the manual motion object which enacts the proper directional output. Motion can be commanded in straight lines in the X and Y directions or diagonally with the arrow keys.

Manual mode also utilizes the XY position graph so the operator can see a trace of the position of the cross-head on the graph which will remain until manually cleared by using the shortcut menu accessed by right clicking the mouse, or by starting the system in automatic mode.

### **External Systems**

Control of the laser and the electrical power supply that is connected to the rotary field probe tips are handled outside of the motion control program provided by DSA. The third screen that the operator

interacts with is the System Settings Screen as seen in Figure 3. This screen allows the operator to enter a record of the settings used for the Electrical Field, Electrical Field Wave setting, Electric Wave Frequency, Laser Power, and target cross-head speed.

When the operator selects a new Contour profile that does not have a previously saved System Setting file, the operator is prompted by this screen to enter the information. The customer detailed that the system would use a new contour file for every single test run in order to meet their system tracking requirements.

**Conclusion**

NI Motion hardware and software products allowed DSA to recycle a previously existing motion system provided by our customer as well as give them the motion control functionality to test new technology for 3D printers.

**Contact Information**

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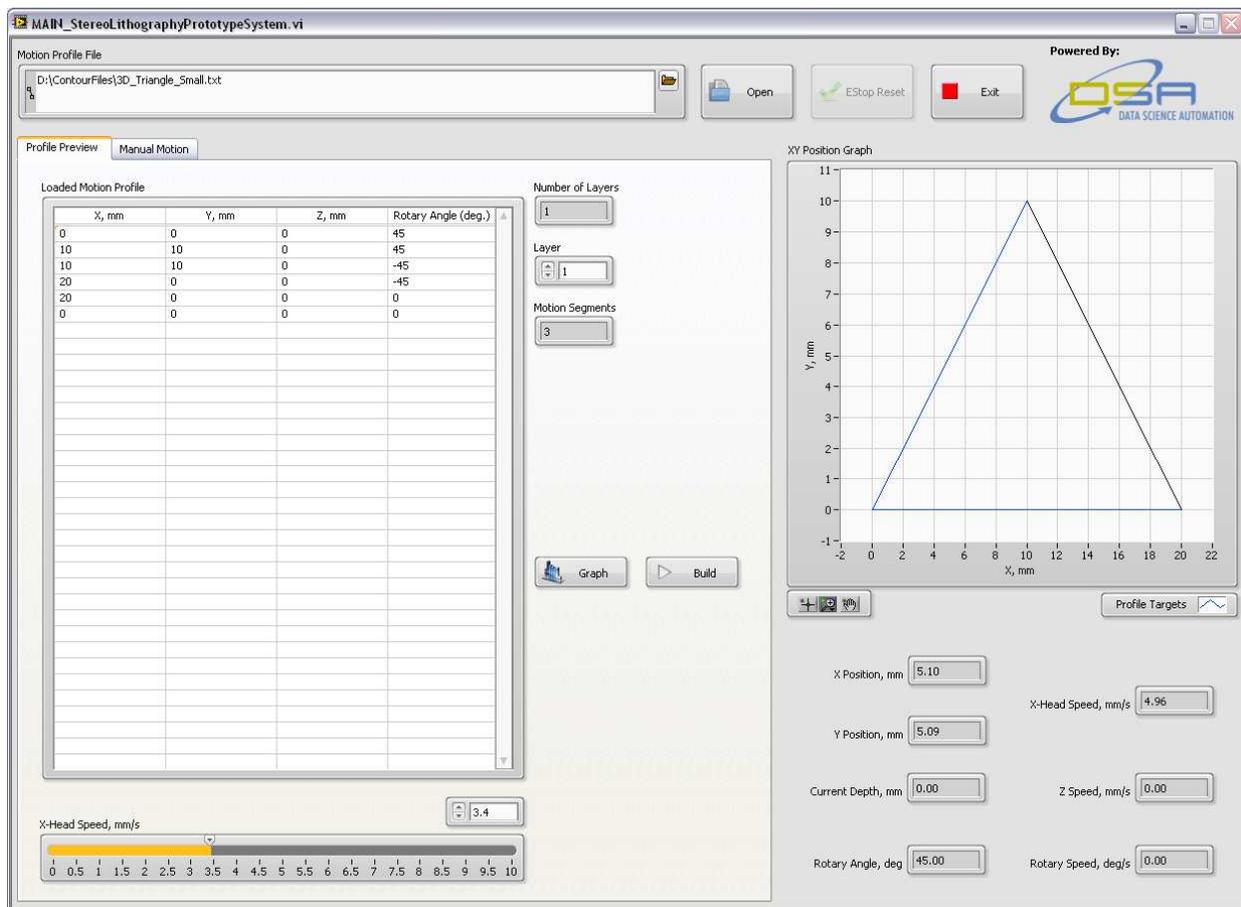


