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Simon Fraser University, Burnaby, BC
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February 18, 2008

Dr. Patrick Leung
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia

Re: ENSC *440 Functional Specification for a 3D-LED Plotter*

Dear Dr. Leung,

The attached document, Functional Specification for a 3D-LED Plotter, defines the functional requirements for the design and implementation of our ENSC 440 project. The 3D-LED Plotter is designed to display three-variable mathematical equations as a visual aid for young math students. Currently, we are in the process of constructing a 3×3×3 cube to prototype this concept.

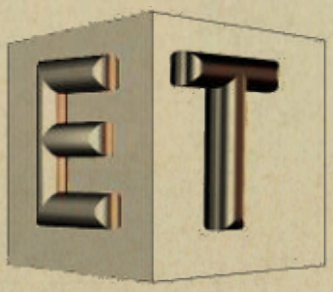
The purpose of this functional specification is to outline the necessary specifications for functional requirements that our 3D-LED Plotter will fulfill. This document also describes the test procedure which will be used to ensure correct operation as we have defined.

EduTech was founded by four motivated and talented senior engineering students: Leah Finkel, Anna Seung, Julio Perez and Iman Shahsavani. If you have any comments or queries, please feel free to contact me by phone at (604) 671-3070 or by e-mail at the above address.

Sincerely,

Leah Finkel
President and CEO
EduTech

Enclosure: *Functional Specification for a 3D-LED Plotting Device*



EduTech

Functional Specification for a 3D Plotting Device

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Executive Summary

The 3D-LED Plotter is intended as a visual aid for students making the leap from analytical to graphical methods in three-variable mathematics. Our motivation for this project arises from team members' past experiences as young math students trying to visualize 3-dimensional equations for the first time. Students' comprehension of math could be greatly enhanced with the use of this system. With the capacity to display true 3D images, it also finds applications in physics, chemistry, and spatial cognition.

This project will be split into three phases, the first of which will focus on the development of a scaled-down prototype (3x3x3 LEDs). The second phase will result in a full-scale prototype (10x10x10 LEDs) with the following functionality:

1. The system will be able to display equations in up to three variables.

2. The system will be able to display a number of hard-coded molecular models.

3. The user will be able to use the system to create three-dimensional 'sketches'.

The projected date of completion for the second phase is April 6, 2008. If time and resources permit, we will proceed with the third phase, which will involve the addition of special features, such as functions allowing the user to 'save' sketches for future retrieval and editing, compile a series of sketches into an animated sequence, and potentially even designing a way for the device to interface with other mathematics software such as Maple.

Table of Contents

Glossary

3D Three-dimensional
AC Alternating Current
CSA Canadian Standards Association
FCC Federal Communications Commission
LCD Liquid Crystal Display
LED Light Emitting Diode
PC Personal Computer
RGB Red-Green-Blue
RoHS Reduction of Hazardous Materials
UL Underwriters Laboratories
USB Universal Serial Bus

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1. Introduction

EduTech's 3D-Plotter is a cubic matrix of multi-coloured LEDs aimed to be a prototype for a true, dynamic 3D display. Users will be able to interact with the device by means of a navigational keypad, and will be able to control each LED individually to display almost any 3D image. In addition to drawing 3D images, the 3D-Plotter can also be used in Mathematics, to solve and visualize simultaneous equations, and in Chemistry to observe and model molecules. The set of functional requirements that will be accomplished by this device are described in this document.

1.1 Scope

The following pages list the functional requirements that EduTech has set for the 3D-Plotter. While EduTech is aiming to include as many of the listed features as possible on the prototype version, this might not be possible due to time and budget constraints. Throughout the document, the distinction is made between requirements that must be included in the prototype and requirements that could be postponed to be included in the production models.

1.2 Intended Audience

This document is intended for:

- Project Managers: To be use as an overview of the project for the estimation of budget and time estimations and the evaluation of milestones.
- Design & Test Engineers: To be use as a guideline in any stage of the project, from product design to implementation and testing.
- Marketing Executives: To be use as an advertising tool, to promote the product and analyze its market potential.

1.3 Conventions

Throughout this document, the following convention is used to denote functional requirements:

R[X-Y] Description of Functional Requirement

Where 'X' is the number of the functional requirement, and 'Y' denotes one of the following:

I	A functional requirement that must be included in the prototype and production model.
II	A functional requirement that must be included in the production model, however, it may or may not be included in the prototype.

2. System Overview

Figure 2.1 shows a breakdown of the three main components that make up the 3D-Plotter. The user-accessible controls are the input mechanism by which images are drawn. The control unit is programmed to interpret the signal from the keypad, mapping the user input to the 3D surface. The 3D drawing surface, which will be made up of a 10x10x10 LED matrix (1000 LEDs in total), will display the user input in real time. In addition to a drawing surface, the 3D-Plotter will also be able to graphically display solutions for simultaneous equations, and will render three-dimensional molecular models.

Device Limitations:

Upon close examination of the functional requirements and overall system design, we have identified the following limitations for the 3D-Plotter:

- Limited Resolution: The requirements for the dimensions of the LED matrix have been set at a grid or 10x10x10 points, which may not provide a good enough resolution for detail drawings.
- Viewing Angle: Due to LED limitations, drawings might not be visible from every angle. In some cases, the intensity of the drawing may vary with the position of the user.
- Display Brightness: Due to LED limitations, proper room lighting is required for the display to be viewed at an optimal brightness level.