Figure 1 - Profile Preview and Automatic Printing Tab - Main GUI Screen

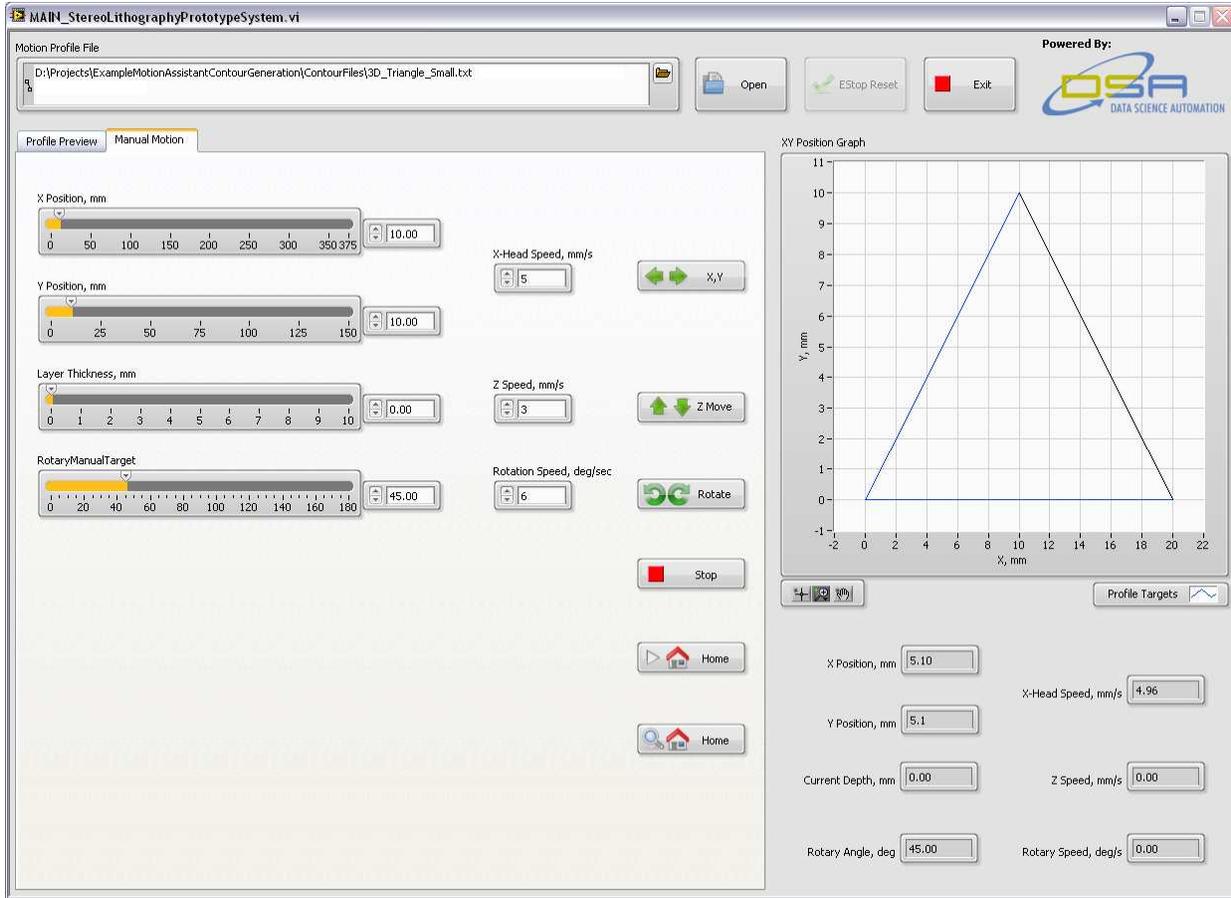
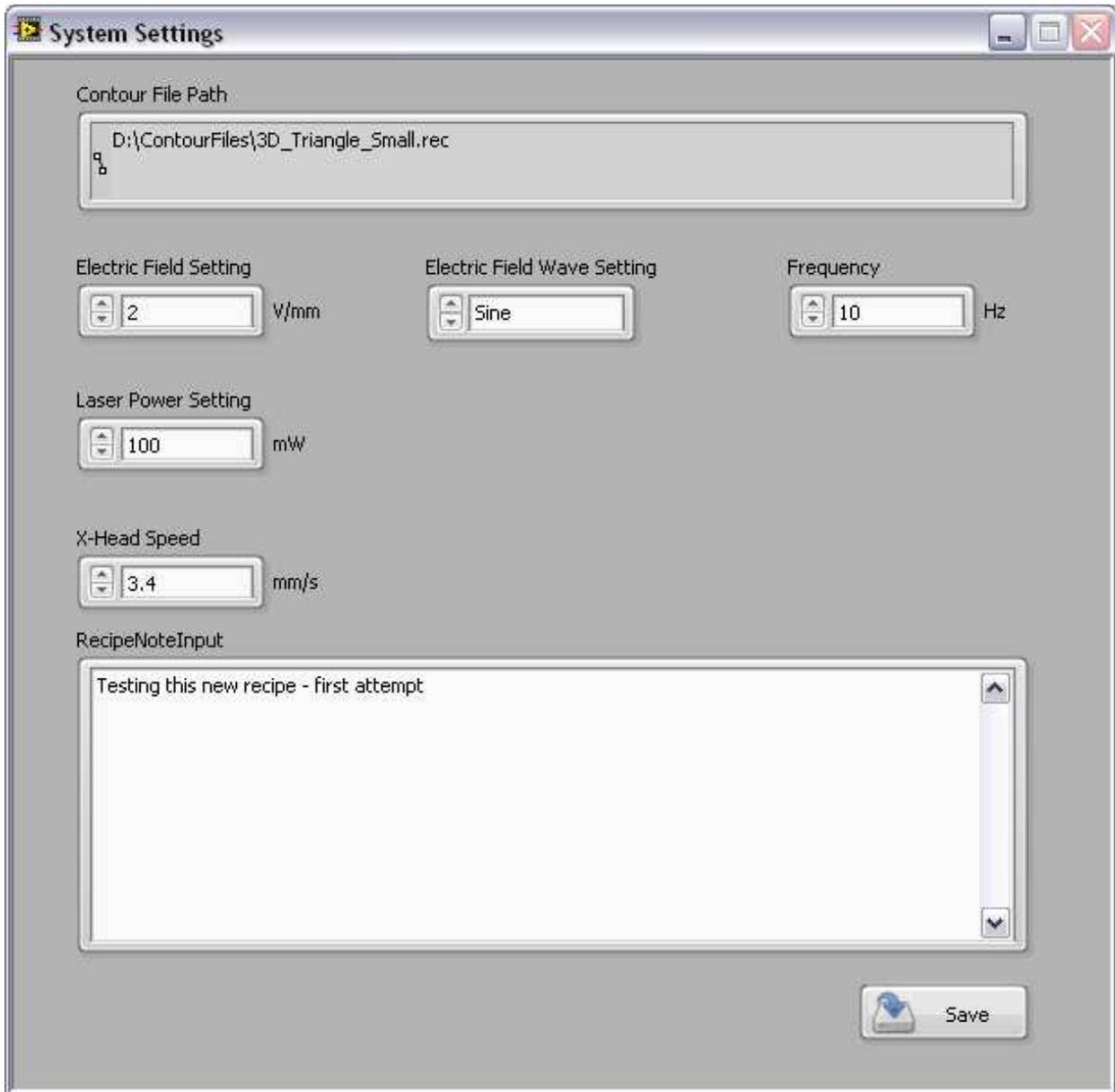


Figure 2 - Manual Motion tab - Main GUI Screen



**Figure 3 - Contour Files Have and Associated System Settings File used to Store Recipe Setup Information**