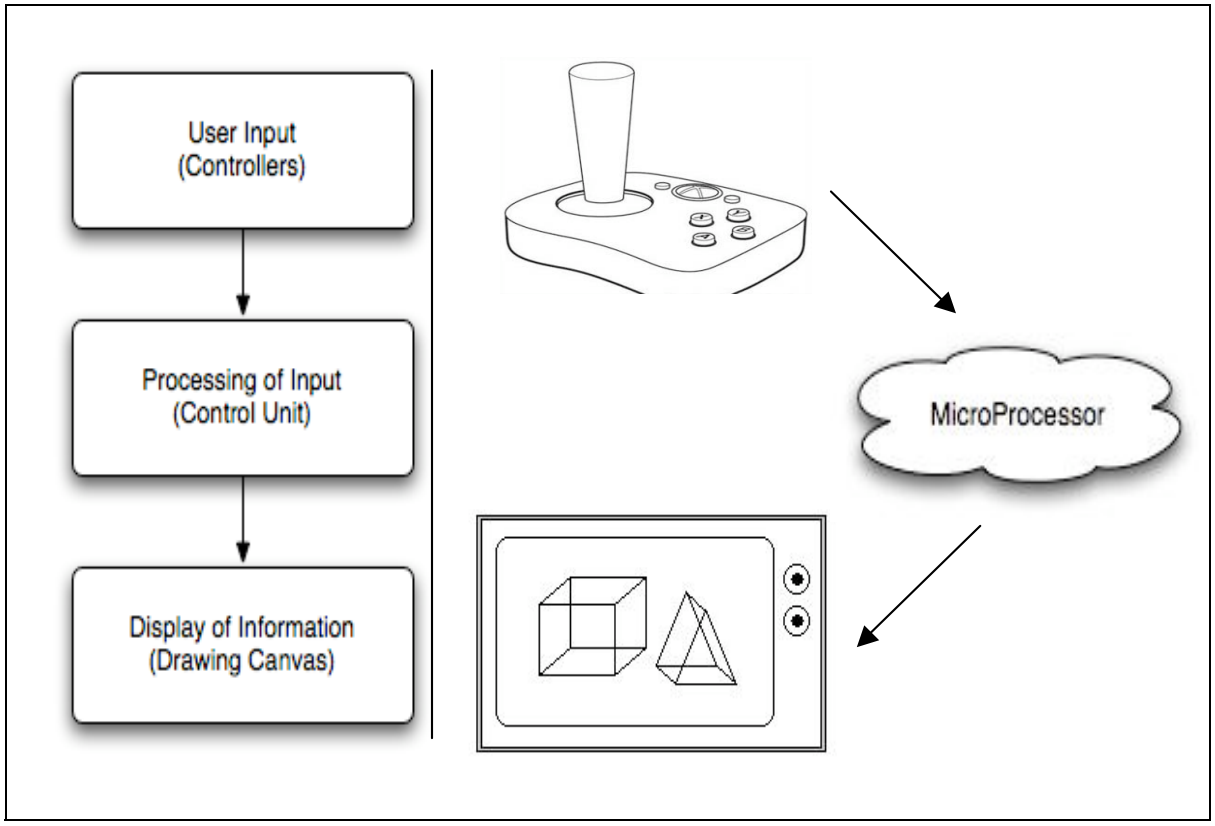

FIGURE 2.1 – Component interaction & flow of information[1].

3. System Requirements

3.1 General

R[1-I] The user interface will be intuitive and friendly to a child as young as 8.

R[2-I] The system will support 3 modes of operation: math, chemistry, and draw/animation.

R[3-I] The system will be capable of displaying equations in up to 3 variables.

R[4-I] The system will be capable of displaying molecular structures.

[1] Controller image taken from http://www.videogamesblogger.com/2006/11/08/microsoft-asks-do-you-want-a-wireless-xbox-360-arcade-joystick-or-black-backlit-controller.htm.

R[5-I] The user will be able to create 3 dimensional sketches in real time.

3.2 Performance

R[6-I] The LED refresh rate must make the image convincing to the human eye (no flicker).

R[7-II] The user will be able to light individual LEDs in any colour in the RGB spectrum.

R[8-II] The user will be able to control the brightness of each LED.

R[9-II] The user will be able to control the speed of animated sequences.

3.3 Compatibility

R[10-II] The system's software and USB interface will be compatible with all commonly used laptops and PCs.

R[11-I] The ports on the device will be easily accessible.

R[12-I] The system will be compact, lightweight and easy to transport.

3.4 Reliability and Serviceability

R[13-I] The system will have a power conservation mode when not in use.

R[14-I] The system will not be serviceable by end-users.

3.5 Physical

R[15-I] The circuitry casing will hide the electronic parts as much as possible.

R[16-I] The sidings will be made of transparent material.

R[17-I] There will be a clearance between the cube and the casing to avoid damage during assembly and also unwanted diffraction of light.

R[18-I] The casing will be made of a hard and insulating material.

R[19-I] The unit will be comfortably portable over short distances.

R[20-II] There will be a detachable handle placed appropriately on the unit to assist with moving.

R[21-I] The size of each side of the unit (cube) will not exceed 35 cm.

R[22-II] There will be a slot positioned on the casing to store away the power cord.

R[23-I] There will be enough clearance between each LED and its neighbouring LEDs in order to provide a clear view of all the LEDs.

3.6 Electrical

R[24-I] The power supply will be drawn from a wall outlet operating at the North American standard 110/120 V at 60 Hz AC.

R[25-II] The power cord will be long enough to provide some flexibility to the user in placement of the device.

R[26-I] There will be no electrical discharge on the power cable other than through the ground.

3.7 Safety

R[27-I] The system will comply with CSA, CE, and FCC standards for domestic use.

R[28-I] The product will not have any sharp edges that may harm the user.

R[29-I] All the electronic components including wires and cables will be enclosed by an external case.

R[30-I] All material contained in the prototype will non-flammable.

R[31-I] The device will operate safely below 40 degrees C.

R[32-I] All inputs and output ports will be shielded from external static voltage sources.

R[33-I] There must be a safety button that will enable and disable the system.

R[34-I] The product will be RoHS compliant.

3.8 Regulatory

R[35-II] The system will be CSA, CE, and UL approved for domestic use.

R[36-I] The device will meet CSA standards, C22.2 No.94.1 & UL 50 12th edition – Enclosure for Electrical Equipment

R[37-I] The device will meet CSA standards, CSA 61000-4-7- :03(R2007) electromagnetic compatibility - EN 55103-1:1997.

4. User Interface

The user interface unit can be subdivided in two components. The input component, made up by a series of user-accessible buttons and the output component, made up of the display area as well as status LEDs. This section covers only requirements related to the state of the device. The System section contains more detail requirements for the actual matrix-display.

4.1 Input Component

R[38-I] A set of buttons and switches will be the primary means of user input.

R[39-I] The user will be provided with a power on/off button.

R[40-I] The user interface will allow the user to select between the following different modes: Chemistry, Mathematics, Drawing/Animations.

R[41-II] The user will be able to manipulate the display along the three-dimensional coordinate system.

R[42-II] The user will be able to "save" the current display.

R[43-I] The control panel will be easily accessible to the user.

R[44-II] The user will be able to use a keypad, a PC or an equivalent input mechanism to pass information onto the device while working on the Chemistry or Mathematics modes.

4.2 Output Component

R[45-I] The user interface will include a status indicator for power on/off.

R[46-I] The unit will shift to sleep mode (minimum power consumption) once it has been idle for 15 minutes.

R[47-I] The user interface will include a status indicator for the currently selected mode.

R[48-II] A method will be provided to allow the user to view the information entered while in the Chemistry or Mathematics mode. This could be by means of an LCD, a PC or an equivalent displaying device.

5. Documentation and Training

Although EduTech intends to make the 3D-Plotter as intuitive as possible, the following requirements will need to be fulfilled to properly inform the user about the device.

R[49-I] Minimal training will be necessary to operate the device.

R[50-I] A user manual will be included with instructions on how to use the device in any of the different modes of operations.

R[51-I] A document will be included that provides the user with basic troubleshooting methods.

R[52-I] A document will be included that indicates any precautions that must be taken during usage of the device. This includes the requirement of adult presence when children use the device.

R[53-I] A document will be included that lists the requirements necessary for the device to function correctly.

R[54-I] All of the documentation will be written in English.

R[55-I] All of the documentation will be written for an audience with little to none technical knowledge.

R[56-I] All of the documentation will include EduTech's contact information.

R[57-II] A hard-copy and a soft-copy of all of the documentation will be made available to the user.

R[58-II] A hard-copy of the documentation will be provided to the user upon purchase.

R[59-II] A soft-copy of the documentation will be made available to the user through a website set up by EduTech.

R[67-II] A forum will be set up by EduTech for users to share tips, ideas and possibly even designs.

6. System Test Plan

We have a series of tests planned to ensure the successful implementation of the functional specifications. Some of the tests plans have been created to check the practical limitations of the device. These will be detailed further in the design phase of the project.

Power consumption:

- Measurement of the power consumption of the device under extreme conditions such as:
    - Simultaneous turn-on of the maximum number of LEDs possible.
    - Maximum LED intensity for an individual LED.

Quality of display

- Observation of the amount of flickering and refreshing characteristics of the image displayed at different refreshing speeds.
- Observation of the intensity and clarity of the image displayed at different refresh rates.
- Observation of the image displayed from different angles to ensure that the user is able to simultaneously see multiple sides of an image

7. Conclusion

EduTech strives to be the leading company in developing the 3D Plotter which shall play an important role in the research for true 3D displays. This document, the functional specification, lists our product's requirements which shall facilitate the desired capabilities. It is important to note that these requirements are not strict and are mostly to be used as a guideline. The target completion date will be April 6, 2008 as scheduled.

8. References

[1] Canadian Standards Association, February 2008, http://www.csa.ca

[2] The Consumer Electronics Association, February 2008, http://www.ce.org

[3] "Underwriters Laboratories" February 2008, http://www.ul.com